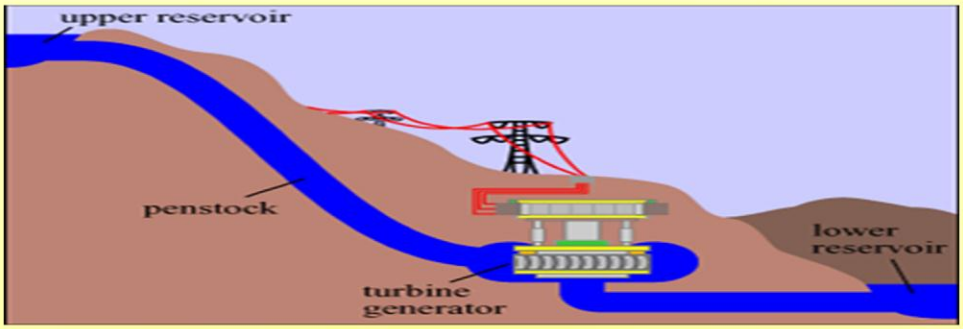
E-Book

An Ensemble of Surround Physics

(A collection of awarded Essays in NCEWP 2019 to 2021)

YEAR 2019

Physics of your city, community and surroundings

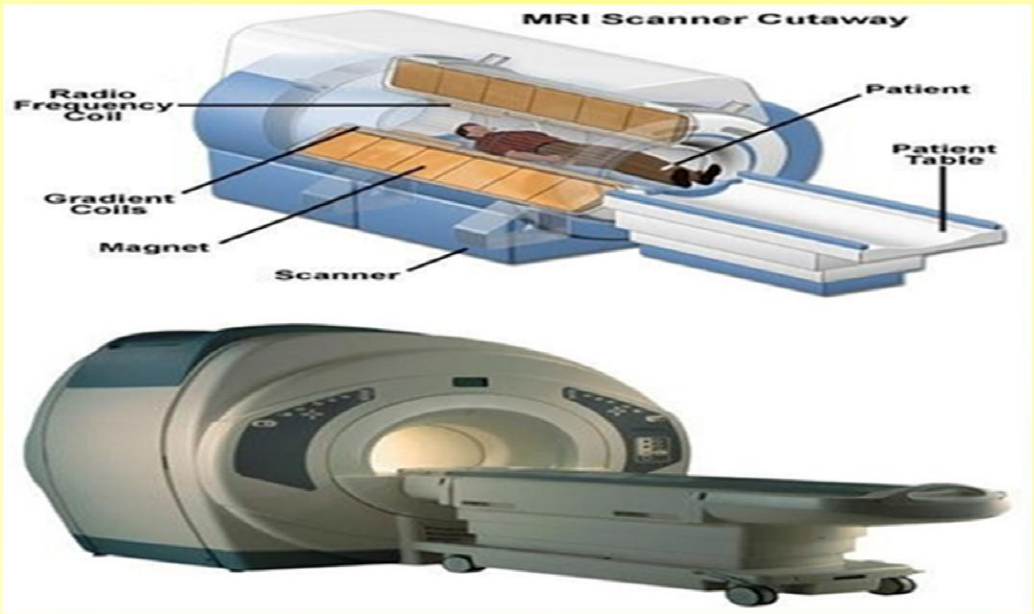


YEAR 2020

Pollution in our community, measurements and Physical insights

YEAR 2021

Modern Physics and Medical Diagnostics



Foreword

From among the skill set of a student, teacher and a researcher the art of communication sits on top of desirable skills. In this genre Science Communication and communicating results of scientific research have a very special place in this era of Science and Technology and the need to communicate its pros and cons to the society in general. Indian Association of Physics Teachers is very keen to help its stake holders both among teachers and students in this genre for the last 10 years. It was initiated as an annual feature as National Competition of Essay Writing in Physics (NCEWP) and has been successfully going on with a good number of participants.

However, it is a very strong feeling among the IAPT members, conveyed from time to time, that we should go ahead with an e-publication of the winning essays in the form of an e-book which can help as an inspiration, guideline and bench mark for the future competitors. In this inaugural issue entitled **An Ensemble of Surround Physics**, we have covered best and prize winning essays on different declared themes for the years 2019, 2020 and 2021 from among the categories of students and teachers.

Coordinator of this competition, Professor S. K. Joshi has taken great pains to give this compilation of physics essays a wonderful editing touch to make them presentable to a wide audience who will be interested in participating in future competitions and also to the lay audience. The guidelines of the essay competition have also been made, included in this collection so as mentally prepare the participants to take a plunge in this prestigious competition of IAPT. Finding these essays at one place also provides readers the sweep and reach of physics as a subject impinging on our day-today lives.

I congratulate Professor S. K. Joshi and his team for coming out with this initiative and placing it in the hands of the readers. Dear reader I want to make a request, do share this e-publication with your students to motivate them to come forward and hone their skills of writing with confidence by bringing them closer to this must participate competition. I wish the team a grand success.

Professor P. K. Ahluwalia
President, IAPT

PREFACE

Writing makes one perfect, essay writing more so……

NCEWP (IAPT National Competition on Essay Writing in Physics) is one of the three national competitions being held by IAPT every year. The competition is open to participants in two categories viz., students and teachers (including Science Communicators).

Category A - Students of Higher Secondary /Jr. College, UG and PG levels;

Category B - Teachers of Higher Secondary/Jr. College, UG and PG institutions, also Science Communicators working in recognized institutions.

Prior to 2019, the 1st Prize winning essay entry in the Teacher's category was published in the IAPT Bulletin. The following entries from 2013 to 2018 were already published in IAPT bulletins. The details are:

1. Astronomy from the Moon by Akbar Ali S.F.A. Saifee. Department of Physics, Maharashtra College of Arts, Science & Commerce, Mumbai. This article is a revised version of the first prize-winner essay in NCEWP-2012 published in IAPT Bulletin, Oct. 2013, pp.244-250.
2. Speed of Light and its central role in Physics by Akbar Ali S.F.A. Saifee. Department of Physics, Maharashtra College of Arts, Science & Commerce, Mumbai. This article is a revised version of the first prize-winner essay in NCEWP-2013 published in IAPT Bulletin, July 2014, pp.180-185.
3. Physics- a fundamental science full of applied flavour by R. Selvapriya. Standard Fireworks, Rajaratnam College for Women, Sivakasi, Tamilnadu. This essay won the first prize in NCEWP-2014 published in IAPT Bulletin, Nov. 2015, pp.261-263.
4. Radioactivity- Physics and applications by Rakesh D. Macwan, St. Mary's High School, Mariampura-Petlad, Gujarat. This is the first prize winning entry in NCEWP-2016 published in IAPT Bulletin, March 2017, pp.61-67.
5. Lasers Today- A century of Einstein's Stimulating Theory of Radiation by Dr. A Raghu, PG Department of Physics, Government College (Autonomous), Mandya, Karnatak. This is the first prize winning entry in NCEWP-2017 published in IAPT Bulletin, Dec.2017, pp.316-323.
6. Role of Physics in ICT Revolution by Pawan K Diwan, Department of Applied Science, UIET, Kurukshetra University, Haryana.

Since 2019, due to Covid Pandemic, the scenario changed and NCEWP was conducted via email submission of essays. Subsequently, an idea of E-Book containing the collection of selected essays, was given by our IAPT, President Prof. P K Ahluwalia. So, in this E-Book, we have decided to include the prize-winning essays from both the categories viz., Teacher's and Student's.

I am extremely thankful to our President for this novel suggestion of E-Book. We feel that this collection of essays will be useful to our readers in general and to young future participants in particular.

In the last part of this E-book, the Guidelines for Essay Writing and Developing Skills for Science Communication have also been included as an Appendix.

As editor, I have tried to rectify language errors and formatting issues, not changing the basic content of the essays. In the end, I am very much thankful to Sambodhi Translation Services, Indore for their professional services in getting this E-book out in the current shape.

Prof. S K Joshi
Coordinator NCEWP &
Editor of E- Book

A Brief History of NCEWP

The following table includes information of topics used in earlier competitions since 2012 (starting year of NCEWP). Under the efficient guidance of Prof. K. N. Joshipura, for the initial 6 years, a necessary framework for this competition was put in place.

Sr. No.	Year	Topic	Coordinator
1	NCEWP-2012	Let us go to the Moon and watch the sky from there (A scientific account of sky gazing from the Moon) **Competition only for Teachers**	Prof. K. N. Joshipura
2	NCEWP-2014	**Any one** (1) From Linear Physics to non-linear nature, a challenging journey **OR** (2) Physics –a fundamental Science, full of applied flavor Competition for both Students and Teachers Started	Prof. K. N. Joshipura
3	NCEWP-2015	**Any one** (1) Light in our lives, in Physics and in Technologies OR(2) From Newton's gravity to Einstein's general relativity	Prof. K. N. Joshipura
4	NCEWP-2016	**Any one** (1) Radioactivity- Physics and Applications **OR** (2) Resonance phenomenon- Physics and Applications	Prof. K. N. Joshipura
5	NCEWP-2017	Lasers Today-A century of Einstein's Stimulating theory of radiation	Prof. K. N. Joshipura
6	NCEWP-2018	Role of Physics in ICT Revolution	Prof. K. N. Joshipura
7	NCEWP-2019	Physics of your city, community and surroundings	Prof. S. K. Joshi
8	NCEWP-2020	Pollution in our community, measurements and Physical insights	Prof. S. K. Joshi
9	NCEWP-2021	Modern Physics and Medical Diagnostics	Prof. S. K. Joshi

For the last four years, I am involved as Coordinator Essay Competition. Our team comprises: **Prof. S. K. Joshi, Coordinator, Dr. Himanshu Pandey, Member and Dr. Shivanand Masti, Member**

Every year a topic is given for the essay competition, then it is published in the Bulletin and also on the IAPT website. As per decision of the IAPT EC, all RCs are supposed to organize Essay competition at their level first. They have a scrutiny of essay entries at their level and select TWO best entries of Students (Category A) each from School, UG and PG level thus making SIX entries from each RC. These selected entries are sent to Coordinator/Member for the National Competition. Teachers (Category B) send their entry directly to Coordinator. Three examiners are assigned the job of valuation of essay entries separately for category A and B. Negative marks up to a maximum of 12 are assigned by the evaluators for copy-paste instances.

We are thankful to all our examiners of essay competition during the last three years as well as from previous years, viz., Dr. M P Maru, Prof. V N Potbhare, Dr. D K Bopardikar, Dr. Tarun Trivedi, Prof. Mihir J. Joshi, Prof. SH Behere, Dr.(Mrs.) D S Kelkar, Dr. Ashok Mody, Prof. S B Welankar, Dr. Dilip Deshpande, Dr. Sapna Sharma, Dr. Usha Singh and Dr. A P Deshpande for rendering their excellent help in this voluntary work.

I am also thankful to Prof. Vijay Singh, then President IAPT and Prof. K.N. Joshipura, General Secretary for entrusting this work to me. Apart from this I am also thankful to my committee members Dr. Himanshu Pandey and Dr. Shivanand Masti for their help. I sincerely thank our President Prof. P K Ahluwalia, GS Prof. Rekha Ghorpade, all EC Members, Office bearers of RCs, all Vice Presidents IAPT, Prof. B P Tyagi, Prof. U S Kushwah. Big thanks to Kanpur Office Dr. Sanjay Sharma, Dr. D C Gupta and Vinod ji for their excellent help in the Prize Distribution Ceremony. It is a long list to mention all individual names. Finally, I am thankful to all participants of Essay competition and those who helped me in conducting this event directly or indirectly.

Prof. S K Joshi
Coordinator NCEWP

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Continued…..

PHYSICS OF YOUR CITY, COMMUNITY AND SURROUNDINGS

Adnan A. Vahora
Zenith School, Vadodara, Gujarat

Key words: Everyday life, dome structure, traffic jam, energy conservation.

Part 1

Do you know the origination of a word φύση? Yes, this word is basically a Greek language word which simply means 'nature' and it is believed that the word physics has been also derived from this word.

Before knowing physics around us, let's learn what physics is! Physics is inherent in every matter and radiation. Occurrence of day and night, changing in seasons, splendid rainbow in the sky, the formation of waves in the ocean, volcano eruption, heating up your tea and cooling down afterward, lightning in the sky. Here, there and everywhere, we are surrounded by a phenomenon which might be questioned or not everything describes, explains and elaborates by physics. The workspace of physics is from zero to infinity. When we ask to nature, 'why you did it?', surely answer will be in the form of laws of physics and those who are raising such questions to nature are called a scientist.

Thepla and Achar is the identity of our 'Gujarati's'. We Gujarati almost every day eat Fulka Roti with dinner and thepla at breakfast. Have you ever think why Fulka Roti is bloating a lot than a Thepla? The answer is hidden somewhere in the formation of dough. In Fulka Roti, an excess amount of water being applied, while in thepla, an excesses amount of oil is used and you know their boiling point. So, it may occur due to pressure.

A small temple in our city tells us a very interesting story. A few years ago, heavy thunderstorm had fallen on our city. In that stormy night, the lightning had fallen on that temple, the thunder was very loud. Some worshipers were present in the temple at the time of lightning and surprisingly they survived from that lightning because of the electrostatic shielding effect of four metal rods installed at four corners to support the flag of temple and rest is physics. All the lightning had passed through the metal supports and hence the people inside got survived.

"What one man calls it miracle, another calls it the laws of physics"

Imagine, you are living in early era of your time. If you want to print anything, you only need to have your hand and a pen, after several years a man named Guttenberg invented printing and then evolution goes on and someone invented type-writer with the principle of lever but still typing something is comparatively slow and bulk printing wasn't handy for all. After some year's, an evolution did its job and one invented the printer and still we are updating this device printing something wasn't as easy as before this time inkjet printing hugely affected our lives. Do you know how ink-jet printer works? This machine made letters by squirting tiny drops of ink at the paper. A negatively charged drop moving between two conducting deflecting plates, between which a uniform electric field has been set up. We know that the charge encounter force in the electric field, so the drop is deflected upward and then strikes the paper at a position that is determined by the magnitude of electric field and the charge of the drop. And this all happens in just a few seconds, this is the impact created by Physics.

It is not unusual for soldiers marching in a long column to be out of step. This is observed when soldiers are marching in time to the music of a band at the head of the column. Can you tell why the

soldiers at the rear are out of step? We know it takes time for sound waves to travel through the air. The music of the band reaches the soldiers at the rear of the column after it is heard by the soldiers leading the column. If the column is about 600 feet long the soldiers at the rear will be a whole place out of step with those who are leading. So, it's act of just physics not the mistake of your soldier when he is out of step while marching.

The friendship of clock and pendulum was also very famous. In earlier time length of pendulum was set in such a way that the time period should be 2 seconds. All gears in a clock are rotating in such a way that in half period watch shows 1 second in summer and winter one had to set a time due to thermal expansion of the length of a pendulum.

Don't you feel amazed that microwave oven in our kitchen heating up food but not the vessel? That contains it because of food contains H_2O and H_2O contains dipole moment. In an oven it tries to adjust in continuously changing electric field hence, they got vibrational energy and that results in increasing of temperature out of it.

When I was so young I got a question in my mind why does it rain more on the high ground than low? Then I came to know the water on the earth is being continuously recycled. The hot sun evaporates the water from the sea and it rises to form clouds these are blown in the land by the wind until they reach high ground such as a range of Hills on mountains near currents of air makes the clouds rise higher into the atmosphere where it is colder. The cold causes the clouds of water vapor to condense and fall as rainfall.

As we are talking about rain, have you ever felt that your T.V. gets some trouble in getting the signals (here we are not talking about cable T.V.) while it's raining outside, why so…? In order to understand this, we need to know how our dish T.V. gets signals. We have the receiver; dish antenna that gets the signals from the main broadcasting transmitter from where the signals are transmitted in the direction of a camera, the dish antenna is adjusted in the direction of the incident waves. When it is raining outside, the medium between the transmitter and receiver get changed, due to this the incident wave deflects due to refraction and our T.V. can't get proper signals.

A beautiful rainbow always fascinates us. I am sure everyone loves to see beautiful seven colours in the sky. How God fills colours so beautifully? The reason is water, light and internal reflection and refraction or we can say two- time refraction and one-time reflection from water droplets is the reason behind it. And one hypothetical prism-like situation occurs and ultimate dispersion is nothing but a rainbow. While talking this how we can forget the best lens created by nature. Auto focused, full HDR auto-focused you got it. It's nothing but eye lens in action from it and we can see this beautiful world.

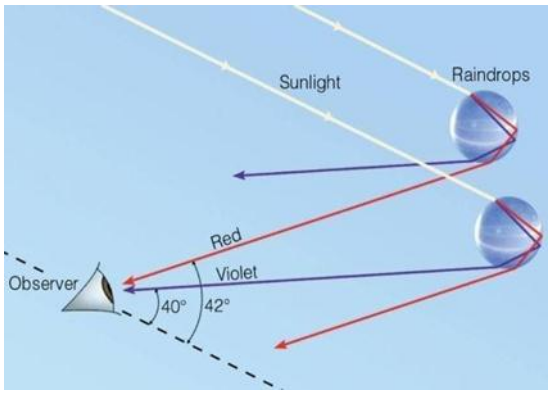

Figure 1: Formation of primary rainbow

Nowadays there are completely race of pictures and Camera quality among youngsters. Starting from 2 megapixels to 48 megapixels quad Camera phones are available in the market. Culture of pen and pad is in trouble and so-called smartphones are there in the market. But when I ask youngsters that, "what is the meaning of good pictures to many friends, they answered: "clarity should be very well of such a good picture".

Now, what does we mean by "clarity"? On further discussion, I came to know it's all about "resolution". That is, How much ability of the lens to separate out to nearest points. Those which can separate it better have a better resolution and those only have a better picture Clarity. Then I thought

how smartly our eye lens design and how nicely our autofocus lenses (eyes) works? Moreover, I read somewhere if we were able to see infrared, then there was no night for us!

We all know that the bolt of lightning seen first then after we hear the sound of lightning. Is there any relation between the time difference of the lightning and its sound? Yes, there is a definite relation between them. You can also determine the distance where the lightning fell by just counting the time between the light and sound. As we know, the sound waves and the light waves propagate differently in the medium where the speed of the sound wave is lower than the speed of light. Let's not fall into tedious physics (although physics is not tedious), we just see an approximation. If you count the seconds between the lightning flash and the first sound of thunder and then divide the number of seconds by five the result will be the approximate value of distance in miles of the lightning flash. This is because at thunderstorm temperature sound propagates in the air about one- fifth of a mile per second. If ten-second elapse between the time you see the lightning flash and hear thunder, lightning is two miles away. Can you believe that the same distance approximation technique scorpion uses to determine the position of prey! (Scorpion has no eye).

Oh no, I forget the tea is here at the table, initially it was too hot to drink so I thought to keep it for some time and then drink, but I amazed to see that hotter tea cools down faster, why so…!! I think the same thing happened to my father's smartphone. Battery reduces faster if it fully charged and with a discharging slowly while it is less. It was amazing to found that the law governs this phenomenon is same that governs radioactive decay which I studied in chemistry (first-order reaction) and is same law which teaches us. How metal expands and resistance of copper metal decrease with increasing temperature. Seriously, then I remember my physics told me that nature loves exponential behavior…!

Part 2

I am basically from Vadodara, Gujarat which is known as Gaekwadi Nagari, great Emperor Maharaja Sayajirao Gaekwad developed it and established maharaja Sayajirao University in 1881. My city had seen the first telescope, 8 inches refractive made from Carl Zeiss lens, one of the biggest in Gujarat. Recently Vadodara is known as the classical urban city which developed with caring of its ancient architecture. Vadodara is a city of domes. Many monuments like the university, Airport, Laxmi villas palace, Rani no hajiro etc. contains imposing domes. Among this domes, arts faculty dome made in1880 has a height of 40 feet, second largest masonry dome of India. Do you think this structure is only for decorative purpose? Or some physics is also involved in ancient time a stone was placed with the help of two columns to make a ceiling. There are chances to collapse it as we are increasing distance between columns.

As we know the problem of buckling occurs for thin long columns. I think the structure of a dome is the best solution of this. Due to this reason load is distributed as shown in fig. We can have a large area in this structure. I am sure that maharaja and their architects were surely aware of this. Due to such a scientific approach is in the soul of our city obviously Nobel Prize is obvious of the son of the city.

Figure 2: Maharaja Sayajirao University

Traffic jam is one of the major problem in every city. To understand how it occurs, let's do an experiment. Suppose you are a drone with a high-resolution camera and looking at the three-lane road from the top. This road contains only cars in a fixed row and at a fixed distance to next row from one side a one small child is crossing the road so one of the rows of cars suddenly stops so naturally rows of car behind this row would also stop, so the chain reaction of stopping of cars starts, after the child crosses the road the first row which stopped first starts with initial velocity that they had before and next rows will also start moving by keeping equidistance as before. The entire process happening here is exactly like sound propagating through air. Here the car is like atoms in the air and a child is nothing but the source of sound such a process printed as a phenomenon of condensation and rarefaction in textbooks of physics. Due to such obstacles and elasticity, sound propagates. So how can we use this visualization in our real life? We can solve this problem by applying some physics we considered the car as atom so can measure the speed in which the dense area of the car is moving so we can alert other arriving cars so they might not be stuck in the traffic jam.

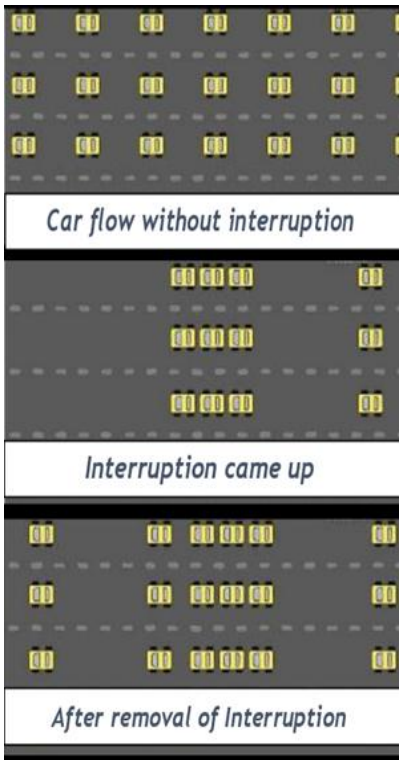

Figure 3. Car flow

In my City, many Traveler birds come in winter. Have you ever noticed when birds fly long distance in flock why do many birds fly in a V formation? When birds fly by flapping their wings instead of light in each downward push by a wing creates a vertical vertex in an air traveling, when birds fly by flapping its wings(instead of gliding) in each downward push by a wing, creates a vertical vortex in an air trailing the bird. The vortex circulates downward on the bird side, and inward on its top side. If a trailing bird positions itself in the up-flow part of the vortex, it receives a free lift. Though it still must flap to stay in the air it does not have to flap quite as hard, and thus its energy requirement is not quite as much as before. To be in the upper floor trailing bird should be off to one side of leading bird and V formation is one of the best formations for placing the birds properly. It also allows them visual contact. Now you know the birds know physics. Isn't it cool! But that's not the end energy savings can also be one reason why fish swim in schools the vortex formation by the leading fish can help reduce the energy requirements of fish further back in the school.

Furthermore, when a fisherman found that they could be used to locate schools of fish, has been no sound reflected from the swim bladders of fish when the fisherman determined the location of the school nets can be cast accurately so there is also Physics in swimming of fish and fishing in bulk.

As discussed we know physics is everywhere not in just a city, community or surroundings but it is in our belief also. When we pass through any river we surely observe people throwing some coin inside it and pray. Do you think any science to be there behind this? As per my thinking, reason should be like that, in earlier time coins were made up of copper and we know that copper contains many necessary mineral. That's why vessels like glass, spoon, dish were also made of copper, so people by throwing coins unknowingly (or some knowingly) making water healthier.

Though physics is everywhere but I think it lies in the eye of beholder everyone see physics in different form. It is continuously enhancing our brain. Some of the principles were not so correctly known by us, after some time they were updated by physicist. For example mass and energy were

treated differently, but it was the Albert Einstein who asked the question to the nature 'does the inertia of body depend upon its energy-content?' [1], and rest is the history he gave famous equation $E=mc^2$ that tells us that energy and mass can be converted into each other. So if you say mass or if you say energy both are quite same things. In short, as per this equation 1kg of matter is approximately equivalent to 90000000000000000 joules of energy. From above discussion, can we say that in the whole observable universe there is nothing but energy?

"I think nature's imagination is so much greater than man's, she's never going to let us relax"
-Richard Feynman

Sometimes I have a question as to why and everything is working? How and from where energy is basically generated from? Let us discuss in another way, basically, how this fan can keep moving? I am sure the answer will be due to electricity. But where it is generated from? It may be from the nearest electricity office. From where that basically gets generated? Yes, from the powerhouse. And what is the source of powerhouse? Surely, answer will be from a fuel like coal or from the kinetic energy of the water or from the sun or something. If we keep on going to ask such questions, interesting realizations will happen. That whole this world is made up of nothing but full of energy and we just convert it from one to another, no one can create no one can destroy. Yes, it is basically a conservation of energy, an eternal universal law.

In addition to this, if we think in a more philosophical manner, noticed sharply, what we are earning in terms of money it's not just money but we are gathering energy by which we can have different types of energy like food, vehicle, servant, and all other things which provide us energy. Moreover, we work for money for consuming our energy. We are giving whatever form of energy we have, be it knowledge, or physical strength, management abilities, everything we have stored internally, we utilize to earn money by which we can have another type of energy. Those who belong to service class are earning energy in terms of money and store for future and business class utilize that energy (money) to earn more energy (money). We can print money, not energy. Not only this, as Einstein proved that mass is also a form of energy by his famous equation $E=mc^2$, we born with special energy and then taking energy from other forms, use it, develop, grow, and then getting died. Interesting point average mass while born is 2.5kg and after death, the average mass of ash is also 2.5 kg!

How amazing!! Universe is following the conservation of energy! It is God who provides this energy. Then who can deny the existence of god? Obviously, he is with us forever ever.

"I want to know how god created this world. I am not interested in this or that phenomenon, in the spectrum of this or that element I want to know his thought, the rest are details."

-Albert Einstein

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PHYSICS OF YOUR CITY, COMMUNITY AND SURROUNDINGS

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Key words: Architecture, Gothic appeal, hydraulic machine, infrastructure, storage.

Area of Shimla is approximately 35.34 km square and temperature averagely ranges from -4^{o} C to 31^{o} C. The Shimla city receives 1480 mm rainfall annually. Recent census shows that the population of the City is 1.7 lakhs approximately.

The water is supplied from tributaries and sub tributaries of Yamuna and Satluj by Municipal Corporation and IPH department. Transportation consists of public buses (fuel and electricity). Government provides Taxi services as well.

The electricity board generates and supplies power through network of transmission and distribution lines and the main project is Nathpa-Jhakri project which supplies 1500 megawatt power.

Architecture and infrastructure of Shimla city

PHYSICS is the comprehension of nature. It is the natural science that studies matter, its motion and behavior through space and time, and that studies entities of energy and force. Physics is one of the most radical scientific regulation and its main objective is to understand how the universe acts.

Public Art is any example of media that has been planned and executed with the intention of being staged in the public empire. The public monarchy refers to publicly-retained streets, parks etc. where buildings are sited. Architecture without any doubt meets this definition. The interaction of people with architecture is seen daily. We are over elaborated on a practical and mental level by both the way a building looks in its surroundings and by its interior environment.

The scientific technique is used by architects to research and develop concepts on multitude levels required to create structures. The levels which include understanding the surrounding context from environmental, historic, and infrastructure perspectives and determining program areas required by users which include interior products, structure, mechanical, electrical, plumbing, fire protection, technological and security systems.

There are three main reasons for that requirement. Firstly, architects have to understand the fundamentals of physics because they have to apply processes taking place in buildings and in structures. Secondly, as part of general education, physics widens the understanding of the physical world around us. Third, since physics is a precise science that mainly depends on mathematics, solving physics problems improves the quality of analytical and scientific thinking skills of the student.

The principles of physics have immense application in development and maintenance of the infrastructure of the city. From the transportation medium to the basic necessity of life like supply of water, electricity and various household equipment and daily cores of life, Physics is used as the underline principle.

A. Viceregal Lodge

The Indian Institute of Advanced Study (IIAS) is one of the oldest research institute of India based in Shimla, India. The building that houses the institute was originally built as a home for Lord Dufferin, Viceroy of India from 1884–1888 and is also called The Viceregal Lodge. The design of building is Indo-Gothic.

The building also is equipped with an enlighted firefighting technique through wax-tipped water channels. The wax used for the firefighting system is particularly polymer wax which has very high durability due to large chain of organic molecules.

Recently the lodge had undergone a facelift. Some parts of this magnificent and imposing grey-stone was crumbled to the dismay of many of its admirers.The Viceregal lodge being more than a 100 year old colonial structure requires good technology for its maintenance. The technology should be such that the static value of the building is constantly maintained. This building is maintained by the organization Archaeological Survey of India (ASI) using state of the art technology and recently they used Swiss-made carbon lamination technique which was used for the first time in the country. They used diamond fitted hydraulic machine, which minimizes the abrasion effect, for drilling holes in stone. Diamond being the hardest substance in nature have very good abrasive quality and hydraulic

machine is based on Pascal's law which states that the pressure at any point in the fluid is same in all the directions. To provide extra stability to the structure steel pins have been drilled in a crisscross manner in the holes. These holes are inserted with chemical that strongly bonds the damaged stones with steel pins. When we insert steel pins in the crisscross manner, the degree of freedom reduces which means the movement of the pins becomes difficult which makes the structure steady and integrated. Therefore, we can conclude that the principles of physics applied through engineering mechanism in the machinery are being used.

B. 108 Feet Hanuman Idol

Jakhoo Temple is an oldest established temple in Shimla. It is located in Jakhoo Hill, Shimla's highest peak at a height of 2,455 m (8,054 ft.) above sea level. The private company Jagson International Limited (JIL) started an aerial Ropeway which links the Ridge with the temple through rope.

The great 108-feet-high idol of Hanuman was revealed at Jakhoo Hanuman temple on 4 November 2010. Being a very tall statue it is subjected to risk of heavy natural disaster like winds, landslides and earthquakes.

The region where this statue is situated comes in one of the highest earthquake risk zone of the country. Due to this reason and keeping these things in mind the foundation of the statue must be very strong.

Thus with the help of physics, we develop such materials and technology so that the structure becomes very strong. Use of composite material is used in formation of the statue. Composite material is the combination of two parts: The Fibre and The Matrix.

Function of the fibre is to reduce strength in a particular direction and the matrix which is generally mixture of cement, gravel and sand is used to hold the fibres together. So the overall composite material have a very high strength due to which it reduces the risk of failure from natural disaster and when we are making such a huge building its own weight can also become the reason of its failure.

C. Gaiety theatre

The beauty of theatre is that not only does it provide a creative outlet for the artiste but begets its meaning through narrative and metaphor.

The exquisite gold carving, paper mache panels, the mint green walls and deep blue pillars, and the Indo- Saracenic style of architecture clearly speaks aloud the magnificence of an unconquerable British Empire. The last time it was renovated was in the year 2005 and that was when the paper mache panels were put further making it look more wonderful.. The acoustics are the finest in design and the voices extends deep and clear from the stage to the audience without even using the mikes. It is a theatre marked with elegance, detailed Baroque enhancement and **GOTHIC APPEAL**.

Gaiety theatre is designed on the basis of gothic architecture. The technological superiority of the gothic approach was a result of three engineering concepts.

I. The pointed arch
II. The ribbed vault
III. The flying buttress

I. Pointed Arch

One of the distinguishable feature of Gothic architecture is pointed arch. These are basically seen in windows, doorways and the series of arches between supporting columns, and it represents a exceptional curved ROMANESQUE Architecture. The service provided by the later is limited because the height of the arch always had to be exactly half its width. Pointed arch offers benefits in term of structural engineering. The pointed arch can have any ratio of height to width. A greater amount of weight above the arch is transmitted down into the ground, instead of applying a sideways force.

II. Ribbed Vault

The stone ceilings of building are made in such a way that they took the form of semi-cylindrical barrel vaults. These were massive and inefficient, and placed intense limitations on the size of buildings that could be constructed. The situation changed dramatically with the arrival of the Gothic style. This used a web of interesting stone arches, known as ribs, in order to provide the strength, while the space between the ribs was filled with lighter stonework which was not load-bearing.

III. Flying Buttress

A buttress is a heavy pillar of stone built up against an outside wall to counter forces- with the help of air turbulence or the weight of stonework- pushing sideways on the wall. This assumes, however, that the wall extends vertically all the way to the ground. In many gothic buildings this was narrower than the lower tier. This meant the supporting pillar for the upper part of the wall had to be built some distance away from the wall, and then connected to it by a load-bearing arch. The resulting combination of pillar and arch is known as flying buttress.

Gothic architecture made a large impact in architecture during the twelfth century. Pointed arches and vaults are some of the main defining characteristics of Gothic design. Through incorporation of these characteristics in cathedrals, cathedrals were able to increase the building height and assume a more slim appearance, as well as incorporate window art on the walls, since the walls were no longer being used to carry the building load. Therefore, because of innovations from gothic design, buildings such as cathedrals were able to increase the amount of light in the building through window art and increase the height of the building through pointed arches and the use of vaults for support.

IV. Infrastructure of Ridge Shimla

Shimla was once the summer capital of British Raj perhaps one of the most beautiful capitals in the country, that's why during peak season the daily influx of tourists ends up creating a huge amount of pressure on infrastructure and resources of Shimla.

Underneath the Ridge, large water tanks are placed from which water is supplied to the British era tourist town. RIDGE which can easily be called the backbone of the capital is above the water tank which is 2,205 m in length. Water reservoir, with a capacity of 1000000 gallons of water, beneath it.

The reservoir is stated to have been constructed in the 1880s without using any cement and only lime mortar. In order to store water in a tank of very large dimensions as that of ridge in Shimla the strength and integrity of the tank should be maintained very properly. This is because from pascals law the fluid applies very high pressure forces at the bottom as well as at the side surfaces of the tank.

By knowing the density and height of the tank pressure can be calculated. Density being 1000000 gallons of water and height being 7,234 feet. So the hydrostatic force at the bottom of the tank will be

ρgh = density x acceleration due to gravity x height of the tank

By using this formula we get to know the pressure of the water in the tank. To counter the force applied to the tank, the tank is divided in small parts so that the forces also gets divided. Same pressure is applied to the vertical surfaces as due to Pascals law pressure at any point in the fluid is equal in all the directions.

In a nutshell 'Infrastructure physics' deals with physics behind the phenomena related to physical behavior of the materials, components and systems involved in infrastructure, in their specific environmental conditions in order to increase their accessibility and efficiency.

Similarly, architecture is the art of science of designing buildings and structures. Buildings are static; in fact they are so static that some languages also calls them structural engineering statics. Architecture probably doesn't need to know particle physics. But in a world where the built environment threatens to overwhelm nature, we need to understand the bigger system and our place in nature. Physics can help with this understanding

Therefore, the study of physical laws, science and technology applied in the architecture and infrastructure of Shimla city gives a conclusive evidence that physics plays a vital role in each and every aspect of the universe. With the ever increasing development in the engineering and technology the application of physics will exponentially increase to develop sustainable future scenario.

PHYSICS OF YOUR CITY, COMMUNITY AND SURROUNDINGS

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Key words: Energy, Water, Physics, Astronomy, Gathiya.

Part I

Image 1: Location of Bhavnagar on Map of Inida. Source: Wikimedia Commons.

Bhavnagar is a city located in the state of Gujarat, on the coast of Arabian sea, near the Gulf of Khambhat. The city lies between the Tropic of Cancer and the Equator.

The coordinates of the city are 21.76˚N and 72.15˚E. This location gives it a strategic maritime trade advantage as it is closer to Surat and Mumbai, Maharashtra by sea and air, than any major city in Saurashtra, region of Gujarat.

The city is spread across a large area of 108.27 sq. kms and houses a large population of over 1.6 million people. This indicates that the city has a population density of 16,000 persons/sq. km. This is the highest population density among all the major cities in Gujarat.

Due to its proximity from the sea and latitude of 21.76˚N the city has a climate that can be referred to as hot and semi-arid. Much of the water in this region is lost due to Evapotranspiration fueled by direct sunlight and windy climate.

In summer the average daily high temperature is about 40˚C while the low is 26˚C. During winter the Average high temperature is 28˚C while the average low is 14˚C. The city receives most of its rainfall in July, with 10 rainy days on average. The annual rainfall is around 23.3 inches or 593 mm.

Image 2: Bhavnagar Location on Map of Gujarat. Source: Wikimedia Commons

The air quality index or the no. of PM $_{2.5}$ particles in ppm concentration remain at a higher side i.e. above 100 for most days in winter and summer. This is mostly attributed to the fine dust in the region due to and windy climate, unlike large metropolis where it can be attributed to pollution levels in the city and surrounding industrial patches.

Energy Demand

The initial wave of industrialization in the region led to the formation of BECL (Bhavnagar Energy Company Limited), which operates several coke-ash and "coal and lignite" based thermal power plants in the outskirts and around the city. A 250 MW lignite based Thermal power plant was set up by BECL - whose capacity has now doubled to 500MW.

The region also exploits its good exposure to wind. Suzlon energy has set up various wind turbines on the Malnath hills. Each windmill generates 3MW power at peak.

With day lengths ranging from 10.67 to 13.33 hours a day a 10 m^2 PV can generate 9.6 units of energy per day. Rooftop solar power has considerably added to the domestic renewable power generation in the city, taking advantages of the government schemes of subsidized installation. My household boasts of a 3KW installed capacity for solar power and the immediate neighborhood combined has approx 11KW of solar power capacity. Solar insulation is the amount of solar power received per unit area. It has a range of 75 to 175 Kwh/m^2 depending upon the month of the year.

My neighborhood and the city, in general, is adapting to cleaner and renewable sources of energy in the recent past. It is also an energy positive neighborhood as it generates more energy than it consumes.

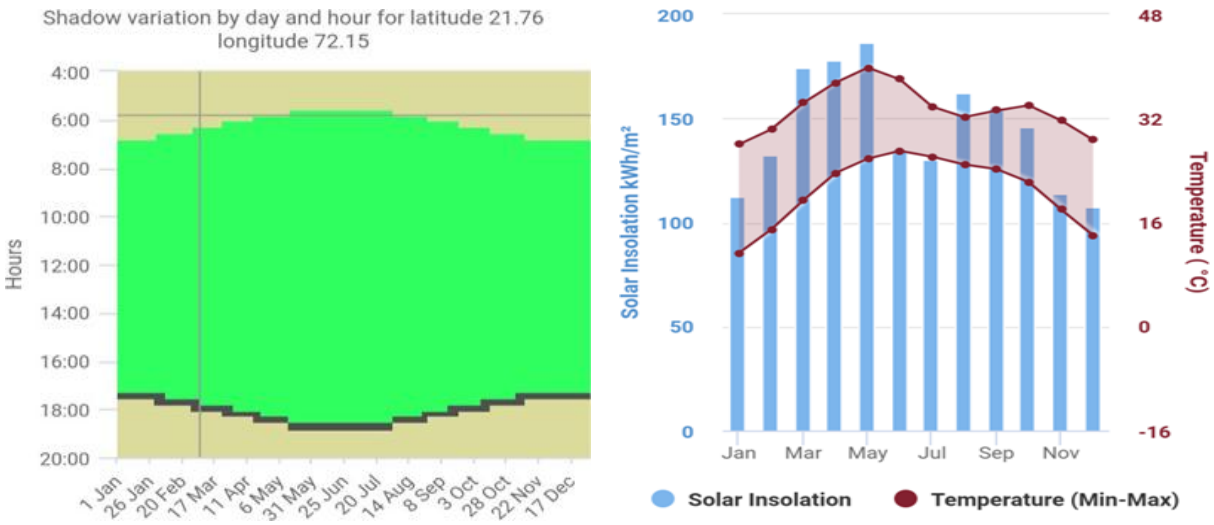

Image 3: Sunlight availability and solar isolation over Bhavnagar indicating excellent solar power
Source: ISRO Vedas

Water Resources

The city in the recent past has become dependent on Narmada waters to fulfill its drinking water and irrigation needs. However, there also exist several local water collection sites that serve the city's interests.

The Gaurishankar dam provides a catchment area for the river water to collect. This water is used throughout the year after the monsoon to fulfill the city's freshwater need. The dam has a maximum height of 65 feet.

The city has storm water drainage designed in a way that all the water, collected from rainfall is brought into the GangaJalia lake that is located in the center of the city. This helps in maintaining the ground water level across the city. Rainwater recharging initiatives have also been taken up. In my

immediate community, rainwater recharge/harvesting is being practiced, further supporting groundwater level.

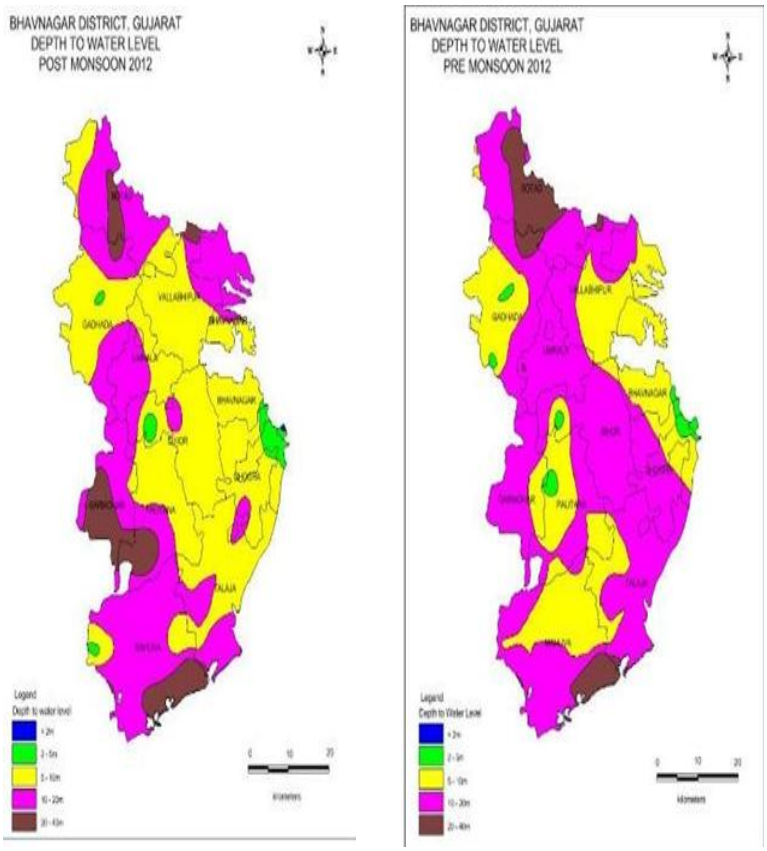

Image 4: Groundwater availability in Bhavnagar District pre and post-monsoon.
Source: Gujarat Govt. Report on water Resources 2013

Many of the residents are exclusively dependent on the groundwater of the region to fulfill their water demands. Post Monsoon there is rise in the groundwater level. This indicates that the groundwater is successfully recharged after each monsoon cycle and the consumption is sustainable.

A probable meteorite impact crater in the city has been converted into a sump that can store water to meet city's demand for a day in case of emergency and serves as a backup storage. It has a capacity of storing 45 Million liters of water. Converting an existing crater to water body has made this an extremely cost-effective solution.

Transport

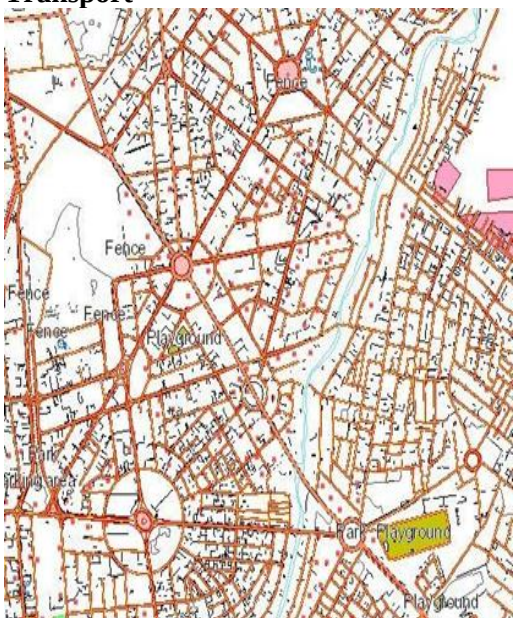

Image 5: Road Network of Bhavnagar. Roundabouts prominently reduce crossroads.
Source: National Cartography Mission.

The city is well connected by four-lane roads to Vadodara and Rajkot, with a four-lane road to Ahmedabad in works. Due to its proximity to the sea and unique location, there is good connectivity through sea routes as well. A coastal Highway under Bharatmala project will connect Bhavnagar to Somnath, which will also support landing of fighter jets for costal defense.

The city benefits hugely from the Ghogha - Dahej Ro-Ro ferry service. It enables passengers to cut through the gulf of Khambhat and reach south Gujarat centers like Dahej and Surat while saving of 4-5 hours in road time, and 200 km in road length.

Bhavnagar has excellent air connectivity. The airport is equipped with a 1920m long runway which can handle large aircrafts like the Boeing 747 and Airbus A320. Flights to Mumbai, Surat, and Ahmedabad are operated on regular basis and service to Pune is in the pipeline.

Bhavnagar Railway station is a terminus, meaning that it is situated at the end of the railway line and most trains terminate at this station. The city is connected to North Indian centers like Delhi and Udhampur. Mumbai and Surat in the west, Kakinada in southern India and Guwahati in the east of India.

One of the most interesting aspects of Bhavnagar is its road network. As you can see from the map above there are large roundabouts and circles instead of cross-roads at all major junctions. This enables traffic management without the use of traffic signal thus saving time. The design is also much safer than crossroads where there is a high probability of collision. Many of these large circles like Ghogha circle and Crescent are beautified with gardens at the center of the circle.

Intracity transport primarily relies on the government bus transport network that is rented to private agencies on a contractual basis. There is also good availability of auto-rickshaw on hire for point to point services. Ride-hailing services like Ola also operate in the city, leveraging the ICT to provide transport facilities to the public.

Part II

The city houses The Central Salt and Marine Chemicals Research Institute (CSMCRI) which is one of the oldest scientific institutions of post-independence India. It was established in 1954 to give a thrust in high purity salt production, and to develop technologies and methods to exploit the long coastline that country has been blessed with. Research activities at CSMCRI span from new salts to marine algae, wildlife, and bloom. It has also diversified itself from the initial goal of developing new-age materials and objects of commercial use. The technology of developing dustless chalk sticks, Portable RO water purifying vans that can be deployed in the event of natural calamities and advances in development, production and use of vehicles that run on biodiesel derived from the trees of Jatropha, has earned CSMCRI a great recognition even in the eyes of the general public due to the immediate benefits to the society.

Bhavnagar is home to one of the large state university called the Maharaja Krishnakumarsinhji Bhavnagar University. The Physics Department in the university was famous in the last decade for its contribution to the advances in material sciences, especially in the domain of Magnetic Ferro-fluids that have found applications in many leading domains like storage and Memory devices, Magnetic Resonance Imaging, Speakers in recent premium televisions and Propulsion of small satellites and probes in the space. The department is one of the few places to have a facility of XRD machines. Many alumni of this university have joined leading National Labs like TIFR and contributed significantly to the development of various fields in Physics like Cosmology, Theoretical Physics and Material Sciences to name few.

"The Kalyan Pradeshik Lok-Vigyan Kendra" is a local physics/science community center that organizes various events and works for the popularization of science in the surroundings. It is a major organization working for the popularization of science in the community. Recently the organization celebrated Zero Shadow day in the district by creating awareness drives in the city, and by organizing a demonstration of Zero Shadow, which happens on the 29th of May and 14th of July each year. Astrophotography and Public viewing were organized during the recent Lunar Eclipse of July 16th.

Bhavnagar as a city is infamously referred to as a 3G city in colloquial terms ('Gai, Ganda and Gathiya') meaning cow, madmen and a local delicacy called Gathiya. Well, the 3Gs are being specially mentioned here as Physics comes alive in a very off-beat way. The city houses a large bovine population due to availability of pastoral land in nearby taluka of talaja. This creates a significant menace of bovines on the road as is the case in many of the cities in the country.

The peculiar behavior of these bovines is that they prefer to sleep in the center of the roads rather than much safer sides. On some observation, I found out that these bovines are frequently pestered by flies and bugs. They are forced to constantly use their tails to keep these flies away. However, by occupying the center of the streets, these bovines experience gusts of wind due to vehicles passing at high speeds. This wind and fast-moving vehicles scare away the flies and bugs providing peaceful sleep to the animals.

Coming onto the tasty delicacy called Gathiya. It is a snack prepared from chickpea flour that is deep-fried in oil. The region is famous across the state for its Gathiya. This is because frying is a surface phenomenon. The snack gets tastier and crisp as more of its surface is fried. One way this is achieved by having a high surface area to volume ratio for Gathiya. Gathiya makers have tried various geometries and a variety called 'fafda gathiya' triumphs in this metric, as they are made into thin sheets before frying. One more parameter is the density of the batter used in making Gathiya. If the batter of Gathiya would lose its adhesion and too dense would not allow it to take an optimum shape for frying. The best Gathiya has the optimum density of batter, that allows for some porosity while frying, this ensures that the snack is also fried inside out increasing the fried surface area to the volume ratio of the snack. This exercise is similar to that done by the physicists working in material science and Nanotechnology where they try to maximize the surface area to cause surface phenomenon to dominate. Another example of the same is the structure of the human lungs, the alveoli are so designed so as to allow a maximum exchange of gases for the blood. It is estimated that the human lung when unfolded can have the area larger than a tennis court.

Nishkalank Mahadev is an extremely famous religious place just a few kilometers from my home. According to religious legends, the place was used by Pandavas in the Mahabharat to seek repentance for their crime of killing their own relatives the Kauravas in battle. On meditation by the Pandavas shiv- lings have said to appear from the ground as a mark of appraisement from lord Shiva. This place is situated deep inside the sea and is accessible only during the low tides. During high tides, the entire site is inundated with seawater. Keeping the religious beliefs aside if we examine the holy site from a rational perspective, we can find that entire sea bed made of black muddy soil the site has a rocky platform around it, suggesting some seismic or tidal activity. What is more interesting is that the site serves as an experimental verification of Newton's Law of Gravitation.

It is well understood now that the occurrence of high tide and low tide in the sea is due to the gravitational attraction force of the moon on Earth. It so happens that due to the gravitational pull of the earth, the Earth-Moon system combine revolves around a common point called barycenter. This point lies inside the body of the Earth but not at its center. This causes the Earth to wobble around this point, while the moon would have completed an orbit around the earth simultaneously. This Wobble of Earth causes the Water in oceans to recede and spill from one coast to another from time to time. The Moon itself can serve as a timekeeping device as the phases of the moon are very regular. Hence the times of Pooja and Arti at the Nishkalank Mahadev temple can be used effectively to verify Newton's laws as they are decided on the basis of expected tide schedule.

Astronomers across the world are known to be fond of extremely dark skies as they provide excellent positions for stargazing. Dark skies are found in areas that do not have an electrical connection so that they remain dark at night or in inhospitable regions of the world like the desert. One more important factor for best terrestrial observation is to have a clear and unobstructed view of the Horizon. Buildings or tall mountains play a spoilsport when we try to observe an astrophysical phenomenon. I am lucky to be born in a place that boasts of several good locations for night time viewing.

One of the key locations in the city is the Takhteshwar temple, built on a tall hillock located at the center of the city, this place is ideal for night time viewing in the city limits. Due to its height, one has the ability to look beyond the terrestrial obstacles like tall buildings and get a view of the entire night sky. Also, one of the important aspects of good astrophysical viewing is reduced light pollution. It is impossible to reduce the light pollution entirely in the city, but due to the strategic location of the temple, most lights of the buildings in the vicinity are so placed that they do not illuminate the temple, nor are they pointed towards the sky. This makes the temple one of the best places within the city for astronomy lovers. Also, being a temple it is accessible and open to the public.

The coast serves as another key place to do more serious astronomy, due to the ocean on one side of the location there is no probability of light pollution. It is possible to easily find the remote stretches on coastal beaches that are ideal for night time viewing. Due to open horizons, it is possible to view the second brightest star Canopus easily which is only seen near the horizon and best during the winters in the Northern Hemisphere. It is important to note that the Location of Bhavnagar is between tropic of cancer and the equator allowing us to view some rare stars that are more prominently seen in the southern hemisphere.

There are remains of the Indus valley civilization, ancient Mughal era in the vicinity of my home. Many of these structures have been so constructed that they align with the rising sun on auspicious days or the equinoxes. Water tanks were always placed in these structures in a way that they avoided direct sunlight during the peak summer months, reducing evaporation. Many community festivals are celebrated here concerning celestial events. One of the biggest examples of it is the Uttarayan, that signifies the change in the direction of the rising sun towards the north. The southwest monsoon hits Gujarat around June 15th every year. The same period is associated with many celestial events, which are relied upon to indicate when it is time for sowing. Thus science, basic physics, and astronomy play a vital role in my proximate community. The knowledge of astrophysics that is embedded into the culture along with modern town planning, modern-day use of scientific knowledge in water conservation and shift towards renewable sources of energy has placed my community on a path of sustainable and prosperous future in the years coming forward. Strategic use of its location to develop sea and air transport route is a key indicator of economic and scientific progress in the years ahead.

PHYSICS OF YOUR CITY, COMMUNITY AND SURROUNDINGS

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INTRODUCTION

I stay in the capital city of North-eastern state Tripura, namely 'Agartala' from my birth. Agartala is the capital city of North-Eastern state Tripura, second largely populated city after Guwahati , which is the home for both Bengali and tribal communities. It is situated at 23˚50' North latitude and 91˚51' East longitude. It is 12.80 meter high from the sea water level having U.T.C +5.30 (IST). It was the capital and historical city of princely State Tripura that had been governed by "Manikya dynasty" up to 1949. Many historical emblems bearing scientific aspects can be found here and there at Agartala.

Picture: Road map of Agartala

Geography of the city: Agartala is the capital city of North-Eastern state Tripura having area 76 km^2. The population of the city is next to the largely populated city of North-east i.e., Guwahati in Assam. The population of Agartala is almost 4.73 lakhs as per projection on 2018. According to 2018 projection of population, number of Bengali people in Agartala is 76% of total population and the rest of the population is divided among 18 different tribes of Tripura. The growth rate of population with respect to year is 2.94%. The population density of Agartala per sq. km is 10119 which is total contrast with various other urban areas.

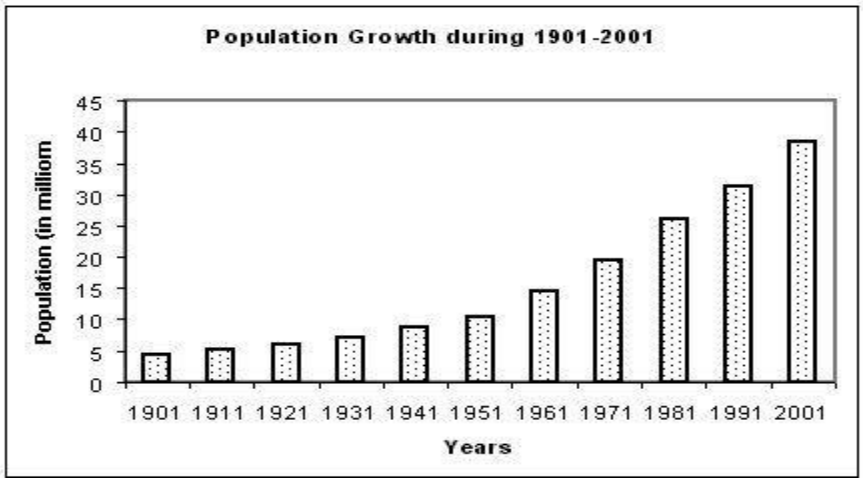

Figure: Population growth of Agartala

YEARLY RAINFALL AND TEMPERATURE: The average rainfall of Agartala in a year is 2146 mm. The last 48 years data projected that the rainfall in monsoon varies from 68% to 70% and in post monsoon period is 13%.

The difference of rainfall of the month having lowest rainfall and the month having highest rainfall is almost about 459 mm.

The average temperature of the hottest month September is 28.7˚ c and the temperature of coldest month December is almost 18.7˚ c.

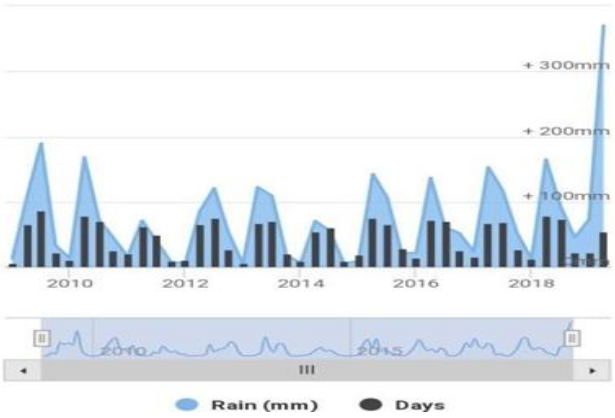

Fig: Yearly rain-fall graph of Agartala

MEANS AND CONSUMPTION OF WATER: Now a days in Agartala the pipe line water service is very much popular though some residents of Agartala till have been utilizing hand pumps that draws water from inside of the ground through the action of suction. These kinds of pumps generally use the principle of creating pressure difference inside the pump; hence draw the ground water from inside.

However the pipe line mineral water service from water treatment plant is being reached to every house by state government initiative. The process of treatment plant mainly follows the principle of sedimentation to precipitate out the extra unwanted and harmful particles to get fresh drinkable water. The pipes that are used to get the water flown through to reach to the end-users are being made smaller in cross-sectional area by special order of government to control the rate of water flow so that the misuse could be prevented. To prevent misuse of water the ferrules are also being given special

shape so that the rate of out-flow can be maintained and digital electronic meters are also being installed in every house of 'AGARTALA MUNICIPAL CORPORATION' and water use charge is induced to keep an watch on the misuse of water.

MEANS AND CONSUMPTION OF ELECTRICAL POWER: The means of electric power in Tripura is generally the electricity produced in a power plant. The name of some power plants in Tripura are PALATANA POWER PROJECT, MONARCHAK POWER PROJECT, DAMBOOR POWER PLANT etc. From these power plants the electricity is being supplied to the houses of my city Agartala.

The maximum electricity power to feed the need of the power of the city as well as the state is supplied by PALATANA PROJECT which is amounting to be 726.6 MW. The PALATANA PROJECT, the massive electric power generation unit in Tripura that also supplies surplus power to neighboring country BANGLADESH, follows the principle of steam generation through the method of firing the natural gas, following which the gas is sent through a gas turbine generator at a high pressure. The gas turbine generator mainly converts mechanical energy into heat energy which produces the steam of exhausted gas.

The another power project that is serving the need of electricity in some extent is the DAMBOOR WATERFALL HYDRAULYC PROJECT. Here reserved water in a dam is caused to fall upon a turbine with a magnanimous speed so that the wrapped blade around a wheel could be whirled along the path of rotation of water-fall. It is generally the conversion of potential energy of conserved water into kinetic energy. Then an electromagnetic generator attached with the turbine could convert the mechanical energy of turbine into electrical energy on account of electro-magnetic induction.

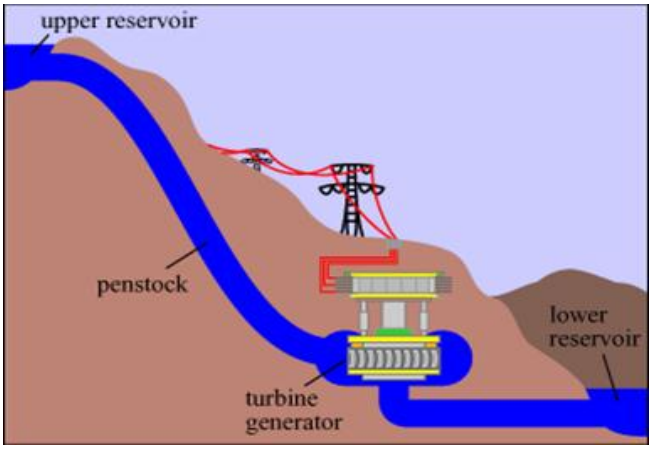

Fig: Mechanism of generating electricity from water-fall

TRANSPORT SYSTEM: In my city Agartala the principal public transport system is road transport though we also have Rail-way and air-way transport system to travel long distances. The transport system of Tripura as well as my city Agartala is getting developed day by day, adopting modern scientific technologies. The width of the high-ways and public roads are being broadened so that the over trafficking can be taken under control due to broadening of the total surface area of the road.

As the speedy particle always tends to move along the tangent of any curvature due to the action of centripetal force. So especially long convoluted turns on the roads generally create massive road accidents on account of the skidding of speedy vehicles away from the road track that claims many lives frequently now-a-days. So the curvature of the roads are also trying to get abolished and made the roads almost straight by government initiative so that the road accidents could be reduced.

In Agartala city especially the electronic traffic system is being followed to control road-accident over jammed traffic. Electronic traffic system is an example of how digital electronics in disguise of physics has been modernizing my city constantly and steadily.

In my city Agartala we also have one fly-over bridge that helps people to save time of travel, distance and also fuel needed proportional to distance. Agartala Municipal Corporation with joint venture of state government are enthusiasing people to use CNG and battery driven vehicles to get a control over prevailing environment pollution due to the exhausted fumes of fossil-fuel driven vehicle.

The Tripura Road Transport Corporation Limited have arranged special buses that use CCTV camera instead of viewing glass to observe the activities of the cars behind the bus, precisely. Electronic metered auto are being used in Agartala widely.

However besides road transport system in my city Agartala we have one rail-way station that is connected to various parts of the state and many principal cities of different states of India.

Agartala also has one air-port namely Maharaja Bir Bikram airport shortly popular as M.B.B air-port that is connected to far-flung places of India to travel the huge distances at a short period of time since the flight can gain a huge momentum due to less resistance of air than solid road or rail-way track.

VARIOUS SCIENTIFIC ASPECTS OF AGARTALA: The people of Agartala have adopted scientific life-styles which in many extent follows physics principles'. One can easily sort out miscellaneous physical aspects surrounding the city. Some of them are really worth mentioning.

As Tripura is a earth-quake prone state ,finding itself on the seismic zone 5 , the most of the buildings of Tripura are generally made 3 storied, maintaining a distance of at-least 10 m between the consecutive buildings so that buildings can balance themselves during the tremor without causing no harm on each other. The shorter object can balance themselves than the taller objects if tremor occurs.

According to municipal corporation act 2009 , owner of every massive buildings such as shopping mall, business establishments , government or public hospitals has been directed to keep fire extinguishers mandatorily, such as C cylinders as a safety measure ,had the building been ever caught on fire.

The modern auditoriums are being designed with special architectures now-a-days in the city which bears physical logic. As an example the big auditoriums are being built with arc-shaped roof so that a good acoustics can be obtained i.e., the sound after several reflections on various angles from arc-shaped roof can be audible to every audience inside the auditorium. The wall surfaces of the modern auditoriums are made a bit rough so that some of the unwanted multiple sound wave reflections can be blocked by the wall surface to prevent the reverberation effect inside the auditorium.

The Municipal authority by their own initiative use suction process to siphon off the liquid garbage and in some extent some light solid garbage and take them away by garbage vehicles.

Agartala possess one of the tallest DOORDARSHAN tower in its heart that uses the mechanism of electromagnetic wave radiations to air the programs on televisions.

SOME SCIENCE INSTITUTES AT AGARTALA: At Agartala various science institutes are over there that could excite and draw the attention of any physicist. We have got one branch of research, on space science at National Institute of Technology, Agartala due to the joint venture of Tripura State Govt., and ISRO that is a nice scope for any enthusiastic to come at Agartala for research purpose.

Also one IIIT has started functioning at Agartala and could become a suitable place for a highly motivated one to come to pursue research.

Central Govt., is funding for research works at the central university of Tripura located at Agartala, to carry on research on various science topics including physics topics.

The science and technology department affiliated to Tripura state government has been sponsoring enthusiastic students and researchers with modern equipment to look for scientific research works in Agartala.

Agartala has one science auditorium namely "SUKANTA ACADEMY" under the department of science and technology affiliated to Tripura govt. It is generally a science academy that shows the aspects of daily life science including the physical aspects of science practically to make students visualize what they are studying in books.

So my city Agartala offers physics lovers to take a scope to saturate with well-equipped modern day science research in this nice city.

PALACES OF AGARTALA: Agartala has different palaces on its heart namely "Ujjayanta palace" and "Malancha Niwas". The architecture of these buildings are carrying historical and as well as scientific temperament. Designs of the architecture of the buildings are inspired from the ancient 'Mughal' styles. The design of the roof of the buildings had been made round in shape to make the acoustics of the room better so that the sound would be audible to the audience sitting inside the room, since the sound wave after several reflections from different orientations of the round shaped roof can move throughout the room and can reach to the listeners. The architecture of the buildings followed such a unique way that in a small space more rooms can be built. The design of the buildings also got a symmetrical shape everywhere to make the enemies puzzle, had the building any day been faced any threat from the enemies of the kingdom.

Picture: Ujjayanta Palace, Agartala

CONCLUSION: So any stranger , if comes to Agartala can observe the scientific life-style of the city very easily from very near and can full-fill the addiction for new discovery. Agartala also can feed the over enthusiastic minds fond of physics to carry on their look for discovering the infinite new, ranges over the city. I believe that any physicist will fall in love of the city and its nice people.

PHYSICS OF YOUR CITY, COMMUNITY AND SURROUNDINGS

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Paris of Saurashtra, Jewel of Kathiawar, Chhota Kashi, Halar,... all these sobriquets belong to a very old city of Gujarat state, namely "Jamnagar" which was established in 1540 A.D. The district of Jamnagar is spreaded widely along the Southern coast of the Gulf of Kutchh. On the globe of Earth, the Jamnagar district is located at latitude 22°13'N and longitude 69°42'E, while the city of Jamnagar is accurately found at latitude 22°28'12" N and longitude 70°4'12" E. The Jamnagar district shadows 14,184km^2 of area in the state. While the city of Jamnagar occupies 125km^2 only. Jamnagar stands at the fifth position in the list of the widely spreaded cities in terms of areas in Gujarat state.

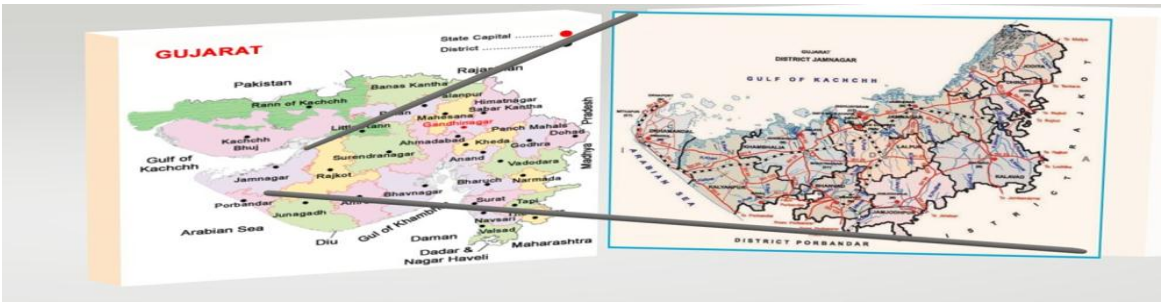
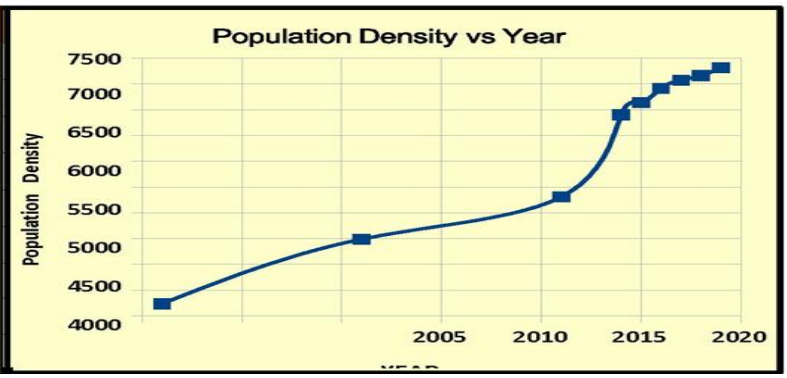


Image: Jamnagar district map popping out from Gujarat state map

population of the city as of now in year 2019 would be 914,324; which is an estimated value calculated from previous years' statistical data of population. The chart showing the population in each year is given below and also the graph showing increment in population densities with year.

Year	Population
1991	341637
2001	498344
2011	600943
2014	800000
2015	830340
2016	864220
2017	884330
2018	895270
2019	914324

Chart: Approx. population year



Graph: Increment of population density year-wise

The population growth since year 1991 in Jamnagar has been 167.63%, showing the tremendous blast in population. The population of whole Jamnagar district is nearly 21.6 Lacs. It is astonishing to know that the population of Jamnagar is almost equal to the population of whole country of Namibia. Jamnagar is occupying 212th position in the ranking list of population in India. The male-female ratio in Jamnagar shows that for every 1000 males in city there are 938 females. The literacy rate of Jamnagar in year 2001 was 66.48%, which took rise up to 73.65% till year 2011.

The climate normal is the statistics of average of monthly observations, strictly in terms of particular variable parameter i.e. temperature, over three decades; wherein the monthly observations are also the

average of daily observations of that particular month. Such climate normal of Jamnagar city as obtained in year 2014, has been given below in the tabular form.

Month	Highest recorded °C	Average High °C	Mean Daily °C	Average Low °C	Lowest Recorded °C
January	36	26.5	18.6	9.7	1
February	38	28.8	20.9	13.8	1
March	44	33	25.4	17.8	9
April	45	35.6	28.6	21.6	13
May	47	36.4	30.9	25.4	18
June	46	35.9	31.4	27	20
July	40	32.3	29.2	26.2	10
August	39	31.5	28.4	25.4	12
September	41	32	27.9	23.9	16
October	43	34.5	28	20.7	11
November	40	32.4	24.3	14.7	8
December	38	28	20.1	11.4	1

Table: Climate Normal of Jamnagar City

From the climate normal of Jamnagar, it is noted that the mean temperature varies very less comparatively than the other cities of the state. This is due to the touch of the ocean. Here, the role is played by Thermodynamic laws. We know that the thermal conductivity of land and water are different which leads to the equilibrium of the temperature. As we know, the water has higher specific heat capacity than the land, which means water takes more energy to let its temperature of 1 gram rise by 1 degree Celsius. While the less specific heat of land makes it hotter and colder faster according to the ambient temperature.

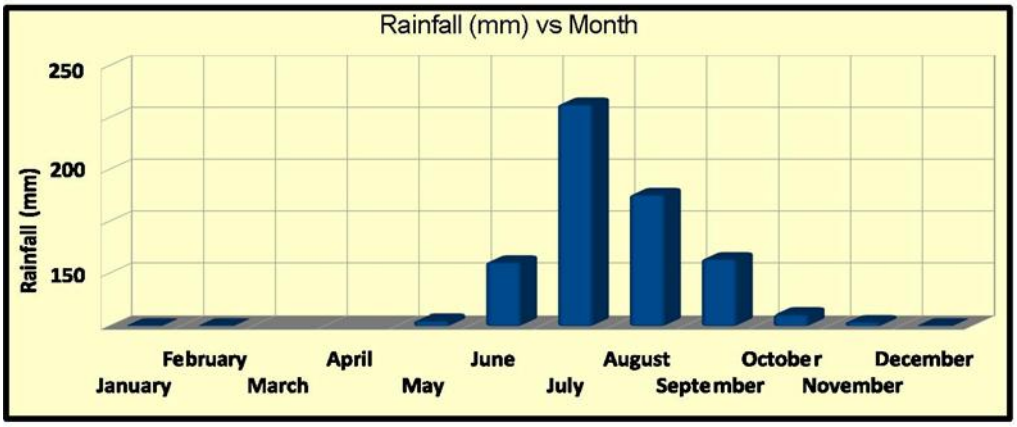
Now at the day time, land gets warmer than the ocean water. So, the air above the land gets warm also due to thermal convection, and as the nature of warm air, it goes up due to low density. This makes low pressure above the land area and a pressure gradient force is generated making the air from the ocean to rush towards the low pressure areas on the land giving a sea breeze.

While at the night time, the land becomes colder than the ocean, which establishes high pressure on the land and low pressure on ocean generating pressure gradient towards the ocean. Hence land breeze is generated from the land to the ocean during the night time. So we can conclude that the water of the ocean has this great ability that it does not allow much temperature variation. The ocean touch of Jamnagar keeps the temperature of the city at equilibrium.

There are several other properties of ocean due to which the temperature of ocean does not vary noticeably, which is the transparency of water towards the heat. It means that the heat absorbed by the ocean is distributed over a large volume and giving no effective change in temperature. Another factor playing role in the temperature equilibrium of ocean is the ocean currents. The ocean currents transport energy from one place to another in the form of temperature, getting all over temperature of ocean at equilibrium. One more factor is the evaporation; due to large surface area and air breezes, the water evaporation rate is high on the ocean comparing to the wet land, so the ocean loses much heat energy due to the evaporation.

The climate of Jamnagar appears to be semi-arid which means that it is having formation of precipitations less than the potential evapotranspiration, but more precipitations than that of desert. The Koppen Geiger climate classification categorizes Jamnagar in BSh group, which is known to have hot semi- arid climate. According to this classification system, Jamnagar is having very less

rainfall, about 573 mm of average precipitation annually. The graph showing the rainfall during each month over a past decade in Jamnagar is shown below.



Graph: Average Rainfall during each month

The humidity in Jamnagar remains around 57% on an average scale of whole year which is comparatively higher than other cities of Gujarat. It seems to be very questioning that even though it is having the touch of ocean and high humidity, the climate is not as expected because of less rainfall.

The average wind speed in Jamnagar in whole year remains around 12 km/h, which is less compared to other cities of Gujarat. Due to such reason, there are not much sightings of kite flying on the days of kite festival. It is known to be the magical phenomenon due to 'no wind - no kite' situation, but a Physicist always has the answer. The scientific reason from personal view for low wind speed is hid into the soil type of the city. Jamnagar is having coastal alluvial and medium black type of soil having large amount of phosphate. Such type of soil is the best candidate for the agricultural activities, and it is known to be fertile due to the presence of rich nutrients. The ground water level is also rich in the Jamnagar city. All these factors imply that the specific heat capacity of land would be higher than that of sandy or dry lands, giving smaller pressure gradient of air resulting in less wind speed.

The alluvial and medium black soil of the district has made it a frontier in agricultural activities. The main crops produced here are Bajri, Jowar, Groundnut and cotton; the fruit crops in case are mostly Mango, Papaiya, Chiku and Coconut. Out of all working population of the district, almost 48.56% of people are engaged in agricultural activities for their living.

There are different geological formations in terms of rocks. The district is having rock formations such as Deccan Traps, Lateritic and Miliolite rocks which are known to have abundance of lime stone, sand stones and Gypsum. The rocks are flood basalt, formed after volcanic eruption covering a large area. Such type of geological formation incorporates rich deposition of Bauxites and lime stone, which gave birth to the industries running on these abundant natural resources in Jamnagar. The other minerals like Calcite and Bentonite are also found in this district. The good quality of Gypsum is used in cement industry and also in the production of 'Plaster of Paris'.

As there is no perennial river in the district, the major dependency for drinking water and other water purposes is onto the ground water. The ground water availability in district as of year 2011 was 855.13 mcm (Million Cubic Metre). The depth range of ground water in district varies from 33 metre to 500 metre in the aquifer. The aquifer is defined as an underground layer of water beared in the midst of permeable rocks or rock fractures. The strorativity of ground water is defined as the volume of water released from the aquifer through unit area of cross section of aquifer. The storability in Jamnagar ranges from 20 m^3/day to 160 m^3/day. Now, the transmissivity of ground water is the

product of horizontal conductivity and the thickness of an aquifer. The unit of horizontal conductivity is given in length per unit time and the unit of thickness is that of a length. Hence, the unit of trasnmissivity of ground water is given as square length per unit time. The transmissivity of Jamnagar district ranges from 0.9 m^2/day to 923 m^2/day. Another parameter which is discharge of ground water is defined as the movement of groundwater in volumes from a subsurface to the surface by any natural means or artificial pumping activities. The discharge of groundwater of Jamnagar district is ranging from 3 litre/second to 30 litre/second.

Paschim Gujarat Vij Company Limited (PGVCL) is the energy provider to the individuals' houses. The energy is produced in Thermal Power Station based on coal burning, which is located at Sikka in Jamnagar district only. A Physicist's eyes always try to find how things work. So, a coal fired power station works basically on steam. The coal is heated in a boiler which produces tremendous amount of steam having very high energy, this steam then rotates the turbine which is connected to the generator that converts the mechanical energy into the electrical energy.

The energy production will be a big challenge in upcoming time because the coal based method will not last due to the uncertain availability of coal. So, Jamnagar Government has taken very smart and green step of planting wind mills around Jamnagar city, thinking ahead about the future. There has been a thousand of windmill plantations for efficient and green energy production. The wind mill also works on the same concept that is the wind will give rotation to the shafts of the windmill which is then connected to a generator giving the electrical energy by conversion from the mechanical energy, achieved from the air breeze. Government installed white LEDs also all over the city, which work on the solar energy.

The citizens of Jamnagar city are having transport facility by bus, which runs whole day round the city. There are CNG powered auto-rickshaws also available for citizens.

Jamnagar District occupies 21.37% coastline of that of whole state's. It is having three ports along the coastline, which are Bedi Port, Sikka Port and Okha Port. All of these ports are known to be all-weather ports which is playing a crucial role in the economical growth of district due to import-export of commodities and resources with other regions.

Along with viewing Jamnagar with the eyes of a Physicist, a little history is important to provide the essence of the legacy and tradition of the district for an effective heartfelt understanding. The princely state of Jamnagar was established by the great emperor Jam Rawal. It was founded near the banks of rivers Rangmati and Nagmati, this region was named to be “Halar of Nawanagar”. Eventually, it was renowned to be “Jamnagar”. The meaning of Jamnagar is the 'town of Jams'. In 19 th century, Maharaja Jamsaheb Shri Ranjitsinhji of Nawanagar, started more development and gave it a modern look. He was so fond of cricket and was known to be a skilled player in it. The Ranji Trophy tournament was named after him only.

Now being a Physicist, many of the below points are astonishing to know how Jamnagar is industrialised. Jamnagar also provides home for thousands of species of birds along with seasonal birds on the carpet of its region.

Jamnagar has extensively been the biggest hub for the developement of Brass Parts in the whole country, due to which it is also called “mini Japan” or “Brass City”. After the year 1940, this industry took birth and it expanded its roots over the years in Jamnagar. Around 40,000 number of people in the city are getting employment due to this industry, which is having around 5,000 of large scale units standing all over the city. The Brass Part industry has given production of screws, pant buckle, auto valve, nut, toys, etc. The smallest amount of Brass part manfacturing is of 1mg and ranges up to a few

of kilos as the maximum weight of a single Brass part. The only pencil sharpener manufacturers all over the country are present in Jamnagar. Although only 20% of the total production of Brass part is being exported, Jamnagar is still one of the biggest exporting cities of Brass Parts in the world.

“World's Oil City” is also one of the nicknames of Jamnagar. Because it it having the largest oil and petroleum refinery in the world. The one, kingdom of oil refinery namely Reliance Industry stands on top for its amount of production and the area onto which it spreaded its roots; after that Essar Oil is the runner up in the same. Reliance Industry produces more than 1.2 million of US gallons or 4,500 m3 of petroleum in a single day; which is almost 5% of whole world's capacity. Its territory in area is almost (1/3) rd the size of Manhattan. It exports all of its productions and does not sell domestically in India, becoming the largest attractor of foreign money into our country. It is so advanced that it can also process the crude oils which contains high-sulphur sour crude. And the second largest refinery in Jamnagar, Essar oil produces 0.4 millions of US gallons per day. Jamnagar is also having a big manufacter of fertilizers, namely, Gujarat State Fertilizers and Chemicals which is operating a Di-Ammonium Phosphate plant in the village near Jamnagar.

A coal-fired Sikka Thermal power station is also located in Jamnagar district. It is having two units of 120 Mega Watts and two units of 250 Mega Watts, giving total capacity of 740 Mega Watts of power generation from the coal. The high quality worsted fabrics are also manufactured in Jamnagar by Digjam, they are having fully equipped composite mill.

Jamngar is the biggest producer of Bauxites also. The Bauxite mines in Jamnagar alone fetches a total of 96% of Bauxite out of the production all over the Gujarat. The commodities like Bauxite, Ground Nuts extracts, Soya Meal extracts are exported annually in amount of 3,912,402 metric tons approximately. While the 1,388,181metric tons of annual import includes coals and fertilizers.

Jamnagar is having all the three wings of defense in its active service; Indian Army, Indian Air force, and Indian Navy. The training of all of them runs daily, the localities hears the bombarding and the burst of speeding fighter planes almost every morning. Due to having Air force in the vicinity of the city, there are no skyscrapers or much tall buildings.

Jamnagar is having only three FM stations, 100.1MHz, 91.9 MHz and 95 MHz because of the security and privacy reasons of the department of defense. In early times there were some issues of interference of frequency with Air force communication system, since then the privacy had been a big concern, hence the result was the less number of FM stations in city.

The Bandhani production of Jamnagar is well known all over the country. Approximately 10% of the total income of the city is achieved from this industry alone. The red coloured Bandhanis are the most popular ones around the each corner of the country for its shine and beauty.

Khijadiya Bird sanctuary of Jamnagar gives shelter to many migratory seasonal birds such as Great Crested Grebe, Purple Moorhen, Pheasant tailed Jacana, Coot, Black Winged Stit, Eagles, Hawks, Wagtails, Martins, Swallows, etc. It has been the favorite tourism location and an attraction to the bird lovers. All over the country, people come here just to see seasonal migratory birds. The very first Marine sanctuary in India, Marine national Park, is located at Pirotan island of Jamnagar. It is the most favorite tourism place for the people who are having keen interest in the study of Marine life.

The Hanuman temple, namely, 'Bala Hanuman temple' located near Ranmal lake has listed its name in the Guiness Book of World Records for its constant and continuous chanting of Ram-dhun since the day, 1st August 1964. The recent beautification project of Jamnagar gave one of the best jogging track in the country around the Ranmal lake.

The Lakhoto, the musuem at the centre of the lake is well known for its beauty. The Bhujiyo Kotho is known for its circumference and height; there are some rumours that it connects Bhuj with a secret underground tunnel.

Jamnagar is a beautiful, peaceful and frontier city running on the track of many industries and technologies. Halaji of Jamnagar and Patti, his hare made a unforgettable memory in the mind of Jamnagari people. A song “Halaji Tara Hath Vakhanu k Patti tara pagla vakhanu...” is a tribute to them only. To make Jamnagar a better tourism place and Green city, has been the primary aim of the Municipal Corporation and the citizens. The city is changing and improving constantly giving new developments.

POLLUTION IN OUR COMMUNITY, MEASUREMENTS AND PHYSICAL INSIGHTS

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Pollution is derived from the Latin word *polluere* which means 'to soil' that is to make something dirty and that is very literal translation of the word pollution which is simply grodying our air, soil, water, etc. In this essay, the scope of analysis of pollution will be limited to my city – **The city of Mumbai**.

South Bombay covers an area of about 70 square kilometers and suburban Bombay region extends over an area of 370 square kilometers. To keep up with its growth, the city has grown even further – the Mumbai Metropolitan Region covers an area of 4400 square kilometers. Mumbai Metropolitan Region was home to 20,748,395 people by 2011.

With such humongous population comes great pollution.

There is ample of pollution related problems already in my vicinity and my city that once we can address these issues at the local level then we can think about combating pollution globally.

Main emphasis here will be given to air pollution and water pollution which are very prevalent even to the most common man's lenses.

Air pollution

Air Pollution is the release of pollutants such as gases, particles, biological molecules, etc. into the air that is harmful to human health and the environment.
Greater Mumbai has good Transport system and well laid down road network.

The vehicle composition is as follows:

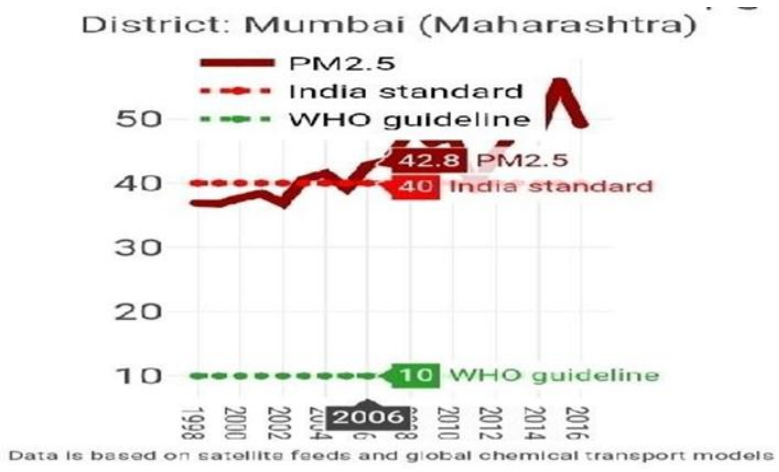
- 49 % two wheelers
- 31.7 % cars
- 4.4 % taxis
- 5.4 heavy vehicles,
- 8.4 % three wheeler and
- other 0.6 %

On the basis of fuels consumption, air pollution load due to auto exhaust is 459 Metric Tonnes (MT) /day consisting of SO_2, NO_2, CO, SPM and Hydrocarbons etc. as pollutants. To control the air pollution due to automobiles, various measures are initiated such as conversion to CNG and LPG, PUC tests etc. On an average it is estimated that 60% of air pollution is caused by Auto- emission. Therefore vehicular pollution is a major contributing factor in causing air Pollution in the city environment.

Air pollution kills an estimated seven million people worldwide every year. WHO data shows that 9 out of 10 people breathe air that exceeds WHO guideline limits containing high levels of pollutants, with low- and middle-income countries suffering from the highest exposures.

From smog hanging over cities to smoke inside the home, air pollution poses a major threat to health and climate. The combined effects of ambient (outdoor) and household air pollution cause about seven million premature deaths every year, largely as a result of increased mortality from stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections.

The funny part is that WORLD HEALTH ORGANIZATION (WHO) guidelines stipulates that particulate matter (PM) 2.5 should not exceed 10 μg/m³ annual means that is the danger line and astonishingly India's limit is set to be 40 μg/m³ i.e., four times the guidelines of WHO and Mumbai's average is exceeding the limits as shown in the graph below.



However this situation is not the same throughout the year, air pollution levels fluctuate due to various seasonal and climatic variations thanks to the tilted Axis of Earth and its revolution around the sun.

Mumbai experiences three main seasons that are summer, monsoon and winter.

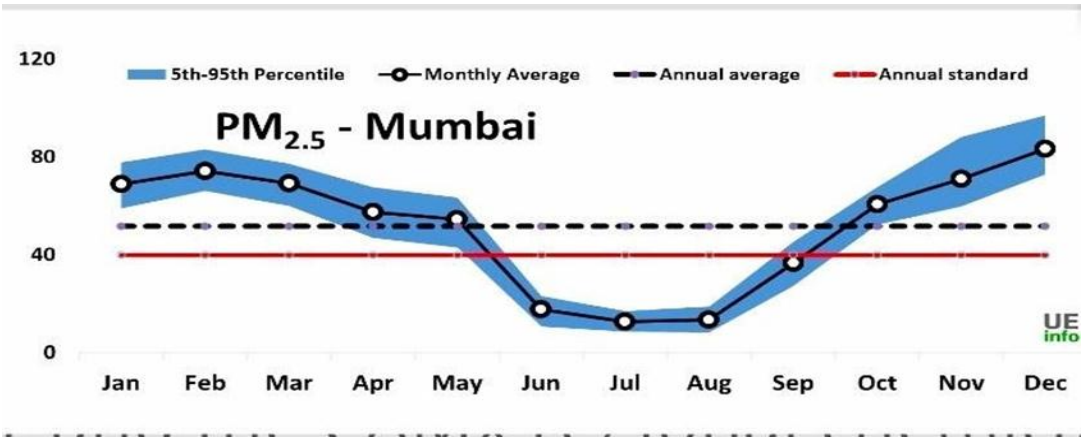
During summer seasons due to intense heat the bad ozone present in the troposphere may break down and create photochemical oxidants and react with gaseous emissions from various sources like

vehicular traffic, industries, and power plants to undergo complex chain reactions in the presence of sunlight, forming a toxic mixture often called 'photochemical smog'.

However during winter season, Cold air is denser and moves slower than warm air. This density means that cold air traps the pollution but also doesn't whisk it away. Air pollution in winter remains in place for much longer and therefore is breathed in at a higher rate. Another major factor that increases air pollution in winter is because of temperature inversion. During cold winter nights, the earth surface loses temperature very fast. The air close to the surface gets cooler faster than the air above it. Thus, the warm air above forms kind of a dome trapping the cold air inside and also various pollutants. This is called as temperature inversion which boosts up the pollution level during the winters.

In monsoon season Rain can clean the air effectively. At the same time however, chemicals and compounds that pollute the air can fall with rain to pollute soil and surface waters. This invariably reduces air pollution level to the optimal level and even below the danger line.

The graph of variations of pollution level in Mumbai with months are given below –



Water pollution

Water pollution is the contamination of water bodies, usually as a result of human activities. Water pollution results when contaminants are introduced into the natural environment. This makes the water unsuitable for sustaining aquatic life like fishes.

The rivers, reservoirs, lakes and ultimately the Arabian sea is drowning in chemicals, waste, plastic, and other pollutants released by the great big city of Mumbai.

It is a very harsh truth that although having strict guidelines for treating effluents and harmful by-products before releasing them into the water streams most of the factories and small industries located in the nooks and slums of Mumbai ignore these guidelines for not being strict rules and very freely release them into nullahs and gutters. Such is the extent of water pollution here that many of the rivers which had life blooming in them about a century ago have now inadvertently become drain line's and big nullahs. With dense slums located along these nullahs it is more dangerous than ever before by dying due to Protozoan diseases transmitted by mosquito vectors multiplying on these stagnant waters choked due to plastics. Physico-chemical indicators are the traditional 'water quality' indicators that most people are familiar with. They include dissolved oxygen, pH, temperature, salinity and nutrients (nitrogen and phosphorus). They also include measures of toxicants such as insecticides, herbicides and metals.

Water along Mumbai's coast is dirtiest around Juhu, Girgaum Chowpatty and Haji Ali, but the city's filthiest water is in the Mithi River which flows into the Mahim creek.

The table of Water Quality Index (WQI) at various locations in Mumbai is given below:

Location in Mumbai	Water quality index
Juhu	44
Girgaum	45
Haji Ali	45.2
Mahim	45.2
Worli	46.1
Nariman point	46.8
Dadar Chowpatty	46.8
Mithi river	28
Versova	47
Thane creek	48
Gateway of India	47

Maharashtra Pollution Control Board (MPCB) analyzed water quality along Mumbai's coast between January and May to create a Water Quality Index (WQI).WQI between 38 and 50 is classified as polluted; a reading between 63 and 100 indicates clean water. Mithi's WQI is 28, which means highly polluted water. Thane creek, Versova and Gateway of India has relatively cleaner water.

Interpretation of Water Quality Index – Surface Water

WQI	Quality Classification	Class (as per Central Pollution Control Board)	Remarks
63-100	Good to Excellent	A	Non-Polluted
50-63	Medium to Good	B	Non-Polluted
38-50	Bad	C	Polluted
38 and less	Bad to Very Bad	D, E	Heavily polluted

MPCB officials have said that untreated sewage from slums and inadequately treated waste from other sources is fouling Mumbai's coastal waters. They have submitted a Mithi River rejuvenation plan and will be spending to the tune of Rs 400 crore to ensure it is clean again. According to Brihanmumbai Municipal Corporation's (BMC) sewage operations department, the city produces sewage amounting to 2,200 to 2,400 million litres per day (MLD). Of this, the civic body treats 1,500 MLD at Bhandup, Ghatkopar, Versova, Malad, Colaba, Worli and Bandra sewage treatment plants (STPs) of the remaining 700-900 MLD, private STPS are treating some of the sewage at hotels and housing complexes while remaining pours into rivers, streams, creeks or directly at sea.

Why Water is easily polluted because Water is a universal solvent and almost anything can dissolve in water making it an ideal source for dumping your wastes.

- Domestic Sewage – Waste generated from households are one of the major contributors to water pollution. The waste which contains urine, faeces, laundry waste lead to a lot of

waterborne diseases such as cholera, dysentery, typhoid, and diarrhea. Domestic waste is loaded with nitrates and phosphorus that also pollute water in small ponds.

- Industrial Waste – Have you noticed the foams on rivers and lakes in some of the prominent cities? One of the main reasons for this is industrial pollution. Waste from different industries contain toxic materials such as heavy metals, which mix with natural bodies and lead to health problems.
- Agricultural Waste – Pesticides, insecticides, and manures used for crops wash off and lead to groundwater pollution. Runoff from the agricultural lands reaches the nearby ponds, lakes, and streams leading to groundwater pollution.

Also due to excessive nutrient rich content like organo compounds being released into the water bodies... The dissolved oxygen (DO) in water decreases. Also releasing warm untreated water raises the temperature of water bodies. We know that according to Henrys law of partial pressure, solubility of gases in water decreases as temperature increases leading to death of life forms and making the water body dead.

Status of the Polluting and Non Polluting Industries

1	2			3	4
Dist Mumbai & Suburban	No. of Polluting Industries			No. of Polluting Industries	No. of Non Polluting Industries
	Water	Air	Hazardous		
Mumbai & Mumbai Suburban	658	691	250	2387	5463

Seasonal variation in Water pollution is observed more strikingly in agricultural region because of agricultural seasons. There is less water pollution during the plantation season and more during the growth season when application of fertilizers and pesticides is maximum. Not much seasonal variation in water pollution is observed in Mumbai. However a famous seasonal event is observed every monsoon that is water logging.

Various Government agencies and also the government are working hard to combat this demon of pollution by laying various strict guidelines and rules and implementation of pro environmental policies which include pradhanmantri ujjwala yojana which distributes 50 million LPG connections to women of Below Poverty Line families. A budgetary allocation of □80 billion was made for the scheme. This will substantially reduce burning of wood and other matter for cooking and heating water in rural areas. Thus helping in the combat against pollution.

In order to avoid the further deterioration of air/water quality in Mumbai, the Govt. of Maharashtra has banned establishment of new polluting industries in Mumbai city and suburban areas and the industrial activities have been shifted to adjacent districts, i.e. Thane, Raigad and other Districts.

Not only Government organizations but industries too are aggressive in combating pollution.

- Rashtriya Chemical Fertilizers (RCF), Chembur has provided STP of the capacity above 5 MLD. Sewage is taken from MCGM. Thus by way of treating sewage in their STP, RCF is recycling/ reusing the treated effluent to maximum extent possible.

- Bharat Petroleum (BPCL) has provided improved treatment system and thereby recycling the treated effluent by 70% (700 CMD).

- Asian Paints is also taking required amount of sewage from MCGM, treating the same in the STP provided and reusing the same in their operations. This firm has developed a team to motivate rain water harvesting to the maximum extent not only in their unit but also other sectors too.

Maharashtra Pollution Control Board (MPCB) is also taking active interest in dealing with pollution and has taken some steps like:

ENVIRONMENTAL IMPROVEMENT PROGRAMME

1. **Damupada- Kandivili**

There is cluster of stone crushers and hot mix plants so the area is facing problem of air pollution. To overcome this problem this office has taken action against above units like issuing closure directions and also taking bank guarantee. This action has led to positive development in the overall air quality.

2. **Powai and Chandivili**

There are a cluster of stone crushers and hot mix plants in this area and hence air pollution is a major concern in this sector too. To overcome this problem, this office has taken action against certain polluting units issuing closure directions and also taking bank guarantee etc. As a result, there is remarkable change in air quality.

3. **Bhuleshwar Area**

There are several gold refinery units in this area, which are causing air pollution. Recently this office has carried out survey of this area and is trying to overcome the problem at the grass root level.

MPCB along with the BMC is working on various plans like –

1. To undertake survey of Hajibundar area - The area is facing air Pollution due to coal handling.
2. Inventorisation of water polluting source in un-organized sector.
3. Use of treated effluents for its recycling and reuse.
4. Identification of new disposal sites for Municipal Solid Waste (MSW) treatment by improved technology.
5. Control of Auto exhaust emissions by using cleaner fuel and adoption of stricture standards in Mumbai.
6. To survey Mithi river water quality, to create data base for effective implementation of improvement plan.
7. Protection of Mangroves and development of green zone around Coastal area along bank of Mithi River.

Recently the new government in Maharashtra has announced the shifting of the Metro car shed from the Aarey forest area in the western suburbs to a government plot in Kanjurmarg in the eastern suburbs at "zero cost". Nearly 800 acres in Aarey has been declared as forest area, making it the first extensive forest blossoming within city limits anywhere in the world.

At last, we the human's, the most superior beings are very much aware about the erroneous and fallacious mistakes that we make and contribute to this demon of pollution. However, our greed and acquisitiveness render more superior than our allegiance and love towards our mother nature.

Science is simply the study of nature and our imprudent use of science is leading towards the destruction of nature itself. It is therefore, the ability of science itself to be employed for the good to undo our wrongdoings and restore the equilibrium of nature and this world.

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POLLUTION IN OUR COMMUNITY, MEASUREMENTS AND PHYSICAL INSIGHTS

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Keywords: Industrial advancement, Land and soil degradation, Global warming, Climate change, Air and water pollution.

''POLLUTION DESTROYES HUMAN POPULATION''

In our world pollution is one of the main causes of many more diseases and ecosystem destruction. Due to presence of harmful substances in the air, land and water which can have adverse effect on living beings and also on the environment. We know that when the environment becomes contaminated or dirty due to human activity or natural disasters it leads to pollution.

There are mainly five types of pollution:

a. Air Pollution
b. Water pollution
c. Sound or Noise Pollution
d. Soil or Land Pollution
e. Radioactive Pollution

The components of pollution are pollutants. Pollutants are the products which affect the normal functioning of pollutants ecosystem and also affect on animals as well as plants. When pollutants are released in great quantity the environment becomes toxic and unhealthy. We know that Carbon dioxide in air is useful for photosynthesis in plants but when it exceeds certain limit of concentration it becomes a pollutant. Listening to music in moderate volume gives pleasure but loud music sometimes increases heartbeat, headache, etc. Thus a substance need not to be harmful by itself but may become a pollutant in certain concentrations or quantities in certain circumstances.

The biggest problem in our community is that of air pollution. What are the possible causes of Air pollution and what effect does this have on animal life and human society? Almost all area throughout the world shows high level of air pollution due to emission from industries, increase in number of motor vehicles and burning of open garbage. In rural areas burning of firewood, cow dung cake, agricultural residue, etc. causes air pollution. Air pollution is in which contamination of air by toxic gases and minute particles of solid and liquid particulates in concentration which is harmful to human beings and surroundings. Air pollutants are classified as Natural sources which include volcanic eruption, sand, dust storm and forest fires etc. Second is the Man-made sources which include human activities such as industries , factories , aircrafts , nuclear experiments , automobiles , agriculture and power plants. There are primary pollutants and secondary pollutants in which primary pollutants are pollutants that are emitted directly from sources and found in the atmosphere in the form which they were emitted. These are DDT, plastic, CO_2, CO, are the primary pollutants. Then the secondary pollutants are the pollutants that are formed in the atmosphere by chemical reaction between primary pollutants and atmospherical constituents. These secondary pollutants are SO_3, O_3, Hydrogen cyanide, ketones, etc.

I. **Air Pollution**

Impact on World due to Air Pollution

a. Air contamination is one of the world's driving danger factor for death and medical problems, credited to 5 million deaths every year.
b. Air contamination is credited to 9% of deaths all inclusive.
c. It is additionally one of the higher hazard factors for malady trouble.
d. Death rates from air contamination are most elevated in low-to-working class salary nations.
e. Globally, demise rates from air contamination have been falling. This has primarily been the after effect of progress on handling indoor contamination quite well. The main causes of Air pollution are:

Causes of Air Pollution

a) Transportation
b) Agriculture Activities
c) Industrial Process and Burning of Solid Waste

In transportation vehicles are major part of air pollution, more than 50% of total air pollution is used by vehicles. Automobiles exhaust emits particulate matters, unburned hydrocarbons, carbon dioxide, nitrogen oxide etc.

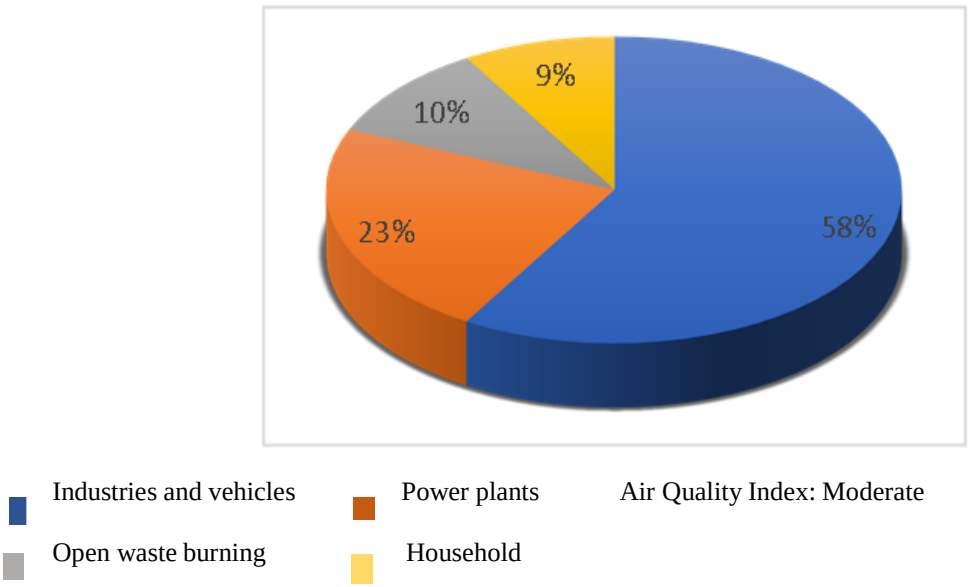

Fig. 1: Pie Chart

Also burning of fossil fuels such as petrol, diesel, natural gas leads to the emission of CO_2 and other gases. Open field burning is the main contributor to pollution due to agriculture. There are pesticides and many toxic chemicals are used in agriculture. Also, there is burning of coals, forest fires and solid waste in industries such as paper mills, cotton mills and chemicals Thermal power plants cause most air pollution.

The smoke running out through the factories has small dust particles, carbon, metal and other radioactive materials from various sources they get mixed in smoke and pollute the air.

The air pollution during the spring and summer, late morning to evening summer air is filled with ozone and during winter, the night air often has high pm 2.5 levels. So, the only consistent high-quality air was from 4 am to 7 am.

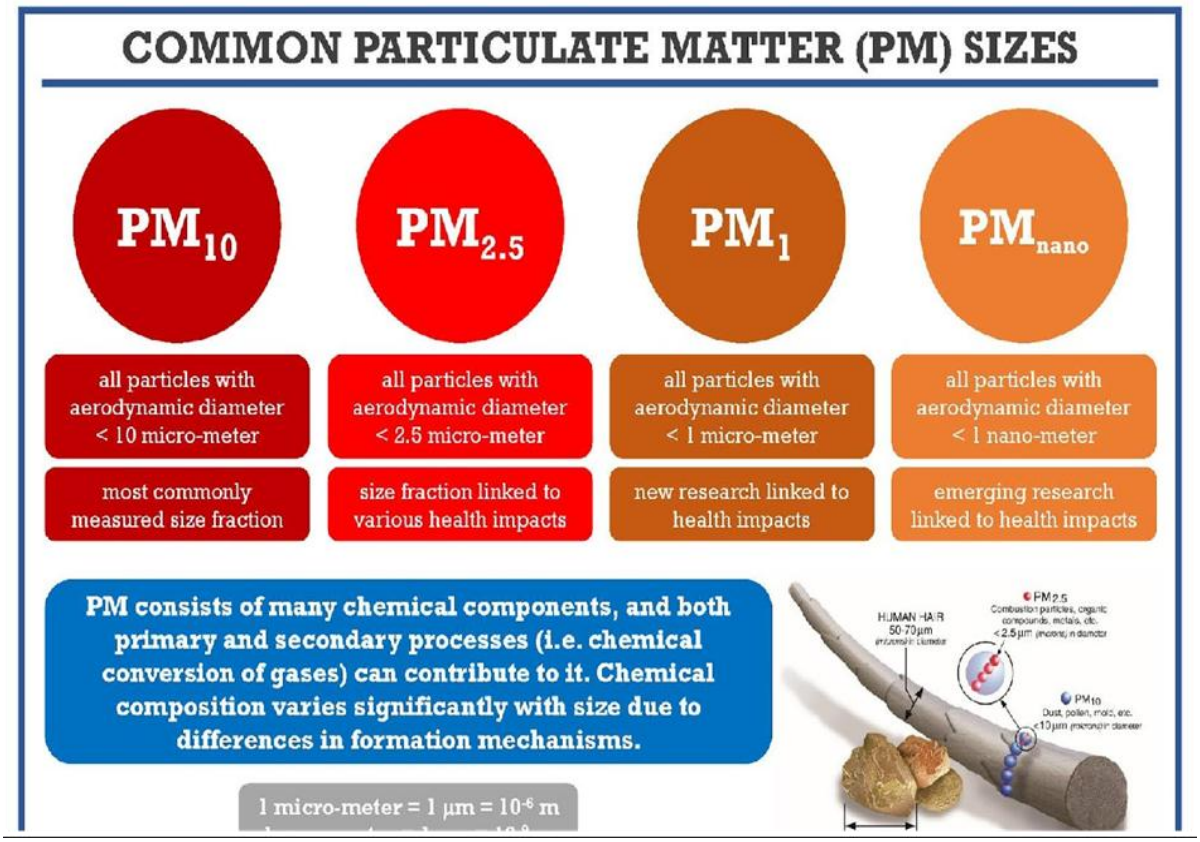

Fig. 2: Different PM Sizes

During day, the sun rises and heats up the atmosphere due to convection, we see that air expands. As the air expands, it slowly rises and takes away the polluted air and improves the air quality. It's also another reason why visibility greatly improves as the day progresses.

The smallest particle present in air known as particulate matter. They are suspended in air in the form of dust released from industrial chimneys. Its diameter range is from 0.001 to 500 Micrometre (μm)

CENTRAL POLLUTION CONTROL BOARD (CPCB) said that if the size of particulate matter is less than 2.5μm then it is very harmful for human health, because these dust particles are inhaled by our lungs directly due to tiny in size then there are breathing problems. The lungs disease (pneumoconiosis) and other respiratory problems are involved.

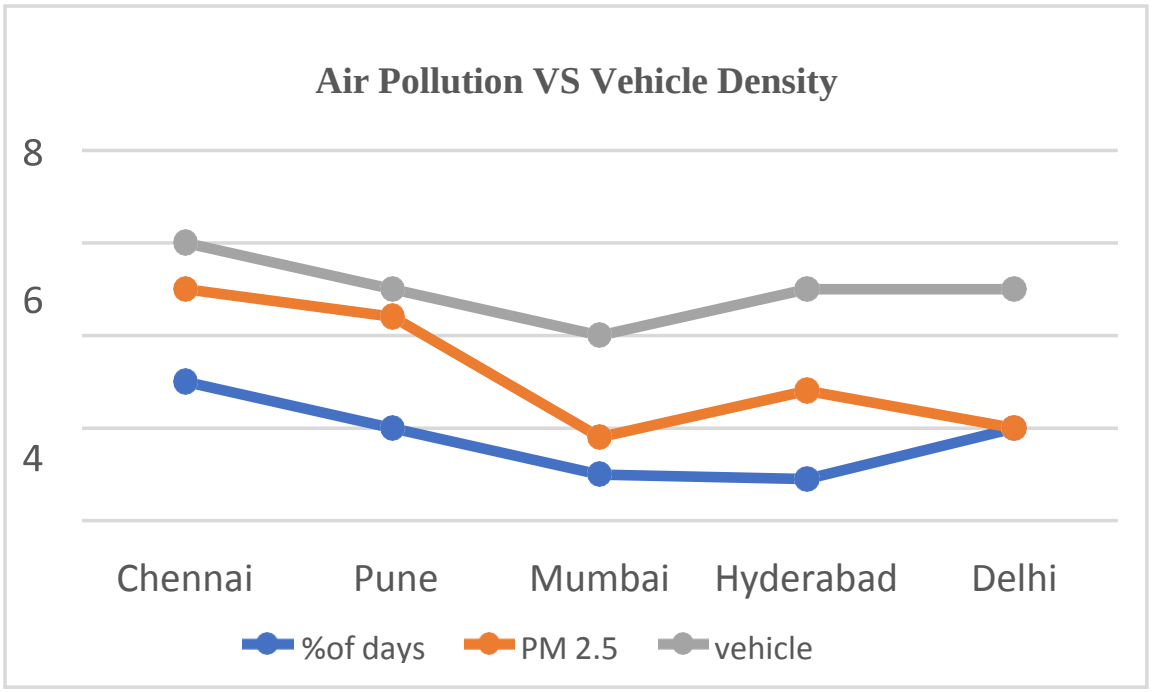

Fig. 3: Air Pollution Vs. Vehicle Density

This is a comparison between percentage of days of violation of air quality exceeding standard, $PM_{2.5}$ and vehicle density in metropolitan cities. The fine particles are particulate matter which is of 2.5µm in a diameter. It is produced from all types of combustion, including motor vehicles, residential wood burning. Vehicle density is number of vehicles per mile.

Name	Vehicle density	PM 2.5	Percentage of days Violent of air quality standards
Chennai	2093	20	81
Pune	1260	89	57
Mumbai	1229	77	33
Delhi	1723	198	45
Hyderabad	1014	81	55

Table 1: Air Quality Standards

From this chart, we found that vehicle density is high to air pollution and still other factors like industrial, power plants might play a vital role in air pollution of metropolitan cities.

"BE A SURVEYOR FOR THE OZONE LAYER"

Stratosphere is the second atmospheric layer; it contains much of the ozone gas known as ozone layer. The density of ozone is maximum at 22km. This ozone layer absorbs harmful ultraviolet rays coming from the sun and protects the life present on the earth. So ozone layer is also called as umbrella of the

earth but the scientific evidence reveals that stratospheric ozone is being destroyed mainly by chlorine atoms of chlorofluorocarbon (CFC) molecules, We know that CFC's were used as coolants in refrigerators , freezers , also in industrial solvents , dry cleaning agents , hospital sterilant , aerosols

and foam. During use of all these materials a lot of CFC's get dispersed into the atmosphere. Once these CFC molecules are broken apart by UV light, it releases chlorine and bromine which further demolish ozone. This ozone layer gets thinner, a hole has been observed in the ozone layer this hole allows the UV rays of the sun to reach on the earth directly. These UV rays cause skin cancer and many other diseases in human beings. Thus by this air pollution there is depletion of ozone layer, this ozone depletion can affect animals as well as plants, so this is one of the biggest effects of air pollution on our atmosphere as well as us. The ozone levels are typically highest during the afternoon hours of the summer months, when the influence of direct sunlight is greatest, so the early morning air can clean up our lungs to very good level "Sleep early in the night, hit the bed on time."

Some air pollutants cause more global warming. Air pollution includes greenhouse gases. The problem we now face is that human activities-particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing- are increasing the concentrations of greenhouse gases. Greenhouse gases include water vapour, CO_2, CH_4, nitrous oxide, ozone and some artificial chemicals such as CFC's. This is the enhanced greenhouse effect, which is contributing to warming of the Earth. Solar radiation reaches the Earth's atmosphere-some of this is reflected back into space. The rest of sun's energy is absorbed by the land, oceans heating the Earth. Some of this heat is trapped by greenhouse gases in the atmosphere, keeping the Earth warm enough to sustain life. This is trapping extra heat, and causing the Earth's temperature to rise, so this is Greenhouse effect. From this Greenhouse effect water level balance of the Earth would be destroyed, Marine life and ecosystem would be destroyed. Air pollution is considered as the major environment risk factor in the incidence and progression of some diseases such as asthma, lung cancer, ventricular hypertrophy, there are short term effects and long-term effects. Short term effects include irritation of eyes, nose and throat. Respiratory infections such as bronchitis, pneumonia and Long-term effects include chronic pulmonary disease, Cardio vascular disease and many more.

To prevent air pollution we have to stop deforestation, using public transport rather than own vehicle. Government already started odd even rule in Delhi for vehicles. We can use electric engines instead of liquid fuels engine, stop smoking in public places as we know it affects on our health as well as on our environment.

II. Sound Pollution

"STOP NOISE POLLUTION FOR HARMONY OF NATURE"

Noise pollution is generally referred to a type of energy pollution in which distracting, irritating or damaging sounds are freely audible. It is measured in dB units. In this type of pollution contaminants are not physical particles, but waves which interfere with the naturally occurring waves of a similar type in the same environment. Commotion is a disparaged danger that can cause various short-and long- haul medical issues, such as rest unsettling influence, cardiovascular impacts, less fortunate work and school execution, hearing disability, and so forth. Commotion has risen as a main natural disturbance in the WHO European Region, and the open gripes about exorbitant clamour increasingly more frequently.

How loud is too loud?

The WHO rules for network commotion suggest under 30 A-weighted decibels (dB(A)) in rooms during the night for a rest of good quality and under 35 dB(A) in study halls to permit great instructing and learning conditions. The WHO rules for night clamour suggest under 40 dB(A) of yearly normal outside of rooms to forestall antagonistic wellbeing impacts from night commotion.

How many people are affected?

As indicated by a European Union (EU) distribution:

a) About 40% of the populace in EU nations is presented to street traffic clamour at levels surpassing 55 dB (A);

b) 20% is presented to levels surpassing 65 dB(A) during the daytime; and

c) Over 30% is presented to levels surpassing 55 dB(A) around evening time.

Just constrained universal figures are accessible on the wellbeing effect of ecological commotion in the European Region.

Who is most affected?

A few gatherings are more powerless against commotion. As kids invest more energy in bed than grown-ups, they are more presented to night commotion. Incessantly sick and old individuals are more delicate to aggravation. Move laborers are at expanded hazard in light of the fact that their rest structure is under pressure. Also, the less well-to-do who can't bear to live in calm neighborhoods or have sufficiently protected homes, are probably going to endure lopsidedly. Irritation around evening time can prompt an expansion in clinical visits and spending on resting pills, which influences families' financial plans and nations' wellbeing use. The hole among rich and poor is probably going to increase if governments neglect to address commotion contamination.

Children, noise and health

Hindrance of youth advancement and training brought about by commotion may affect scholarly accomplishment and wellbeing. Studies and insights on the impacts of constant introduction to airplane commotion on youngsters have found:

a) Steady proof that commotion presentation hurts intellectual execution;
b) Steady relationship with weakened prosperity and inspiration to a marginally more constrained degree;
c) Moderate proof of consequences for circulatory strain and catecholamine hormone emission.

There are different sources of noise pollution

a) Transportation
b) Social Events
c) Commercial and Industrial Activities
d) Household Sources

In Transportation, there are various vehicles like auto, cars horns, scooters and aircrafts, helicopters produce lots of noise. Then in social events like market area, parties, loud speakers and places of workshop produce noise pollution. Also commercial and industrial activities including construction sites such as air compressors, loaders, dump trucks, etc. and in household there is TV noise, cooler, dryer, music systems at home produce noise pollution. Effects of noise pollution are respiratory agitation, high blood pressure, headaches, it can increase stress levels and anxiety, and even lead to coronary artery disease. The Hierarchy of Controls concept is often used to reduce noise in the environment or the work place. Engineering noise controls can be used to reduce noise propagation and protect individuals from overexposure. If people are around loud sounds, they can protect their ears with hearing protection (e.g., ear plugs or ear muffs). Noise from roadways and other urban

factors can be mitigated by urban planning and better designs of road. Roadway noise can be reduced by the use of noise barriers, limitation of vehicles speeds, alteration of roadway surface texture, use of traffic controls that smooth vehicles flow to reduce braking and acceleration and tire design. An important factor in applying these strategies is a computer model for roadway noise; that is capable of addressing local topography, meteorology, traffic operations. Also, Aircraft noise can be reduced by using quieter jet engines, altering flight paths and time of day.

To control Noise pollution, our Government has rules and regulations against firecrackers and loudspeakers. Supreme Court has banned playing of music on loudspeakers after 10pm. Also, there are apps like Noise level from a leaf blower, using (NIOSH) sound level meter app. NIOSH is the National Institute for Occupational Safety and Health, part of the Centers for Disease Control and Prevention (CDC). NIOSH estimates that 22 million workers in the United States are exposed to hazardous noise levels each year. The Second Level Meter (SLM) app can help you prevent permanent hearing loss caused by noise-a problem that can occur immediately or over time. By this NIOSH SLM app it makes workers informed about their noise environment. It is therefore, we can reduce noise pollution.

We know, pollution is increasing day by day whether it is air pollution, water pollution, noise pollution or soil pollution. To reduce this pollution there are many rules, regulations and Acts are passed by Government, so we have to follow all this. The effect of pollution is threatening not only the environment but also ours and animal's life. For the sake of the world's health, it is hoped that anti- environment behavior is cut out sooner rather than later.

"STOP POLLUTION, SAVE OUR PLANET"

POLLUTION IN OUR COMMUNITY, MEASUREMENTS AND PHYSICAL INSIGHTS

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Keywords: Industry, Air Pollution, Water Pollution, Ph level.

INTRODUCTION

I have been there in the capital city of Tripura from my early childhood. It is the second largely populated capital after Guwahati in Assam. It is situated at 23˚50' North latitude and 91 51' East longitude. It is 12.80 meter high from sea level. The less polluted wonderful environment and mind-blowing scenario of the city have been drawing attraction of several travelers across the state, outside of the state and from abroad too. The natural scenario of my home state Tripura and its pollution free comfortable surrounding has made it unique from most other states of the country.

SCALE AND SCOPE OF THE STUDY

My study area of pollution of my community and surrounding includes 23 .8616 ˚North and 91.3349 ˚ East of Agartala city area specifically known as BODHJUNGNAGAR INDUSTRIAL AREA, where the factor of pollution are enormously takes place the frequent movement of vehicles and exhausted fumes from the industrial establishment out there. The continuous and highly dense traffic jam and medium and small scale industry per unit area of this part is solely and highly responsible and functioning as a conductor to increase the rate of pollution with respect to time. The focus of my study is to determine the relation between the intensity of traffic jam and industrial outlets in this area with various kinds of pollution (viz. air pollution, water-body pollution etc.)

Fig 1:- GLOBAL POSITIONING SENSOR IMAGE OF THE BODHJUNGNAGAR AREA (CREDIT: GOOGLE MAP)

AIR POLLUTION IN MY COMMUNITY

My area is so much congested that various kinds of pollution can not help prevailing round the surrounding and one of the pollutions is air pollution. Having been an industrial area it is bonafide that exhausted fumes from different factories would fill up the atmosphere. Adding to that the large population density in small volume causes day by day increment of vehicles in and around my study area. These all are the principal causes of the air pollution to occur in the area.

PHYSICAL CAUSES OF THE AIR POLLUTION

The following causes are the factors that are directly proportional to rate of air pollution in the area,

a) Cutting of trees

To fulfill the demand of increasing population per unit area and to construct large establishment the rate of cutting plants is being increased as a function of time. Since plants absorbs the exhausted CO_2 from exhausted fumes of industries and vehicles and get the air rid of excess exposure of CO_2; the decrease of the number of trees is directly proportional to increase of air pollution.

b) Increase of Industries

The increase of no of industries in the area is one another reason for the pollution to be occurred. We know the rate of density of aerosol increases due to emitted fumes of industries and factories. The aerosols frequently move in the air medium and gets combined with the vapors and forms smog. After getting combined to aerosols the mass of the vapor-aerosol system gets increased and on account of being subjected to attraction of relatively greater gravitational force the smog comes down near to the earth surface. This smog is one of the main causes of air pollution to occur in industrial area Bodhjung Nagar of Agartala and creates asphyxiation. Smog increases the density and refractive index of the medium, due to which problem of resolution occurs. Due to increased refractive index, of the medium light from any car deviates from its path and problem of anomalous dispersion occurs, that causes accident in the city which in turn claims many lives in this part of Agartala city (Bodhjung-Nagar).

c) Increase of vehicle

The number of different sorts of vehicles is getting increased in the city area day by day which also contributes to air pollution. The most of the roads of Agartala city themselves are one-way and narrow. Adding to that the rate of increment of vehicles has been increasing the turbulent motion of traffic over the roads. Maximum vehicles of city Agartala are driven by petrol, diesel-like fossil fuels. The enormous amount of fumes, exerted from the vehicles everyday increases the density of pollutants in air which are the majority carriers of air pollution in the city Agartala and especially my study area Bodhjung Nagar.

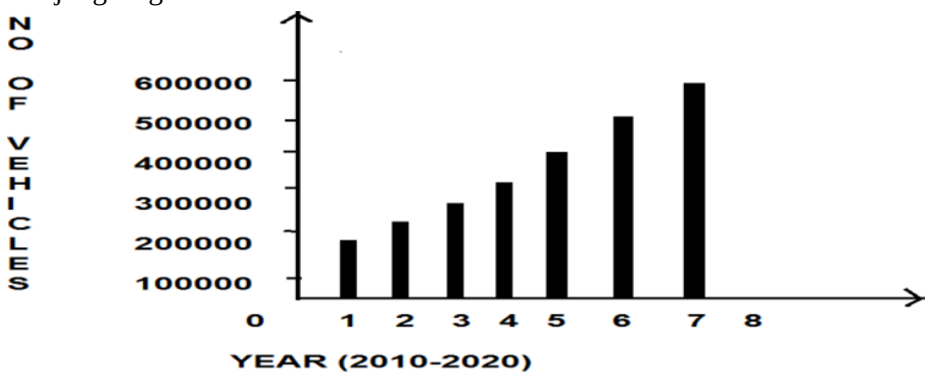

FIG 2: INCREASE OF VEHICLES IN MY STUDY AREA IN LAST 10 YEARS[1]

How Physics can help to measure air pollution

To measure the quality of air in a certain area there are lots of physical techniques and instruments to be utilized. One of the instrument is the remote sensing satellite. Remote sensing satellite works on the basis of resolution technology. If the amount of pollutant, dust particles and aerosols are prevailing in the atmosphere then due to large refractive index the image captured by the remote sensing satellite will be blurred and that is the signature of bad quality of air. So, remote sensing satellite functions on simple refraction phenomenon of light.

There are several other methods to measure air quality physically. There are Nano-sensors available which work on the theory of high surface to volume ratio and adsorption of aerosols and other pollutants on its surface. The more surface to volume ratio it does have the more it can adsorb pollutants over its substance (e.g., Graphene based ammonia gas sensor).

How physics can reduce air pollution

To reduce air pollution in my area of study (Bodhjung-nagar) few simple physical techniques can be adopted as follows:

a) The exhausted air can be purified using any filtration technique so that the pollutants get separated from the air.

b) Condenser can be utilized at the exit of exhaust pipe of an industry so that the pollutants can be condensed and their weight can be increased and they will be sedimented due to attraction of gravity.

c) The surface of the exhaust pipe can be possibly made up of the substances which can have a high surface to volume ratio and power of adsorption on its surface so that most of the pollutants get stuck over the surface and the amount of coming out of pollutants get reduced.

PREVIOUS DATA OF AIR POLLUTION AND PHYSICAL INFERRENCE[2]

AREAS	Observed Concentration of RPM in $\mu g/m^3$		
	Summer	Post-monsoon	Winter
Kayerpur	49	83	58
Kalinagar	72	98	105
RK nagar	43	88	148
Majlishpur	47	78	88
Laksmilunga	32	83	109
Fatikchara	35	54	117
Kalkalia	36	65	104
Mohanpur	37	64	86

Here we are observing that the air quality index is within the permissible range as per CPCB standard although there are some exceptions in winter season. The bad air quality in the winter happens to be on account of condensation and fog in our surrounding due to low temperature. As a result the dust particles, come out as industry outlets, gets condensed and come to lower level of the atmosphere as smog due to the weight of the particles becoming greater than that of their buoyancy force in air and consequently makes the air quality hazardous for health.

WATER POLLUTION

We have too many water bodies to name and Tripura's largest river Howrah passes by suburb area of the Agartala city. These water bodies and the river also covers a large area of the industrial area Bodhjung Nagar of Agartala. The wastage and outlets of industries are being drained to these water bodies and river Gomati which is directly responsible for the water pollution. The chemical wastage while directly comes into the river, increases the density of the water medium. The sunlight would then refract at a smaller angle into the water medium and would not disperse equally inside the water which definitely harms the growth of eco-system under the water severely.

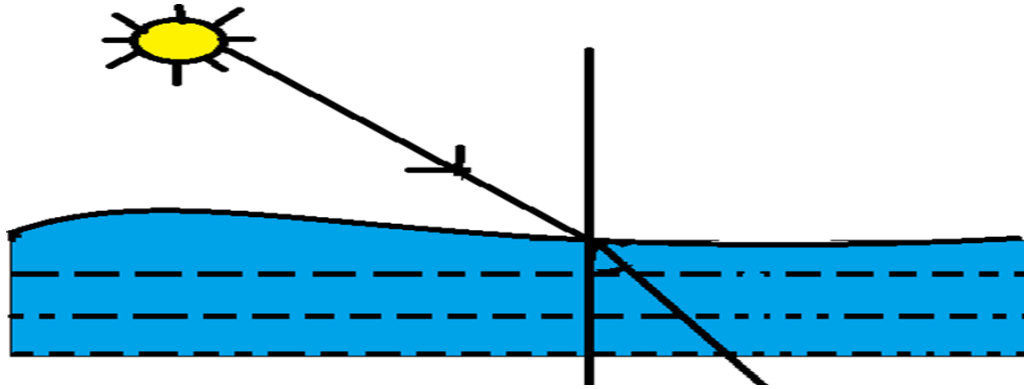

FIG 3: REFRACTION OF SUNLIGHT THROUGH RIVERINE WATER

PHYSICAL CAUSES OF WATER POLLUTION

Behind water pollution in an industrial area there are some physical reasons mentioned below:

a) The plastic-like non-biodegradable elements while assemble as outlet in the river, prevents the water to flow for which the kinetic energy of the water layer gets reduced since ½ mv^2 due to decrease of water velocity v which in turns actually increases the possibility of wastage to have conglomerated which increases the possibility of water pollution.

b) The more the linear speed of the flowing water of river decreases the more the wastage would precipitate into the bottom of the river. This causes the eco-system under the water severely challenged for existence and gets the water contaminated.

c) The contaminated water from the industrial area gets marinated to the river water and increases the density of water, number of impurities (PPM Or PPB) of water, which in turn increases the water pollution.

HOW PHYSICS CAN HELP TO MEASURE WATER POLLUTION

Physics in many ways can help us out to measure water pollution in water-bodies. We have various sensors (such as conductivity sensor, turbidity sensor, ph sensor etc.) that work after the simple physical principles to determine the amount of solvent pollutant with the water. Through conductivity sensor the electrical conductivity of a water sample is measured. The more the conductivity the more is the probability of the water to have ionic conductor mixed up with it whereas the lowering of the conductivity indicates the water of getting mixed with non-conductive pollutants. A ph sensor measures hydrogen-ion activity of water which tells the acidity or basicity of the water sample indicating the amount of acidic or basic solvent pollutant being mixed up to the water.

Tripura pollution control board is taking such measures to keep a watch on the pollution level of water.

HOW PHYSICS CAN REDUCE WATER POLLUTION

To reduce water pollution we ought to take on the issue tactfully with the help of scientific temperament. Physics can help a lot to achieve this goal. Any kind of manual or mechanical scientific arrangement that is used for reducing water pollution is known as the contribution of Physics.

For having fresh water the riverine water should be purified using centrifuge method in water purification plant where riverine water is being centrifuged with high speed. In centrifuge method the high speed is being used so that centrifugal force on the pollutants, mixed with the water, would be high enough ($F_c = mv^2/r$) so that they can be sedimented due to the enacting centrifugal cum force due to gravity combo on*r*each of the pollutant particle inside the water. The centrifugal force acts on the pollutants since they had been moving in a circular path about an axis in the container which was creating the whirlpool motion of the water.

So this is a technique derived from Newtonian mechanics that is generated the particular centrifugal force. That's how physics plays a major role in taking on water pollution.

And we have various water purification project in Agartala and round the state Tripura to have fresh pollution free mineral water which is being supplied to houses under "Atal Jal dhara mission" named after honorable late Prime minister of India Atal Bihari Vajpayee, under a Tripura Government initiative.

CONCLUSION

The nature is our mother. We can't see our mother to be ruining day by day due to our foolish, greedy activities. But there is no pause of ongoing non-sense activities of people. To harness this challenge to save our community and society from the massive debris of pollution we have science, especially Physics to be tactfully applied to compensate some of the natural losses that is occurring due to our own wrong doings.

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POLLUTION IN OUR COMMUNITY: MEASUREMENTS AND PHYSICAL INSIGHTS

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Keywords: Industrialization, Sewage, Effluents, Eutrophication, Contamination

SOIL AND WATER POLLUTION IN OUR COMMUNITY

INTRODUCTION

Water, a prime natural resource and precious national asset, forms the chief constituent of ecosystem. Water sources may be mainly in the form of ecosystem. Water sources may be mainly in the form of rivers, lakes, glaciers, rain water, ground water etc. The availability and quality of water either surface and ground, have been deteriorated due to some important factors like increasing population, industrialization, urbanization etc. Water quality of any specific area or specific source can be assessed using physical, chemical and biological parameters.

Here, analysis of groundwater sample collected from various location of Bhavnagar region revealed that water quality parameter were within PL as per IS- 10500 standard. However TDS, Chloride, fluoride, Chromium were observed beyond PL in some samples. Using Physicochemical analysis, various quality parameters are measured including PH, electrical conductivity, TDS, Ca, Mg, Na, K content of eleven sampling rural area of Bhavnagar Taluka in period of winter 2014-15 in order of quality index.

Table-1: Water Quality – Heavy Metals

Sr. no.	Sampling Location	Na	T-Cr^{+3}	Cu	Pb	Fe	Zn	K	Ni	S^{-2}
1	Project-site (GIDC Water)	39.92	<0.005	BDL	<0.005	2.12	<0.022	5.84	BDL	<0.2
2	Vartej	53.11	<0.005	BDL	<0.005	1.13	<0.022	1.98	BDL	<0.2
3	Fariyadka	133.65	<0.005	BDL	<0.005	0.24	<0.022	4.08	BDL	<0.2
4	Sodvadra	40.34	<0.005	BDL	<0.005	0.29	<0.022	0.77	BDL	<0.2
5	Juna Bandar	11.30	<0.005	BDL	<0.005	0.89	<0.022	1.32	BDL	<0.2
6	Bhavnagar City	17.50	<0.005	BDL	<0.005	1.55	<0.022	3.84	BDL	<0.2
7	Shampura	59.70	<0.005	BDL	<0.005	0.87	<0.022	4.70	BDL	<0.2
8	Adhewada	103.06	<0.005	BDL	<0.005	0.78	<0.022	4.89	BDL	<0.2
9	Nari	35.69	<0.005	BDL	<0.005	0.40	<0.022	1.77	BDL	<0.2
10	Kamlej	22.14	<0.005	BDL	<0.005	BDL	<0.022	1.24	BDL	<0.2

Source: M/S Misa Finechem PVT LTD Environment Impact Assessment Report

- BDL – Below Detection Level

WHAT IS WATER POLLUTION: Water pollution occurs when harmful substances often chemicals or microorganisms contaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment.

WHAT ARE THE CAUSES OF WATER POLLUTION: Water is uniquely vulnerable to pollution. Known as a "universal solvent," water is able to dissolve more substances than any other liquid on earth. It's the reason we have Kool-Aid and brilliant blue waterfalls. It's also why water is so easily polluted. Toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution.

- Pollution of Water Due to Urbanization and Demographic Change: Urbanization has various facets with respect to water bodies within the city premises. Usually such water bodies perform multiple functions of ground water recharge, adding aesthetic value to our cities and towns besides performing many ecological functions like contributing to the moderation of temperature in the areas around them. Unfortunately, the replacement of ponds, lakes, and water bodies with construction sites has not only robbed us of aesthetic beauty but also distanced future generations from nature.

- Industrial Pollution: Industrial pollution can cause tremendous pressure on water resources, particularly if it goes unchecked and unattended. Water pollution can have severe implications on the health of lives dependent on these resources.

- Agricultural Pollution of Water: Agricultural pollution of water may be understood in the context of water contamination as a consequence of agricultural practices. Water contamination occurs in drinking water environments due to runoff from farms bringing ammonia, pesticides, fertilizers, oils, toxic compounds, and animal waste into water bodies. Agriculture-led pollution of water bodies and ground water exert pressure on existing and newly-created sources of water.

- Climate Change : Global warming has also an impact on water resources through enhanced evaporation, geographical changes in precipitation intensity, duration and frequency (together affecting the average runoff), soil moisture, and the frequency and severity of droughts and floods. Future projections using climate models pointed out that there will be an increase in the monsoon rainfall in most parts of India, with increasing greenhouse gases and sulphate aerosols.

The district is characterized by a tropical climate with general dryness, except in the coastal areas. There are four seasons in a year, viz., hot season from March to May, monsoon season from June to September, post –monsoon season from October to November and cold season from December to February. Details of climatological data as recorded at IMD (India Meteorological Department), Bhavnagar is given in following table and same is depicted graphically.

Table 2

Month	Max Temp (°C)	Mini Temp (°C)	Humidity (%)	Wind Spd. Kmpd	Sunshine (Hours)	Solar Rad. (MJ/m2/d)	Eto (mm/d)	Rainfall (mm)
Jan	28.00	12.60	44.50	233.80	9.00	17.34	4.86	1.20
Feb	30.70	14.90	39.00	249.10	9.20	19.60	6.01	1.50
March	35.00	19.50	36.50	274.70	9.80	22	7.70	2.40
April	38.10	23.80	40.00	307.10	10.40	25	9.04	0.40
May	39.80	26.20	50.50	385.60	10.80	26	9.86	4.60
June	37.10	26.90	64.50	441.90	7.60	21	7.86	114.90
July	33.40	25.90	75.00	395.90	4.40	16	5.36	180.50
August	32.30	25.00	76.50	329.30	4.20	15	4.76	152.90
Sep	33.00	24.10	71.50	267.90	6.30	18	5.17	117.40
Oct	34.90	22.30	50.00	223.50	7.90	18	5.97	26.10
Nov	32.30	18.20	44.00	203.10	8.00	16	5.12	10.80
Dec	29.00	14.30	47.00	203.10	8.90	16	4.46	2.00
Total								**614.70**
Avg.	33.63	21.14	53.25	292.92	8.04	19.53	6.35	

Source: climatological data of IMD station

Rainfall: The normal rainfall in the district is 598.4 mm (IMD India Meteorological Department data) and 90% of the total annual rainfall is received during the monsoon season with average of 31 rainy days in a year.

Climatological Data – Bhavnagar

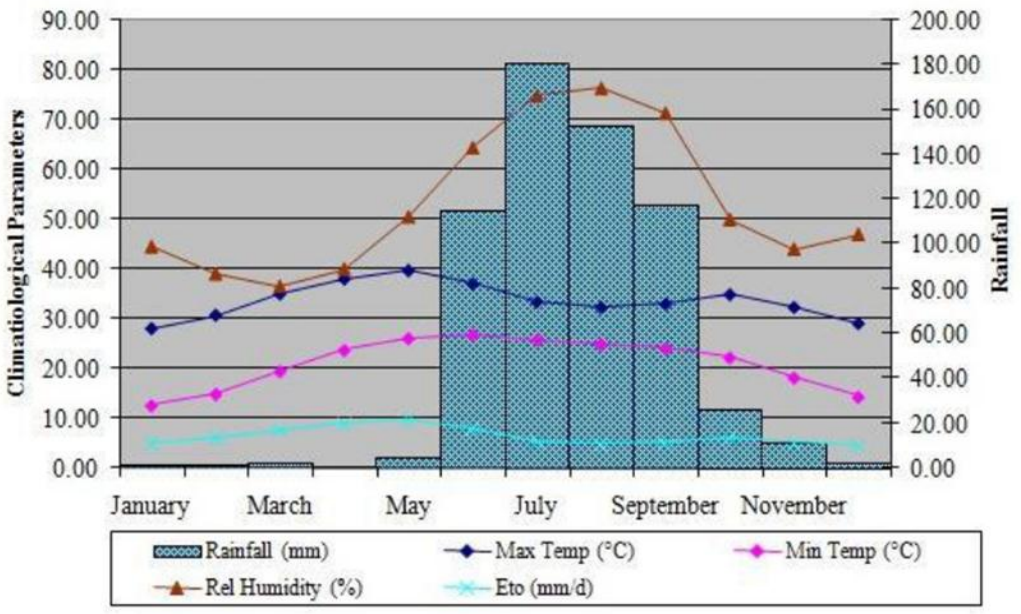


Fig. 1: Source: climatological data of IMD station

EFFECT OF POLLUTION OF WATER

- **Diseases:** In humans, drinking or consuming polluted water in any way has many disastrous effects on our health. It causes typhoid, cholera, hepatitis and various other diseases.

- **Destruction of Ecosystems:** Ecosystems are extremely dynamic and respond to even small changes in the environment. Water pollution can cause an entire ecosystem to collapse if left unchecked.
- **Eutrophication:** Chemicals in a water body encourage the growth of algae. These algae form a layer on top of the pond and lake. Bacteria feed on this algae & this decreases the amount of oxygen in the water body.
- **Affects the food chain:** Disruption in food chains happens when toxins and pollutants in the water are consumed by aquatic animals which are then consumed by humans.

PREVENTION OF WATER POLLUTION TAKEN BY GOVERNMENT

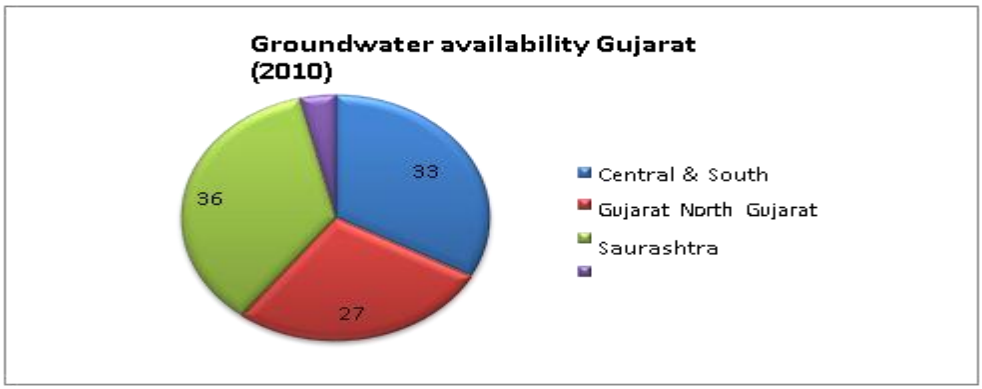
- **Common Effluent Treatment Plants (CETP):** The concept of CETPs was introduced in the early 1990s to enable efficient treatment of waste water. CETPs have reduced the burden of construction and maintenance of effluent treatment plants on individual industries. Gujarat has 28 operational CETPs located in the districts of Ahmedabad, Vadodara, Bharuch, Surat, Valsad, Junagadh, Rajkot and Gandhinagar. The total capacity of these 28 CETPs accounts for 496.75 MLD. Six CETPs with a cumulative capacity of 210.04 MLD have been proposed in the districts of Surat, Jamnagar, Rajkot, Junagadh, Ahmadabad and Valsad (GPCB, 2011).
- **Sewage Treatment Plants (STPs) and Oxidation Ponds:** The State constituted an autonomous company, the Gujarat Infrastructure Company Limited (GICL) in a bid to combat the magnitude of sewage water, murky fallout of rapid urbanisation since the 1970s. The idea was to collect, treat and dispose sewage properly . GICL has facilitated the technical support of all urban local bodies in Gujarat for establishing STPs and municipal sewage water disposal facilities. The state has 43 operational STPs operated by different Municipal Corporations and Nagarpalikas. These are located in the districts of Ahmedabad, Vadodra, Rajkot, Surat, Anand, Gandhinagar, Bhavnagar, Valsad, Bharuch, Kutch and Kheda. Under installation are 17 STPs. The total numbers of 28 Oxidation Ponds are mostly operated by various Nagarpalikas (GPCB, 2011). These numbers are far less than the actual requirement.
- **Environmental projects:** Key institutions like GPCB, GWRDC, NWRWS have been monitoring water quality parameters for many decades under various projects. The main projects are GEMS (Global Environmental Monitoring System), MINARS (Monitoring of Indian National Aquatic Resources System), Water Quality Project, Kalpsar Project, Coastal Monitoring and Festival Monitoring. These are being funded by MoEF, CPCB, DoEF and other departments of Government. The GEMS project has been focusing on the monitoring of major rivers of Gujarat like Narmada, Tapi, Mahi and Sabarmati. In order to assess industrial and domestic pollution in coastal waters, the GPCB has identified 41 locations on coastline to be monitored monthly in 2010–11.. During major festivals like Navratri, Diwali and Ganesh Utsav the pollution content in air and water is known to rise phenomenally. . The monitoring of river bodies to study the environmental impact of Ganesh Utsav ha s, thus, been set in motion in the state by the GPCB.
- **E-governance:** E-governance has emerged as an innovation to bring about a paradigm shift in environmental management. The GPCB has used this medium to spread awareness about pollution control and manage ment amongst citizens, businessmen, entrepreneurs, and government officials. Services include information spread to end users through bulk SMSes, monitoring of public actions and complaints, hospitals for various contingencies, generation of waste inventory etc. (Gujarat Pollution Control Board 2011).

GROUND WATER

The regional percentage distribution of 12000 million cubic meters of ground water resources in Gujarat has been shown in Figure 3.9. Saurashtra has a maximum ground water availability of 4300 million cubic meters followed by South and Central Gujarat, North Gujarat, and Kutch with 3950, 3300 and 450 million cubic meters respectively.The state of Gujarat has three distinct regions.

The Saurashtra region comprising the districts of Bhavnagar, Amreli, Junagadh, Rajkot, Surendranagar, Jamnagar, and Kutch is the most rainfall scarce region which receives between 380 mm (in the northern part of the region) and 680 mm (in the southern part) of rainfall annually.

Figure 2: Ground Water Availability in Gujarat



Source: NWRWS n.d.

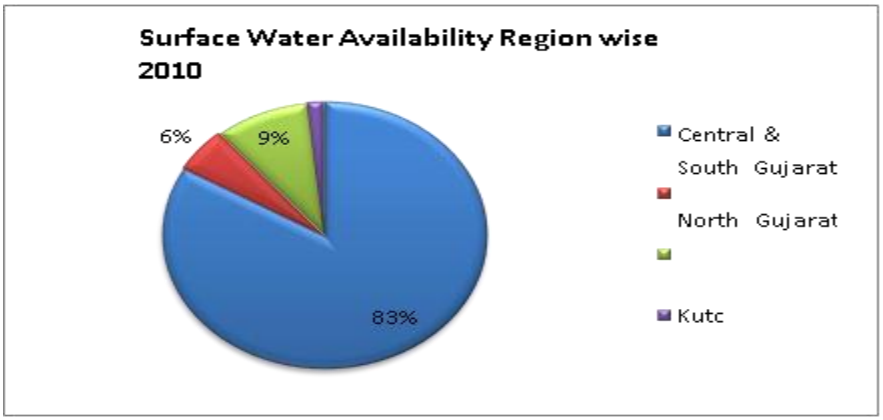
Pollution of Ground Water

There have been several reports on the pollution of water in 55 wells and tube wells. In the Luna village of Padara taluka in Vadodara district water turned red and yellow due to contamination. Luna and the surrounding villages are known for their drumstick production and often referred as Gujarat's vegetable basket. Farmers from the area have reported decline in the vegetable yield. A seismological report by the Gandhinagar-based Institute of Seismological Research has established that the dye production unit was responsible for ground water contamination in and around Luna village. Complaints from the villagers, sarpanch, a proactive NGO, and foll ow-up by GPCB officials led to this report and further action. The report indicated that the industry continues to use its waste storage tank beyond its life limit and even raised its height by three meters in 2006 to dump 50 percent more waste than its capacity. The Gujarat Pollution Control Board (GPCB), seems to have issued the closure notice and asked the company to prepare a time-bound action plan for the remediation and assessment of the ground water and soil pollution levels. As a result, the company has come out with a detailed remediation plan.

SURFACE WATER

A total of 50,100 million cubic meters of water including surface water, ground water and storage capacity of reservoirs (excluding Sardar Sarovar) along with surface water resources, contributes to 38100 million cubic metres of water. Figure 3.8 represents the regional distribution of surface water resources in Gujarat.

Figure 3: Region-wise Surface Water Availability in Gujarat



Source: Source: NWRWS

Pollution of Surface Water

Traditionally, water bodies like rivers, lakes, ponds, wells, etc. have been a major source of water supply relevant to domestic and drinking water needs. With the phenomenon of urbanization and industrialization becoming predominant, it is now imperative for monitoring agencies to ensure that polluted water be released into water bodies only after treatment with permissible pollutant contents. Cities in Gujarat, like most Indian cities, are having to deal with most of their water bodies receiving untreated waste water leading to subsoil water pollution and at times, even ground water pollution. As presented in Table 2.5 all the four major rivers- Sabarmati, Tapi, Mahi and Narmada are faced with pollution, albeit in selected patches within their course.

Table 3: Unfit Patches of Four Major Basins in Gujarat

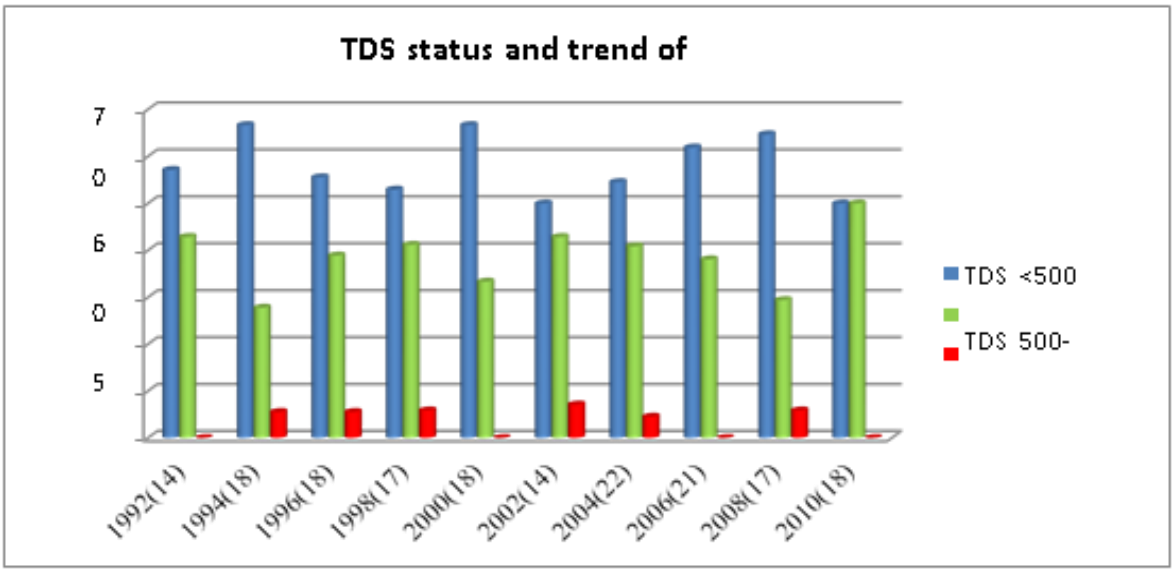
River	Total length (km)	Length unfit for Bathing or drinking (percent)
Sabarmati	325	49
Tapi	977	45
Mahi	522	44
Narmada	1382	35

Source: CSE (2012)

TOTAL DISSOLVED SOLIDS (TDS)

TDS is measured to quantify the amount of inorganic salts as well as the small amounts of organic matter present in water. TDS usually consists of calcium, magnesium, sodium and potassium carbonates, hydrogen carbonates, chlorides, sulfates and nitrates' salt. It affects the taste of water and imparts hardness in higher concentrations. BIS has prescribed a desirable TDS limit of 500 mg/l for drinking water and the maximum permissible limit of 2000 mg/l in the absence of any alternate source.

Fig. 4: TDS status of key Lakes and Talavs in Gujarat.



Source: Data provided in GPCB annual reports 1990–91 to 2010–11 INDUSTRIAL

INDUSTRIAL POLLUTION

With the coming of the Industrial Revolution, humans were able to advance further into the 21st century. Technology developed rapidly, science became advanced, and the manufacturing age came into view. With all of these came one more effect, industrial pollution. Earlier, industries were small factories that produced smoke as the primary pollutant. However, since the number of factories were limited and worked only a certain number of hours a day, the levels of pollution did not grow significantly. But when these factories became full -scale industries and manufacturing units, the issue of industrial pollution started to take on more importance. Most of the pollution on the planet can be traced back to industries of some kind. Industrial pollution is wreaking havoc on Earth. Every nation is affected and there are people who are working tirelessly to increase awareness and advocate for change.

CAUSES OF INDUSTRIAL POLLUTION

Lack of policies to Control Pollution	Unplanned Industrial Growth
Use of Outdated Technologies	Inefficient Waste Disposal
Presence of a large no of small Scale Industries	Leaching of Resources from Our NaturalWorld etc.

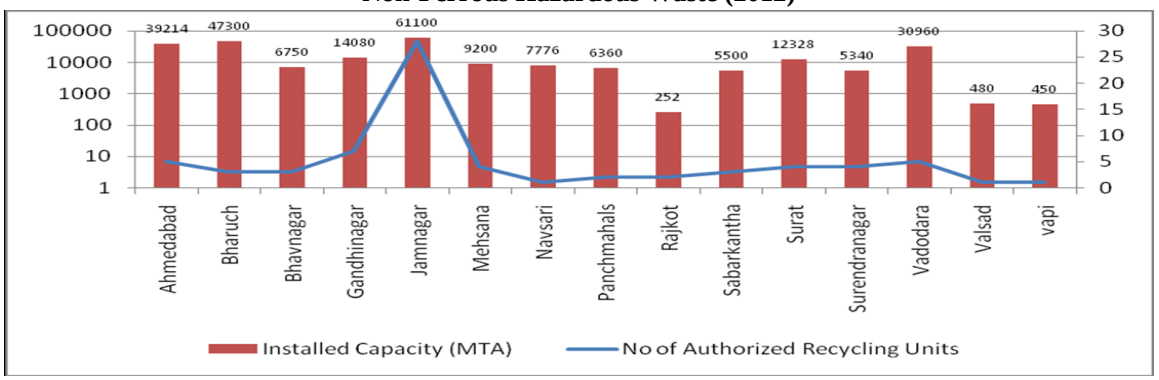
WAYS TO CONTROL OR REDUCE INDUSTRIAL POLLUTION

The issue of industrial pollution is critical to every nation on the planet. With the increase of the harmful effects of industrial pollution, there are many agencies and individuals who are working to reduce carbon footprints and live and work in an eco-friendly way. However, industrial pollution is still rampant and will take many years for proper control and regulation. Many steps can be taken to seek permanent solutions to the problem.

- Source Control
- Cleaning of resources
- Stricter Laws and Enforcement

- Proper Treatment of Industrial Waste
- Industry Site Selection
- Rebuilding Habitats and Afforestation
- Recycling etc.

Fig 5: Number of Recycling Units and Installed Capacity of recyclers of Non-Ferrous Hazardous Waste (2012)



Source: Gujarat Pollution Control Board, 2012

o MTA – Mineral Trioxide Aggregate

For recycling of waste/used oil, total 30 units across the state are granted authorization with total installed capacity of

1.73 lack kilo liters per annum (KLA). Ahmedabad district houses 42 per cent of the total installed capacity with 17 units, followed by Bhavnagar district with 14 per cent and Vadodara district with 14% of total installed capacity.

PRE-EMERGENCY ACTIVITIES

Non-destructive testing (NDT)

- To prepare list of equipment and pipelines in the plant which require NDT as per the rules of Factories Act.
- To arrange for Non-Destructive Testing (NDT) as per the rules under Factories Act by Government certified competent person on due dates.
- To maintain record of testing and certificates issued by competent person and make them available to Factory Inspector at the time of inspection.

Frequency of Non-Destructive Testing: Once in a year.

Fire system testing

- To prepare list of various fire-fighting equipment (Fire Extinguishers, etc.) installed at various locations in the unit along with detailed specifications.
- To prepare schedule for testing of all these equipment and check operability.
- To maintain record of testing and mark dates of testing on the equipment.
- To carry out repairs/replacement of defective equipment Frequency: Once in a month

CONCLUSION

The Ground water level as well as the industrial Effluents in the Bhavnagar district increase year by year. But it is important to keep a close control over pollutants so that we can maintain the environment in an acceptable condition for future generations. Pollution monitoring can be done via remote sensing, water monitoring, and enterprise monitoring etc. methods. There are different

institution techniques also widely used such as software, robotic fish etc which are helpful in the detection of pollution. There are many scientific researches going in th is field to control different types of pollution.

Industrial activity, improper disposal of waste and agricultural chemicals cause soil pollution. Excessive use of chemical fertilizers can change the soil PH and destroy the structure of soil. Major source of water pollution are discharge of domestic and agricultural waste, pollution growth, excessive use of pesticides, fertilizers and urbanization also. Pollution content reveals significant result in the foreign trades of India. The presented study deals with interpretation of soil quality monitoring data using hierarchical cluster analysis (HCA) and principal component analysis.

I would conclude from the survey of the reports that there is a constant growth in the level of pollution; whether it is soil, water or air. My study in the subject also reveals that if no proper care or treatment is given to the waste released from the factories and industries then, in future it may even get accumulated in the environment and our surroundings which may create life threatening world. So, it is our fundamental duty to save our earth from different types of pollutants by preventing the situation from getting worse day by day.

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POLLUTION IN OUR COMMUNITY, MEASUREMENTS AND PHYSICAL INSIGHTS

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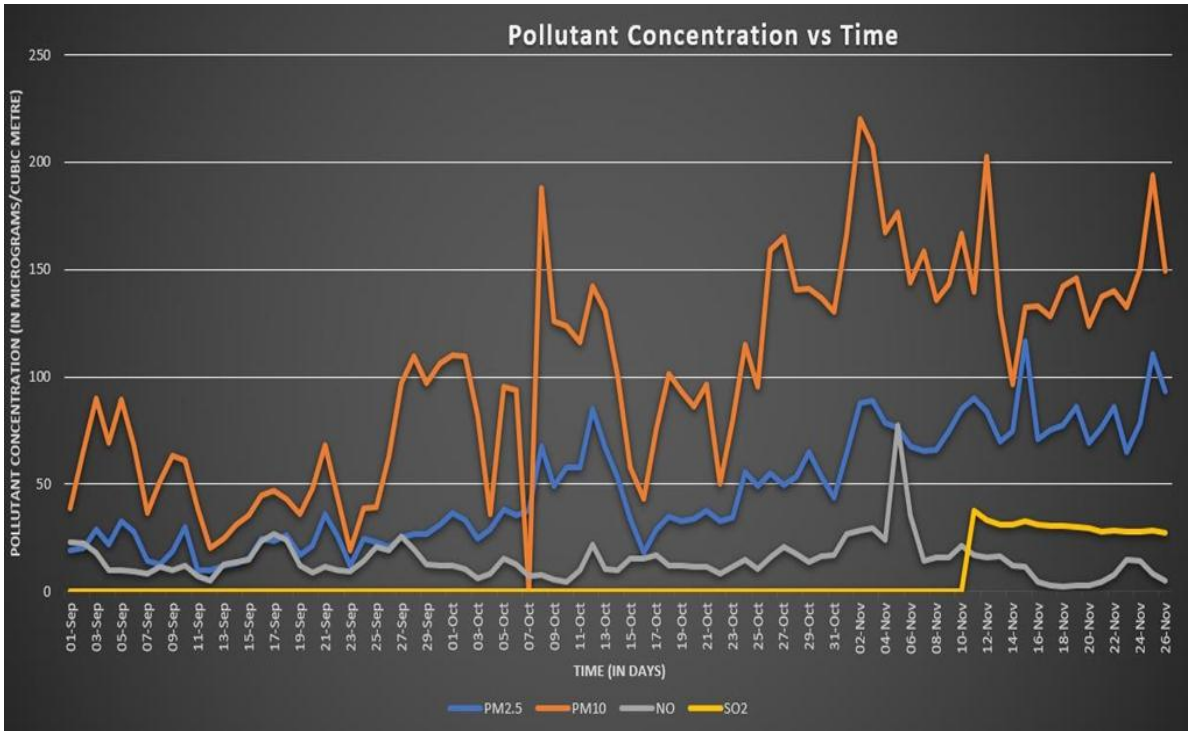
Keywords: Air Pollution, Noise Pollution, Neighborhood, Community, Study.

Current situation of pandemic has put spot light on the discussion of pollution. The very initial days of the lockdown saw record dips in the air pollution levels in major cities with clear skies and canals making international headlines. This compels us to question about the condition of our own locality. So, to learn and understand the real situation, the next logical step would be to measure and analyze pollution in our communities. Air pollution is a result of natural processes and human activities. Volcanic eruptions lead to the release of considerable amounts of gases like Sulphur dioxide, nitrogen dioxide, carbon monoxide, etc. Also, forest fires or grass fires lead to a lot of smoke and soot in the air. Although the very recent forest fires was a result of human carelessness. However, these cases are very few in number compared to the unstoppable air pollution caused due to burning of fossil fuels and vehicles. While the country's capital secures its place as one of the most air polluted cities it has become irrefutable that the rate of pollution caused by human activities is causing irreparable damage to nature.

Air pollutants could be broadly classified into primary and secondary pollutants. The first category includes compounds like Sulphur dioxide, Nitrogen dioxide, Carbon dioxide and Particulate Matter. Examples of secondary pollutants are Ozone and photochemical smog; these are a result of chemical reactions between primary pollutants. The quest to discover and decipher what contributes to the overall well-being of a locality has led to the study of two areas in particular. This evaluation has focused its attention towards two kinds of pollution viz. air pollution and noise pollution in two neighbourhoods namely Khadakpada circle, Kalyan west and Raunak city, Kalyan west. Khadakpada circle is one of the well-developed regions of what people call New Kalyan. The name itself highlights the most significant trait of it being an intersection of four roads. Another notable feature of Khadakpada Circle is that it is a part of the "Ring Route". This route sees major inflow and outflow of traffic encircling the City of Kalyan. On the other side, Raunak city is a rather quiet neighborhood with low vehicular density but with some ongoing construction activity.

The main concern was the concentration of primary pollutants because secondary pollutants have not been observed in both the neighborhoods. The two neighborhoods have been categorized into commercial area for Khadakpada circle and residential area for Raunak city. This categorization helped the application of standard limits of pollution on the collected data. Readings were procured from over 9 days for noise pollution and 87 days for air pollution The Air pollutant concentrations in the study were procured in real- time as it was made available on the website of Central Pollution Control Board (CPCB). Four main parameters that were selected for the analysis are Sulphur dioxide, Nitric oxide, $PM_{2.5}$ and PM_{10}. There are several Air Quality Monitoring Stations setups in different regions. They usually collect data and send them to remote servers. Then these huge sets of data are tabulated and made available on official websites. The air quality monitoring station nearest to the area of study is the MPCB RO Kalyan Office.

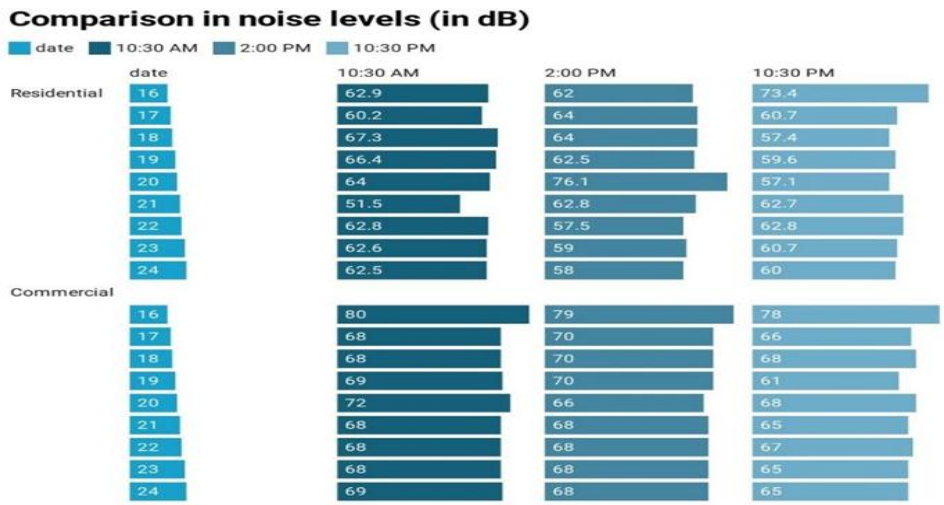


Air pollutants of four kinds have been depicted in the first figure above. Each line in the graph corresponds to a different colour denoting particular pollutants. Over the time starting from 1 September to 26 November, temperatures have been decreasing. The gradual rise in Concentration levels of Particulate Matters of sizes

2.5 microns and 10 microns can be seen from second week of October (i.e. around 6th October). Standard limits of concentration levels according to CPCB for $PM_{2.5}$ and PM_{10} are 60 $\mu g/m^3$ and 100 $\mu g/m^3$ respectively. Clearly, the graph in the first figure shows that particulate matter concentration levels have been surpassed well above declared limits.

The Concentration level of Nitric oxide (NO) has shown a steady trend over the time. NO usually oxidizes in the atmosphere to form Nitrogen dioxide which is an important ingredient of photochemical smog. Natural processes of microbial activity also release nitrogen oxides to a small extent. But irrespective of its sources, the concentration levels have remained well within limits and hence poses little to no risk.

The last one on the list of considered pollutants that is the Sulphur dioxide has shown an interesting trend. The concentration of Sulphur dioxide in the atmosphere was zero till the first week of November. With the onset of firecracker sales during the second week of November, the concentration levels showed a sharp peak around10th of November but are fortunately within standard limits of 80 $\mu g/m^3$. While in the last week of November and there is no firecracker bursting, the Sulphur dioxide levels have still remained the same. This could be attributed to the fact that lower temperatures tend to keep the pollutants in the Troposphere for a longer time. The rise in concentration of PM in the area can be associated to the drop in temperatures starting from the month of October because cold climates have historically shown rise in pollution.

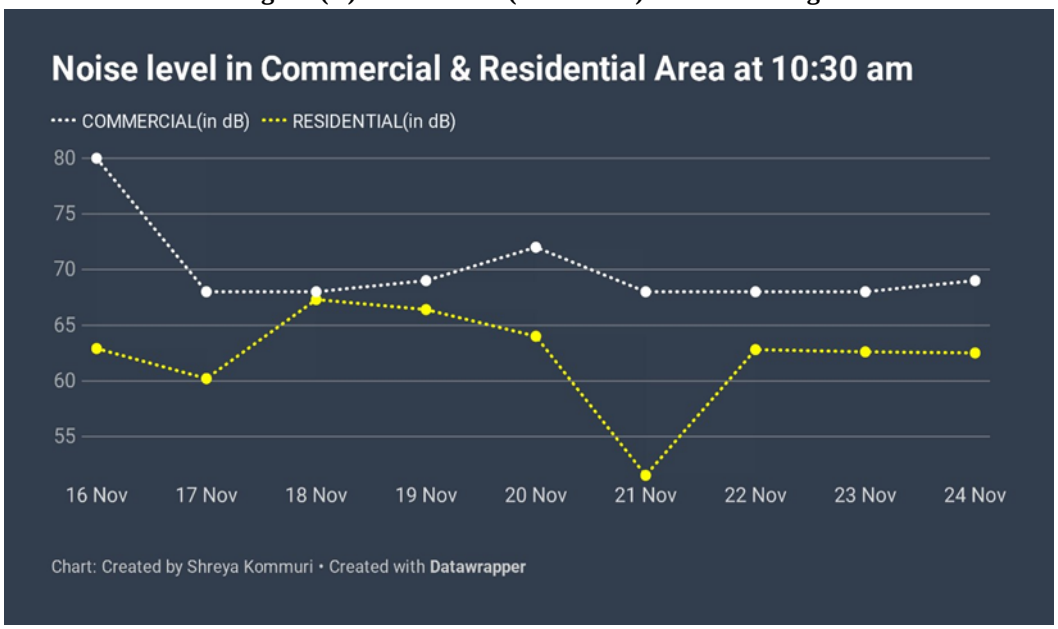


Noise pollution has been an underestimated threat for a long time because of its sheer unsuspecting nature. People tend to become used to exposure of moderate to high levels of noises. The dangers to continued exposure leads to decreased hearing capability over the course of time. The sound decibel levels in the study have been aggregated from real ground-based monitoring. The sound was measured three times in a day with the help of an app called NIOSH SLM. Noise Levels that have been categorized into Commercial and Residential areas as depicted in the second figure for three times in a day for nine days. Readings for 8 am and 10:30 am are considered in the day time bracket while 10:30 pm is considered in the night time bracket.

Much difference was not observed in the decibels level for morning and afternoon times. The daytime allowed a decibel level in residential area is 55 dB while it is 65dB in Commercial area. But the startling observation is the consistent high decibel levels even at 10:30 pm because the standard limits are 45 dB and 55 dB in residential and commercial areas respectively. The commercial area that has been considered is Khadakpada chowk has a children's hospital under a radius of 50 m from the crossroad (chowk). Also, the nursing home is adjacent to one of the busiest roads in the area. Decibels levels here range from 60 to 70 all throughout the day.

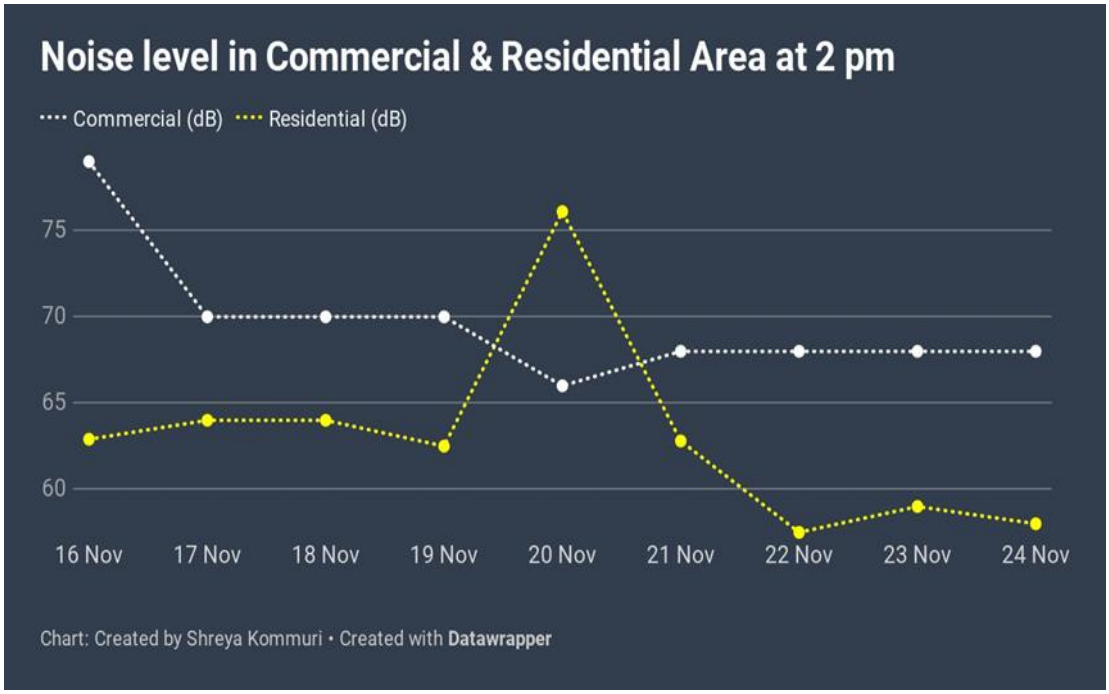
Now, comparing the neighborhoods for individual times would be the next sensible observation. All three figures below show decibel levels for different times while comparing data for residential and commercial areas simultaneously.

Figure (A) Noise levels (in decibels) in the morning



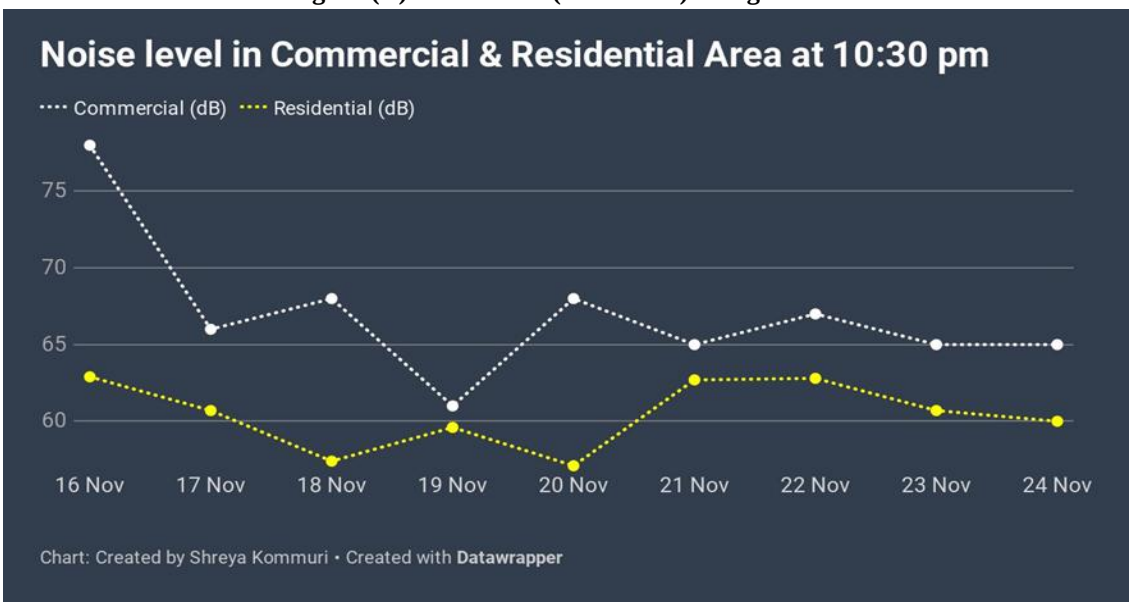
The initial peaks around 16 November are prominent as it was the last day of a three-day festival. This peak was only temporary and decreased within 2-3 days. Other than few outliers, the trend was almost constant for all three times in a day. In figure A, that is at 10:30 am, the range for residential area is 60 – 62 dB while the range is 68 – 69 dB for Commercial area.

Figure (B) Noise levels (in decibels) in the Afternoon



In figure B that is at 2 pm the range for residential area is 58 – 64 dB while the range is 68 – 70 dB for Commercial area.

Figure (C) Noise levels (in decibels) at night-time



In figure C, which is at 10:30 pm, the range for residential area is 57 – 62 dB while the range is 65 – 68 dB for Commercial area.

The most striking and prominent revelation during the study was the utter disregard of the concept of silence zones in the area. Clear violation of norms set by the MPCB for the construction of hospitals is observed. Also, the region of Kalyan was completely skipped from the section of "REGIONAL ENVIRONMENTAL PROBLEMS and CONTROL MEASURES TAKEN IN RESPECTIVE REGIONS" in the annual report 2018-2019. Therefore, to understand about current issues and action plans, the annual report of 2017 – 2018 had to be referred. Issues stated in this report regarding air and noise pollution do not pertain to the area of study. Regardless of area, the report states about strict compliance of techniques and technologies included in APC (Advanced process control) systems. Even though the graphs mentioned above show that the decibel levels in both neighborhoods exceed permissible limits provided in Noise Pollution (R & C) Rules, 2000 amendment dated (21st April, 2009), no such documented action has been mentioned.

The totality of data presented above and the important conclusions drawn, were made at a time of partial lockdown. All colleges, schools and major workplaces were shut during the period of study. Thus, the possibility of all these numbers being much higher than presented, cannot be overlooked. Increase in air pollution and noise pollution ruin the quality of life in a community. A healthy community is an essential part of any society because small units come together to lead big changes. Therefore, when these communities become aware about the pollution in their localities, implementation of control measures becomes much easier.

Numerous air quality monitoring stations have been setup in the city and all the data is available online on respective websites. But the lack of awareness of the results of this data among common people is the issue. So, if Local authorities and NGO's put up illustrative posters around the localities and instruct co-operative housing societies to conduct seminars, this situation could improve. Offering reasonable incentives can encourage residents to participate. Also penalizing violators with heavy fines helps deter others from harming the peace and wellbeing of the community.

MODERN PHYSICS AND MEDICAL DIAGNOSTICS

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Key words: Technetium-99m, Radioactive Tracers, Nuclear Medicine and Medical Physics.

"When you change the way, you look at things, the things you look at, change."
Max Planck

Introduction

We are living in the century of science and technology which is changing rapidly. Being one of the oldest and most fundamental scientific disciplines, physics can be considered as the backbone of science, before going into details and facts we must have an understanding that what is physics and what is its main goal is, so we can define the physics as follows:

"Physics is a branch of science that studies matter, its fundamental constituents, its motion and behavior through the space and time."

The main goal of physics is to understand and explain how this universe behaves.

In this modern era physics is as vital and important for the field of science as water for the human body. If we look around us, we can easily find out that how very simple and concise laws of physics operating this huge machinery from which our whole universe is consist of, ranging from subatomic level to the vast galaxies with the length of thousands of light years. Physics is the language of this universe; the range of its applications is countless; with the help of physics, we can explain the motion of a pendulum and the time delay near a massive object such as black hole.

Here we are going to talk about how physics plays a major role in the field of medical. The branch of physics which is related to prevention, diagnosis and treatment of human diseases is known as Medical Physics'. We can define the Medical Physics as follows:

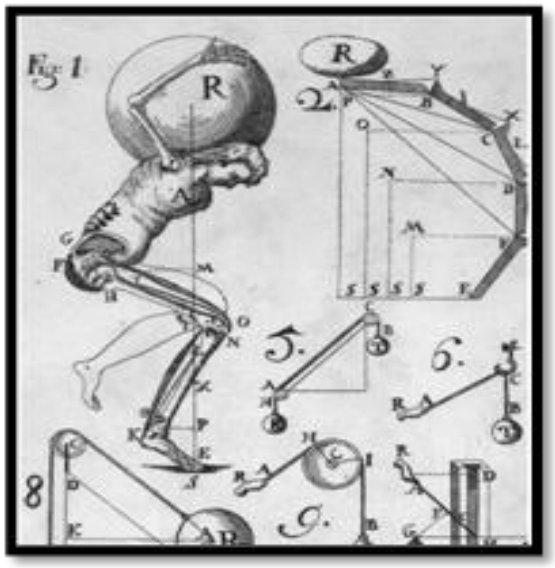

Figure 1: Image Credit: physicamedica.com
A European Journal of Medical Physics

"Medical Physics is a branch of physics that uses principle, theories and applications of physics to detect and cure diseases"

A Brief History of Medical Physics: - The traces of links between physics and medicine can be found in some of the oldest intelligent civilizations. An old document from ancient Egypt contains information about the medical use of physics. Greek physician Hippocrates mentioned in one of its writings that how skin temperature distribution could be measured by using wet clay. 'Herophilus' also regarded as the 'Great Greek Physician' had measured the pulse rate using a water clock

Later an Arabic scholar had shown that human eyes is simply the receiver of light and doesn't emit any beam of energy or particle as some Greek philosophers and scientist had imagined. Some great work related to medical physics came from an Italian physicist Giovanni Borelli, who was the first ever person to place mechanistic ideas to describe the motion of human body. In the above image we can clearly see that how Borelli described the motion of human spine as well as other body parts in terms of physical quantities.

The origin of medical use of modern physics dated old as the discovery of X rays, in the year 1895 the great German physicist and engineer Dr. W.C. Roentgen discovered a new type of radiation while experimenting with cathode rays. Later he realized that it could pass through the opaque objects as well as the human tissue too. Because of this property of X-ray, it could be used in rendering the bones and tissues beneath it. After a year of discovery, the doctors in Europe and U.S. were using X-rays to locate bone fracture, bullets, and stones in human kidney.

The next big turn come in the field of medical physics with the phenomenal work of Rosalyn Yalow who developed a technique known as the 'Radioimmunoassay' through this extremely sensitive and precise technique physician could measure the tiny amount of biological substances with the help of the radioactive materials.

Some other big steps in the direction of medical physics are the invention of 'Computer-assisted tomography' (CT scan) by Allan M Cormack and Godfrey Newbold Hounsfield in 1979, and the invention of **'Magnetic Resonance Imaging'** technique by Paul Lauterbur and Peter Mansfield, this invention later awarded by the Nobel Prize in medicine.

Different Types of Medical Diagnostic Tools: There are number of medical diagnostic tools based on the principles of physics such as X-ray, CT scan, MRI, and Nuclear Medicine etc.

Here we are going to talk about a special branch of medical physics known as **'Nuclear Medicine.'**

As we can easily understand by name 'Nuclear Medicine' is the method of cure, diagnose or detect a

disease in which we use very small amounts of radioactive materials, or radiopharmaceuticals.

These radioactive materials also known as radiotracers, typically in the procedure of nuclear medicine swallowed or injected in the blood stream then the radioactive substance travels through the area which is being examined and releases the energy in the form of gamma rays which can be easily detected by a special camera known as gamma camera.

After capturing all the images with the help of the camera, we use special computers and software to create 3D images of the interior of the subject.

The process mentioned above is known as 'Nuclear Imaging'. Nuclear imaging provides us some unique information which cannot be obtained by using traditional methods of imaging; also we can detect or cure a serious disease at its earlier stages with the help of nuclear medicines.

Evolution of Nuclear Medicine: Nuclear medicine has a long history in which many prestigious scientists, physicists, chemists, and engineers have contributed.

It is difficult to determine a precise origin of this amazing field, but many scientists and researchers believe that the birth of this field occurred somewhere between 1934, the year in which 'Frederic Joliot-Curie' and 'Irene Joliot Curie' discovered the phenomenon known as artificial radioactivity.

However according to some historians and scientists this remarkable medical idea originated somewhere in mid 1920's by famous Hungarian radiochemist and noble laureate 'George Charles de Hevesy'.

He had done some amazing experiments on rats; with the help of radionuclides, he displayed the metabolic pathways of rats, and we can say that he was the first who established the tracer principle in the field of nuclear medicine.

Technetium-99 known as Technetium-99m. This discovery can be stated as a milestone in the field of nuclear medicine because Technitium-99m is the first tracer which can be easily traced by the gamma camera. Even today, Technetium-99m is the most used element in this field.

In May, 1946 Dr. Saul Hertz and Dr. Arthur Roberts published a paper titled as "Radioactive iodine in the study of thyroid physiology; the use of radioactive iodine therapy in hyperthyroidism" in 'Journal of the American Medical Association' in this paper they described how radioactive iodine could be used to treat Grave's Disease.

By the early 1950s American physicist 'Benedict Cassen' invented an imaging device which could be used to capture the energy emission due to the radiopharmaceuticals, but the breathtaking discovery came from a American biophysicist and electrical engineer named as 'Hal O. Anger', he built a camera which could capture the gamma radiation. Today this camera is known as 'Anger Camera' over his name.

By the year 1960 scientist developed a technique in which they used xenon-133 with the help of this phenomenal idea they were successful in drawing the blood flow map of human brain, and by the end of the 1970 most of human organs and their working cycle could be visualized using nuclear imaging techniques.

Nuclear Medicine in India: The origin of nuclear medicine in India lies in the roots of development of nuclear reactors. In 1954 Dr. Homi J. Bhabha also regarded as 'Father of Indian Nuclear Program' established AEET (Atomic Energy Establishment, Trombay). The first two nuclear reactors of India, APSARA and CIRUS become operational respectively in year 1956 and 1960. This led us to the production as well as the availability of many radioactive elements with several medical uses. In 1958 the first field unit of radiation cell was established at Safdarjung Hospital, New Delhi.

Because of extraordinary efforts of Dr. Bhabha and hard work of our scientists as well as the support provided by Indian government and many other major contributors such as BARC and BRIT, today India is one of the leading countries in the field of nuclear medicine.

Treatment Procedure: We can divide the nuclear medicine in the three parts which are as follows:

I. Tracer (Also known as Radiopharmaceuticals)
II. Receiver or Detector (A gamma Camera)
III. Data Analyzer (A set of unique computers and software to analyze data received by detector)

Tracer: Tiny amount of radioactive substance which is used during the procedure of nuclear medicine to guild the exam is known as radioactive tracer or radiopharmaceutical. Human tissues absorb this radioactive substance then the radioactive material start giving off energy in form of gamma radiation which later studied by a gamma camera.

Radiotracer works like the messenger of internal human body by studying the behavior of these tracers, the healthcare provider can diagnose and cure many serious diseases such as cancer, tumor, infections, hematomas, and organ enlargement etc.

The distribution of radio tracer can be different in the human body, the areas with greater amount of absorption is called 'hot spot' and the areas which do not amount the radionuclide or absorb less amount of it is referred as 'cold spots.

Many elements can be used as the radioactive tracers, isotopes of gallium, iodine, xenon, thallium, and technetium are the most used elements.

Technetium-^{99}m, which is denoted as ^{99}mTc, is a metastable nuclear isomer of element Technetium.

Technetium-99m is the most used medical radiotracer in the world; here we are going to talk about its working, production, and some precautions which one should have to obey while using this radiotracer.

So, firstly we are going to talk about the working, $^{99}mTc_{43}$ is swallowed, injected, or inhaled by the patient. Now being a metastable (i.e., excited state of an atom) the $^{99}mTc_{43}$ has a half-life of only 6 hours, it will quickly decay in $^{99}Tc_{43}$ and gamma radiation. This process can be easily understood by the following reaction.

$$^{99m}_{43}\text{Tc} \longrightarrow {}^{99}_{43}\text{Tc} + {}^{0}_{0}\text{y}$$

After this decay we get the $^{99m}_{43}\text{Tc} \longrightarrow {}^{99}_{43}\text{Tc} + {}^{0}_{0}\text{y}$ which has a halflife of ~25000 year which means it is very stable.

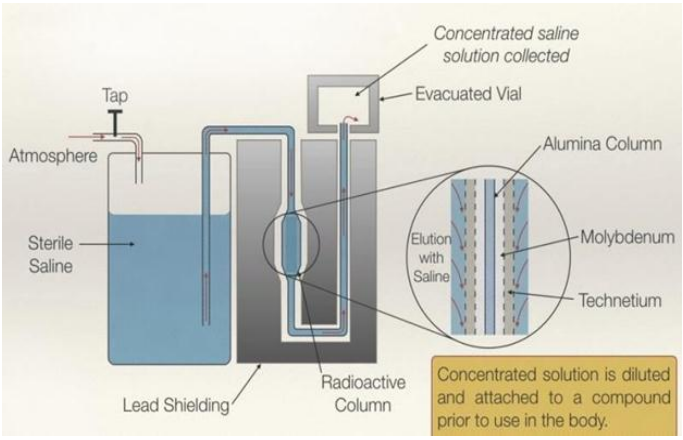

Figure 2: Production of 99m/43Tc at hospitals
Image credit: Youtube.com

Because $^{99}m/43Tc$ has a half-life of about 6 hours it is need to produce on site (hospital) or very near the site.

It is produced by the decay of molybdenum. In molybdenum – technetium generator system, molybdenum is parent radionuclide. The general principle for such kind of generator system is that a daughter nuclide with short half-life can be easily isolated from a parent nuclide which has a long half-life.

The major requirement to obtain technetium from molybdenum is that the, molybdenum must be in pure form. There are two reliable and low in cost method to get good quality molybdenum, one of them is by separation of the material of the fission products of uranium the other one is from neutron activation of cold molybdenum. After getting pure molybdenum we produce technetium with the help of above machinery mentioned in the figure – 2.

The whole apparatus has a protection layer of lead so that the workers or hospital staff don't get any fatal dose of radiation.

By the reaction mentioned below we get technetium from molybdenum.

$$^{99}_{42}Mo \rightarrow {}^{99m}_{43}Tc + {}^{0}_{-1}\beta$$

Radiotracer works like the messenger of internal human body by studying the behavior of these tracers, the healthcare provider can diagnose and cure many serious diseases such as cancer, tumor, infections, hematomas, and organ enlargement.

So, in the above reaction we can cleary see that the molybdenum decays in technetium-99m and beta particle.

If we look at figure no.3, we can figure out that how the cycle of this generator system works. This diagram is known as 'Decay energy Level Diagram'. This diagram can be constructed by using energy scale and tabular data.

Here in graph we see that peak activity of technetium occurs at ~ 22-23 hours

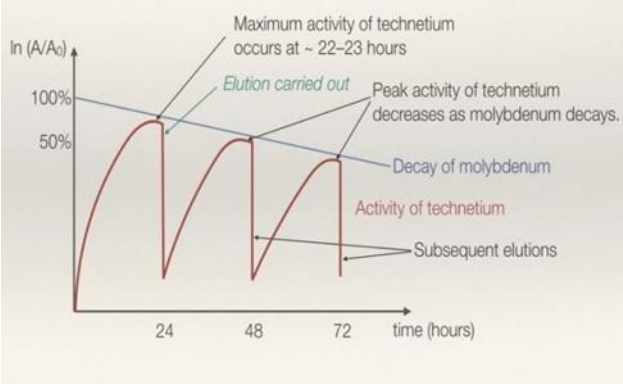

Figure 3: Decay Energy Level Diagram Image credit: Youtube.com

Receiver or Detector (Gamma Camera): A gamma camera is device which is used by the radiologist to detect the gamma radiation emitted from a radiopharmaceuticals. The gamma camera also known as scintillation camera utilizes the principle of scintillon.

We can divide the 'Gamma Camera' in three parts, collimator, scintillator, and photomultiplier.

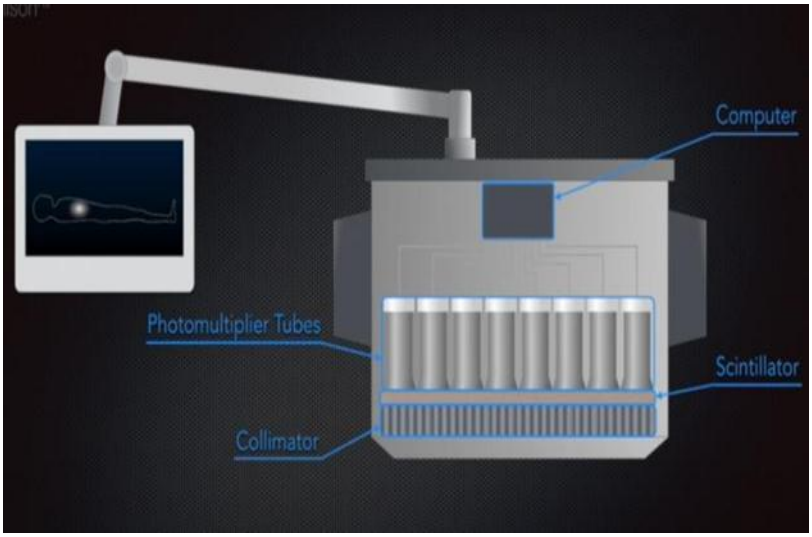

Figure 4: Gamma Camera, Credit: Youtube.com

The collimator is the first part of gamma camera. These are basically hollow lead tubes which confirms that only parallel rays reach to the scintillator because if the unparallel rays reached then it is difficult to find the origin of gamma rays which could lead to wrong image formation.

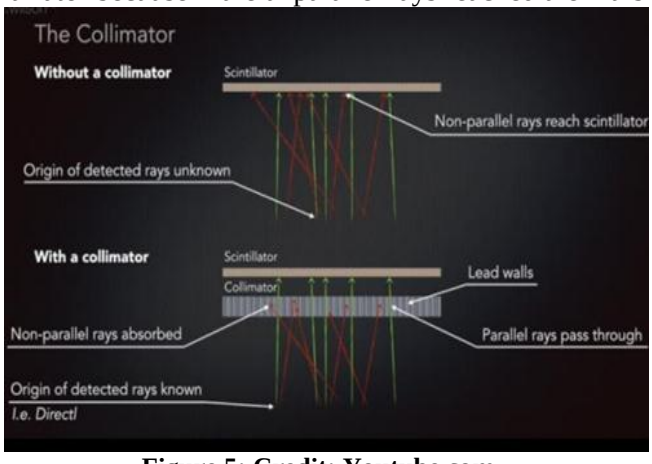

Figure 5: Credit: Youtube.com

After passing through the collimator the gamma radiation reaches to the scintillator which converts it into visible light.

Due to the abortion of energy, there occurs creation of primary electron hole pair which generates secondary pair due to the 'cascade effect'. After this comes the stage of thermalization, after this stage the free electron hole pair migrate through the material, and they transfer their energy to luminescent centers present in the scintillator material. This energy transfer is very quick and takes merely 10-12 to 10-8 second to be completed. After this energy transfer comes the stage of scintillation, in which, visible light photon emitted by the scintillator.

Here we must remember that the energy of an emitted photon is an important parameter through which we can differentiate between different kinds of radio isotopes.

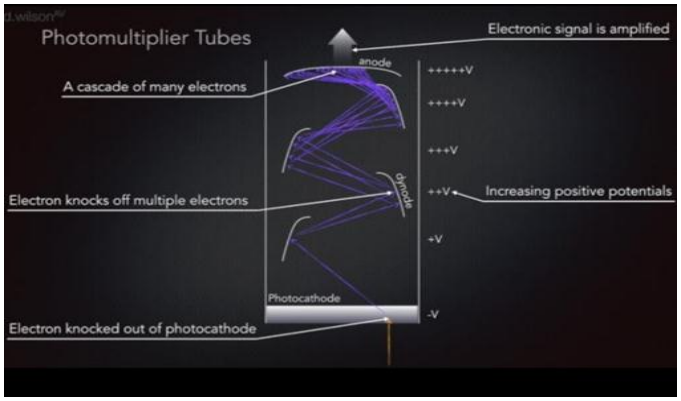

Figure 6: Photomultiplier, Credit: Youtube.com

After this the emitted photon reached inside a photomultiplier tube here, they descended upon a photocathode. Photocathode works on the principle of 'Photoelectric effect'.
The photocathode converts these photons of visible light in electric pulses.

Now these electric pulses received by the computer and by the help of these signal computer generates pictures.

Data Analyzer: After collecting data from a receiver (A rectilinear scanner of gamma camera) we stacked the images or scan slices either by using analytic algorithms or by iterative algorithms.
Generally the radiologist and physician prefer the iterative method because it has a unique property that correction can be made in all physical quantities and transport of gamma rays can be mathematically modeled.
There are some important parameters for image processing as mentioned below:

- Filtering
- Motion Correction
- Attenuation Correction
- Normal Database
- Volume Fraction Calculation

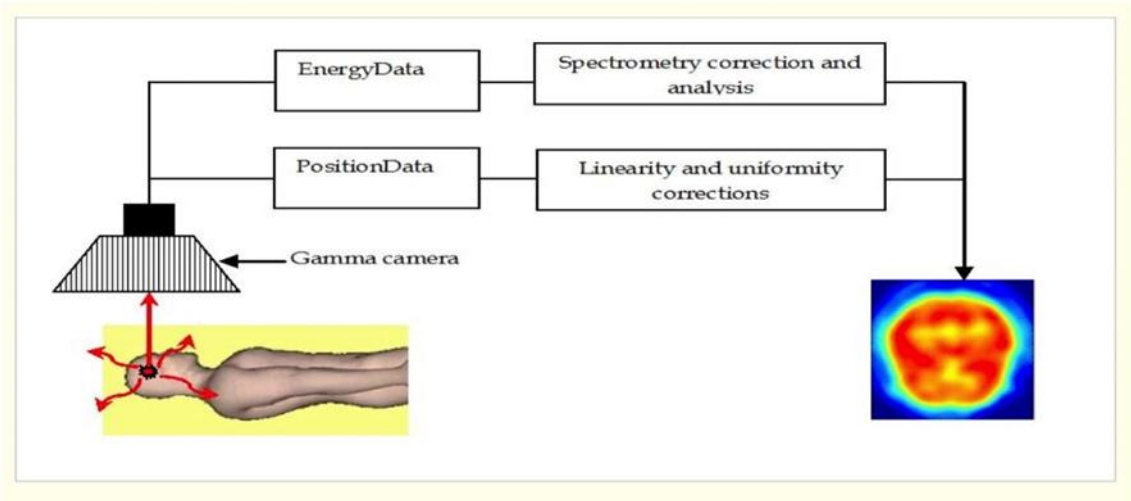

Figure7: working of a computer (Data Analyzer) Credit: Intechopen

This diagram defines that how the image processing works.

Clinicals Applications of Nuclear Medicine: In Nuclear Medicine we use scans to diagnose any disease.
Some of the most common scans are as following:

• **Brain Scan:** Brain scan is used to monitor the blood circulation of brain, investigate tumors inside brain, detect swelling and any other abnormality.

• **Gallium Scan:** To diagnose tumors, active infections and inflammatory diseases.

• **Heart Scan:** In identifying abnormal blood flow to the heart, determine the damage of heart tissues

after a serious heart attack or to measure the heart function.

• **Renal Scans:** To detect the abnormalities in the renal blood flow.

• **Thyroid and Bone Scans:** Both these scans are used to diagnose the disease related to thyroid and bones respectively.

Some major protocols during a Nuclear Imaging Process:

• The patient can not wear any type of jewelry because it can interfere with the procedure also have to wear a special type of gown which is provided on site.

• The patient will be connected to a ECG machine to monitor his blood pressure as well as his/her other vitals.
• Patients are advised to remain as still as they can to avoid blurring in images.
• Patients may be asked to change positions to get clear and more precise images of affected area or tissue.

Government's Guidelines to Operate Nuclear Medicine Facilities in India: There are some common safety measures which have to be followed by every nuclear medicine facility to ensure safety:
• Minimum furniture should be used.
• Top surfaces of work tables have a smooth laminated finish.
• Remote handing devices should be provided to working staff.
• Ventitalated fume hoods for handing large dose of radiation.
• All the drainage ducts, sinks and toilets should be connected to sanitary facility.

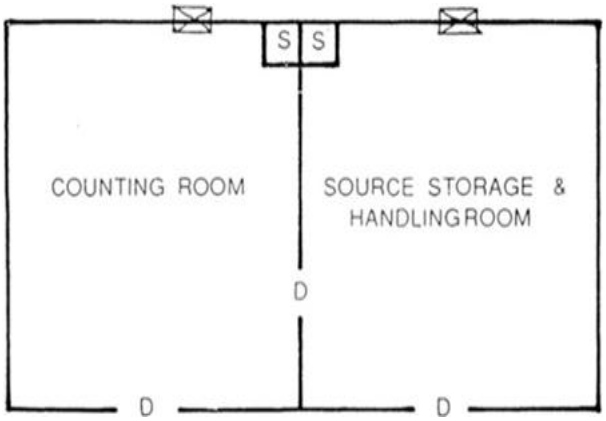

Figure 8: Credit: inis.iaea.org

Category 2: Laborites carrying out radiolabelling of ligands with preparations of kits and using them for in- vitro radioassays. This facility should have the total area ~50m^2

Figure shows the typical design plan for Category 2 lab.

Categories of Nuclear Medicine Labs: We divide the nuclear medicine facilities in 4 categories on the basis of different types of procedure carried out by them.

Category 1: Labs which are performing in- vitro radioassays with ready to use kits.

This Figure shows us how a category-1 lab should be designed according to the Government of India.

This facility have total area ~30 m^2

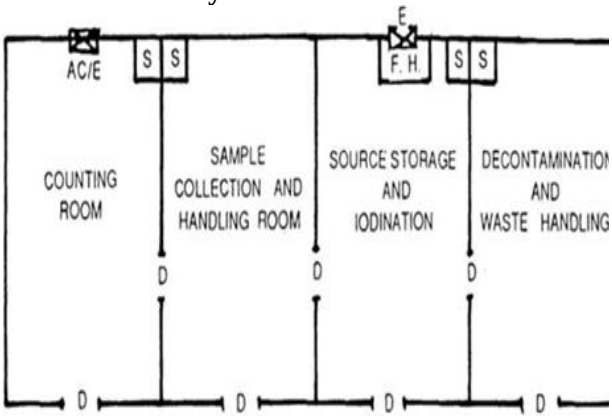

Figure 9: Credit: inis.iaea.org

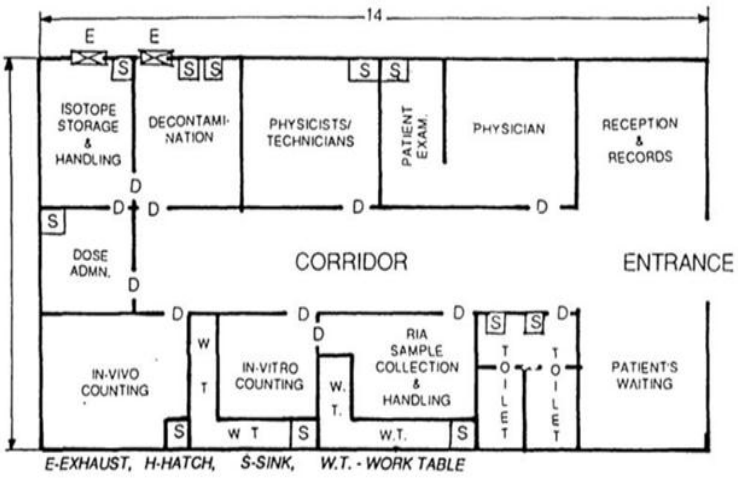

Figure 10: Credit: inis.iaea.org

Category 3: Laboratories performing in- vivo non imaging procedures and in- vitro assays.

This lab have a total area of ~100m^2

Figure shows the layout of a category 3, Nuclear medicine facility.

Category 4: Same as category 3, but this lab also performs some additional experiments such as, in-vivo static and dynamic imaging procedure.

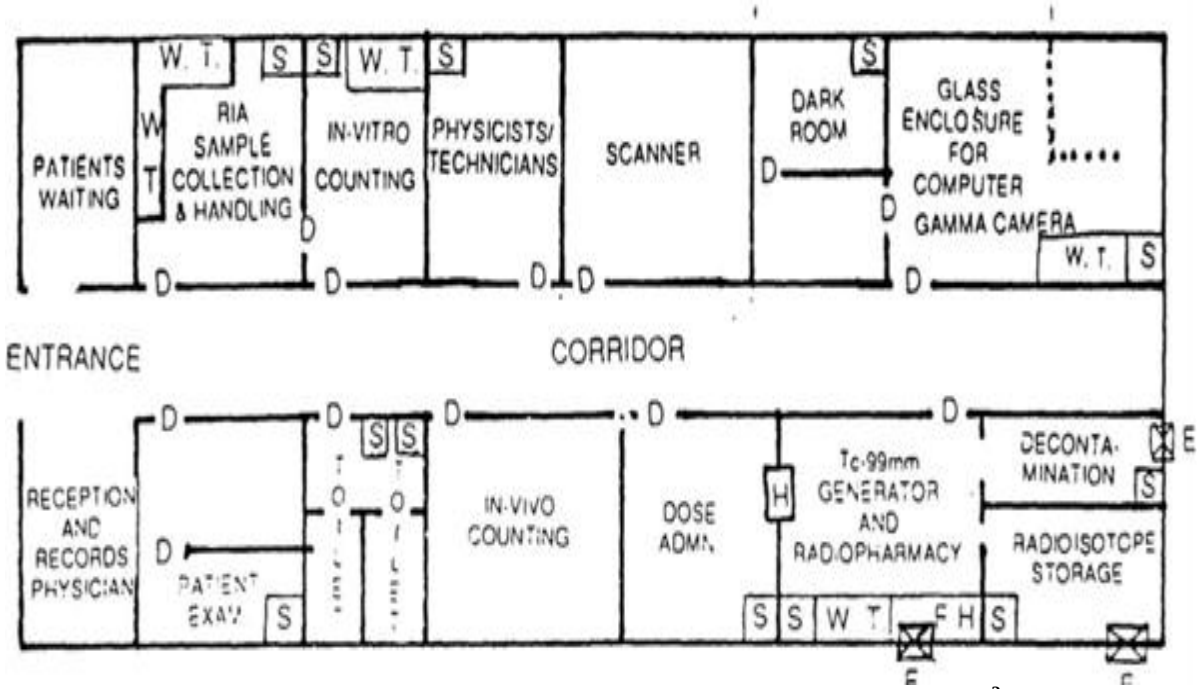

Figure 11: Layout of category 4 Lab. This lab has total area: ~200m^2
Credit: inis.iaea.org

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MODERN PHYSICS AND MEDICAL DIAGNOSTICS

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Brief Introduction to the Topic

- Modern physics is an effort to understand the underlying processes of the interactions of matter utilizing the tools of science & engineering.
- Many remarkable **medical** technologies, **diagnostic** tools, and treatment methods have emerged as a result of **modern** physics discoveries in the last century-including X-rays, radiation treatment, laser surgery, high-resolution ultrasound scans, computerized tomography (CT) scans, and magnetic resonance imaging. Doppler ultrasound, echocardiography, MRI and the operation of ventilator machines.

LASER IN MEDICAL FIELD

What is a Laser?

- Laser is an acronym for "Light amplification by stimulated emission of radiation". Laser is a device that stimulates atoms or molecules to emit light at a particular wavelength then it amplifies the light, producing a narrow beam of light.

- Laser emissions generally cover an extremely limited range of visible, infrared or ultraviolet wavelengths.
- **Three key characteristics about a laser are:**

1. The beam of the laser is collimated; hence it focuses only on a small area. (Collimate- To make all the rays of light parallel to each other).

2. The beam of radiation from the laser is usually monochromatic, i.e., Red, Green or Invisible.

3. In a laser, the crests are lined up with crests of other waves, similarly for troughs. This is because the light waves are coherent **(Two waves are said to be coherent if they are produced from the same source and maintain a constant phase difference)** in nature and in phase with each other.

- Due to the tight beam, laser can concentrate light over a small area and can also produce a heating effect. This characteristic distinguishes lasers from torch. In a torch, the light spreads over a wide area because the light is neither coherent nor does it have a constant phase difference.

How does Laser work?

- For a Laser to work we require an **Active laser medium** which is a source of optical gain within a laser. This lasing medium consists of a large number of atoms which in turn contain electrons. If we apply a lot of energy to the atom, the electrons in the atom leave the ground state and enter an excited state. The level of excitation depends on the amount of energy that is applied to the atom via heat, light, or electricity.
- The lasing material may be solid, liquid, gas or even a semiconductor.

- To raise the electrons from the ground state to an excited state, we require devices that can provide enough energy to raise the electrons. This energy can be provided by optical pumps.
- Optical Pumping is a process in which a light source is used to raise the electrons from the low energy level to an excited state. For optical pumping, the following sources can be used Flash Tubes, Discharge diodes, laser diodes or another laser. The most commonly used one is a Flashtube, these are made of a length of glass tubing with electrodes at either end and are filled with a gas that, when triggered, ionizes and conducts a high voltage pulse to produce the light.
- The process of optical pumping is often used in laser construction to bring about population inversion**

****Population Inversion:**

- Population inversion means, due to optical pumping the low energy atoms get excited and hence they jump to higher energy level due to which now the system has a higher proportion of high energy level atoms.
- Once an electron goes to a higher energy orbit it has to return to its ground state, this is done by releasing energy in the form of a photon.
- Once the lasing medium is pumped, the electrons present in the atoms, get excited and enter into higher energy level. This energy can then be released in the form of a photon. When an incoming photon of the same frequency/energy as that of the electron interacts with it, it leads to the production of a tight beam of radiation due to stimulated emission**.

****Stimulated Emission –**

- When an incoming photon of a certain frequency/energy interacts with an excited electron of the same frequency/energy it leads to the release of radiation followed by the electron dropping to a lower energy level. In the case of a laser, there are many electrons in the excited state (at higher energy level) these leads to a chain reaction where radiation from one atom stimulates another, hence forming a beam of radiation of a single wavelength called 'laser.'

- Only if stimulated emission occurs laser will have the three properties:
  I. It is coherent.
  II. It is coherent.
  III. It is very directional and can span a long distance.

The different types of lasers are:

1. Solid-state lasers-A kind of laser in which the lasing material is distributed in a solid matrix and leads to an infrared light emission.

2. Dye Lasers-They use complex organic dyes (like Rhoda-mine) and can emit a wide range of wavelengths.

3. Gas lasers-a lasering in which electric discharge is through a gas medium and have a primary output of visible red light.

Further, there are other types of lasers as well that include, Semiconductor lasers, Excimer lasers etc.

Where in Medical fields are lasers used?

Ever since lasers were discovered it brought about a massive paradigm shift. Many diseases which were deemed uncurable, the invention of lasers brought about a new beacon of hope. Lasers started having many new applications in the medical field. And in the medical field it is not limited to cutting and coagulation of tissues in surgeries it is also often used in dentistry

for curing fillings and hence strengthening the bond. Hence, as conclusion lasers are one of the most utilitarian devices in the medical practice.
A few applications of laser technology that will be mentioned here are:

A. Angioplasty
B. Cancer Treatment
C. LASIK
D. Dentistry
E. Lithotripsy
F. Microscopy

ANGIOPLASTY

What is Angioplasty?

- In the term angioplasty, "angio" refers to blood vessel and "plasty" means opening up.

- Angioplasty, also known as percutaneous transluminal angioplasty (PTA), is a procedure used to widen narrowed or obstructed arteries or veins, typically to treat coronary heart disease, where the arteries in your heart are narrowed or obstructed by a sticky material called plaque.

- Due to a heart attack, the plaque in the artery may rupture causing the cholesterol to spill into the artery that can form a clot which might hinder the blood flow.

Tools used in laser angioplasty

1. A fibre-optic catheter.

2. A laser is attached to the tip of the catheter.

How it works
Laser angioplasty also referred to as excimer** laser coronary angioplasty is a technique that is used to clear the plaque and hence clear the artery. It comprises a fibre-optic catheter with a laser at its tip which is then inserted into the artery then is advanced through the artery till it reaches the blockage. When the laser is perfectly positioned, the laser emits the directional beam of light to disintegrate and further vaporize the plaque.
Laser Angioplasty is advantageous over balloon angioplasty **(This is a procedure where a balloon is attached at the tip of the catheter and then advances through the artery till it reaches the area of the plaque. Then the balloon is inflated to displace or compress the plaque)**, as laser angioplasty directly vaporizes the plaque, unlike balloon angioplasty where the plaque material is compressed or displaced.

**The Laser used here is EXCIMER Laser. Excimer Laser is made of reactive gases like chlorine and fluorine mixed with inert gases like xenon or krypton. When electrically stimulated it forms a pseudo molecule that produces an output of ultraviolet light.

CANCER TREATMENT

What is Cancer?

- Normally, human cells divide by cell division, to form new cells. Sometimes, when this orderly process is disturbed, it leads to abnormal or damaged cells growth and multiplication. This leads to the formation of lump-like structures that are called tumours.
- These tumours may be cancerous or non-cancerous in nature. If the lump is non-cancerous or 'benign' the tumour won't spread into or invade other cells. But if the tumour is cancerous, then it may spread into different parts of the body and can cause serious symptoms and at times even death.

How to treat Cancer

Since Cancer is mainly caused due to a tumour, usually removing the tumour can help in treating cancer. But the removal of the tumour doesn't reassure that the Cancer won't come back, it might return at the same place it started or may occur in a new place in the body.

How Laser works in Cancer treatment

Laser therapy uses a very narrow, focused beam of light to shrink or destroy cancer cells. It can be used to cut out tumours without damaging other tissue. Laser therapy is often given through a thin, lighted tube that is put inside the body. Thin fibres at the end of the tube direct the light at the cancer cells. Lasers are often used along with other types of cancer treatment like chemotherapy, radiation therapy etc.

Most commonly used types of lasers

1. **CO_2 Lasers:** CO_2 lasers release an infrared beam of light; the CO_2 laser can cut or vaporize the tumour with little bleeding and reduced damage. This laser does very little damage to the surrounding cells. This laser is usually used to treat pre-cancerous tumours and early-stage Cancers.
2. **Argon Laser:** Argon Lasers are useful in treating skin cancers and some types of eye tumours. Argon Lasers when used with a light-sensitive drug can be used to kill cancer cells, known as photodynamic therapy (PDT)**. Apart from these, Argon lasers are also used to patch or seal the blood vessels of patients who have undergone radiation therapy. This is needed in a few cases as radiation therapy may damage the surrounding cells while trying to remove the tumour, causing them to tear and bleed.
3. **Nd:Yag lasers:** Nd:Yag lasers are also known as Neodymium: Yttrium-Aluminium-Garnet lasers. Unlike CO_2 lasers and argon lasers Nd:Yag laser can penetrate deep into the tissue and make blood clot quickly. Nd:Yag lasers can be used along with thin flexible tubes like endoscopes (A tube with light at one end used for inserting into natural openings), which are then put into a tumour and then lights heat can destroy it.

   ****What is Photodynamic Therapy?**
4. In Photodynamic Therapy, a photosensitizing agent (chemicals activated by certain types of light) is used. This photosensitizing agent is injected into the bloodstream, where the tissues absorb it over time. These agents stay in cancer cells longer than the normal cells. When these cancer cells containing the agents are exposed to lasers (argon lasers) a chemical reaction occurs which kills the cancer cells.

   Laser Therapy may be considered as a better option for Cancer because laser therapy takes less time and it is more precise while causing minimal bleeding and damages to tissues. But laser treatment tends to be on the more expensive side.

LASIK

What is LASIK?

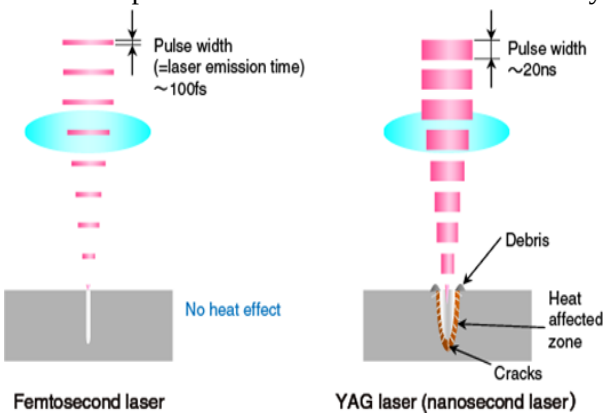
- LASIK stands for Laser In-situ Keratomileusis, the popular surgery is carried out to correct the myopic, far-sighted or astigmatic vision of people. It's one of many vision correction surgeries that work by reshaping your cornea, the clear front part of your eye so that light focuses on the retina in the back of your eye.
- When the light doesn't focus on the retina as intended to, the vision becomes blurry, often called a refractive error. This error may be myopia, hypermetropia or even astigmatism.

Tools used for LASIK

- A Femtosecond Laser, for cutting the corneal flap.
- An Excimer Laser which releases cool UV radiation for reshaping the cornea.

How does LASIK work?

To start, LASIK uses a mechanical surgical tool called Femtosecond Laser which is used to cut a thin, circular flap in the cornea. This reveals the underlying corneal stroma.



- A **Femtosecond Laser** is a laser that uses optical pulses with a duration of the order 10-15s or 1fs. When the femtosecond laser is used on the cornea, it leads to photoionization (Due to the interaction of matter with EM radiation the matter divides into electrically charged particles i.e., electrons and protons) and photodisruption (the disruption of the tissues due to rapid ionization of matter).

- Then an excimer laser is used to reshape the corneal stroma. The primary output of this laser is cool ultraviolet light to remove microscopic amounts of tissue and eventually reshape the cornea so that it more accurately focuses light on the retina for a better vision.

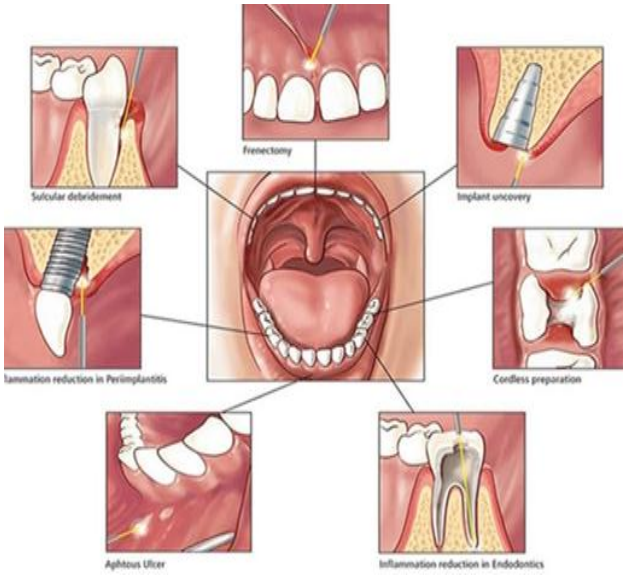
- Then the corneal flap is laid back which then adheres to the corneal stroma without surgery.

- The stroma is made of dense collagenous substance (Collagen is a sticky protein which is the most abundant kind of protein in the body), hence the flap easily sticks to the stroma.

- LASIK is advantageous because it provides 20/20 or better vision after the procedure and it is painless. With LASIK no bandages or stitches are required and enhancements in vision can easily be done in the later years.

DENTISTRY

- Dentistry is the diagnosis, treatment, and prevention of conditions, disorders, and diseases of the teeth, gums, mouth and jaw. Taking care of oral health is just as important as taking care of the whole body.



How does Laser work in Dentistry?

A laser can be used in many fields in dentistry like:

1. **Tooth Decay:** Lasers can be used to remove the decay within the tooth to prepare it for filling. The lasers used have fine beams of energy hence it is accurate. These lasers when aimed at the plaque or the tartar they break it up and zap it away.

2. **Gum Disease:** The focused beam of Lasers is useful to alter or remove the tissues that are infected. This laser beam can be used to reshape gums, remove bacteria and also draw out the overgrown tissues.

3. **Biopsy or Lesion Removal:** Lasers can be used to detect mouth cancer. Lasers can be used to remove a small piece of tissue from the mouth to examine it for cancer. These lasers can also be used for removing the lesions from the mouth.

4. **Teeth Whitening:** Firstly, a peroxide-based gel is pasted onto the teeth then, a laser with a focused beam is used. The heat from this laser causes a chemical reaction in the teeth which breaks down the stain and lightens the colour of the teeth.

Laser used in dentistry

1) Erbium: Erbium lasers are built with two different crystals, the Er:Yag (yttrium aluminum garnet crystal) and Er,Cr:YSGG (chromium sensitized yttrium scandium gallium garnet crystal) both having different wavelengths. Erbium Lasers have a bactericidal effect; thus, it helps in preventing or reducing the growth of bacteria.

2) Nd:Yag: These lasers have a primary output of near-infrared light beam, exclusively used for periodontal treatments. These lasers are useful for debridement (Debridement is removal gingival or subgingival {'Gingiva' also known as Gums} plaque to get rid of obstruction while performing an evaluation) and disinfection of periodontal pockets and also prevent bacterial disinfection.

Lasers in dentistry are advantageous over traditional drill because it reduces pain, minimizes bleeding and swelling and helps to preserve the healthy tooth during cavity removal. But laser treatments tend to be on the more expensive side and requires more experienced professionals.

LITHOTRIPSY

What is Lithotripsy?

Lithotripsy is a procedure where high energy shock waves are used to break kidney stones** and stones in the other organs like the gall bladder or liver into smaller particles, which can then be passed out of the body through urine. There are 2 types of lithotripsies but here we shall discuss about Laser Lithotripsy.

**Stones are hard pebble-like substances that are formed due to the accumulation of certain types of minerals. These stones are mainly found in the kidney but may also be found in other organs like the liver, bladder and pancreas etc. These kidney stones are usually made of crystal-forming substances such as calcium, oxalate and uric acid.

What is Laser Lithotripsy?

Using a fine beamed laser, which is made to pass through a cystoscope or a ureteroscope is targeted on the stone, breaking it into smaller pieces that can easily pass-through urine.

Cystoscope is a tube with a light and camera at its one end which is inserted into the urethra and into the bladder to visualize it internally.
Ureteroscope is a small telescope that is passed through the urethra and the bladder up to the ureter where the stone might be present.

How does the Laser work in Lithotripsy?

As previously mentioned, the laser is passed through a certain scope consisting of a light and camera which is then passed through the urethra to the organ where the stone is located. The laser provides a fine but strong beam that breaks the kidney stone and passes through urine.

There are 2 types of Lasers used for Laser Lithotripsy:

- **Ho: Yag Laser:** This laser is also known as Holmium-Yttrium-Aluminium-Garnet Laser. This is a solid-state laser of wavelength 2100 nm and produces pulsed radiations. Ho:Yag Laser can be used to superficial ablation and stone removal. The Ho:Yag laser is capable of fragmenting urinary stones of all compositions while maintaining a wide margin of safety.

- **Pulsed-dye Laser:** A dye laser uses an organic dye as its lasing medium. Pulsed-dye laser releases acoustic pressure wave which acts like a hammer which fragments the kidney stone.

MICROSCOPY

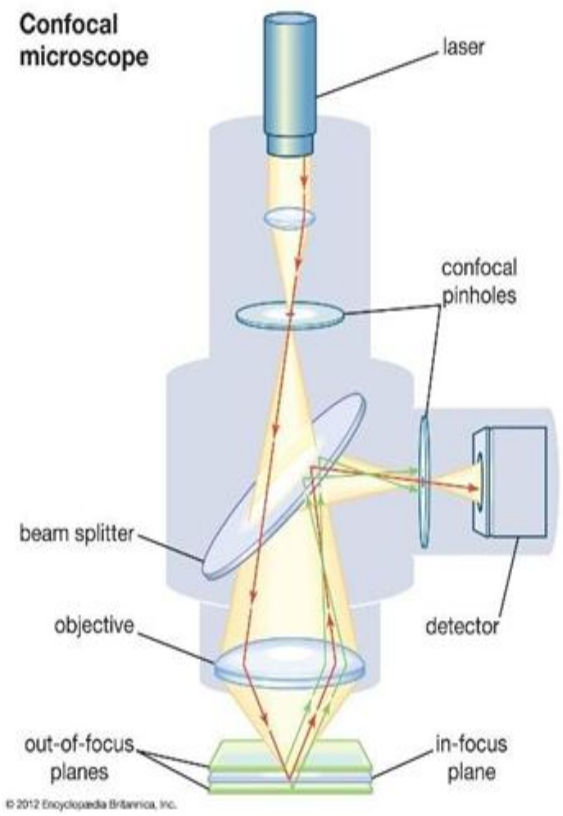
- Microscopy is a technical field of using a microscope to view objects and areas of the object that cannot be seen by the naked eye. A microscope uses a resolution that cannot be perceived by the human eye.

- Microscopy is further divided into three fields-Optical, Electron and Scanning probe Microscopy. Optical microscopy involves using diffracted, reflected or refracted light sources to interact with the specimen.

- **What is Confocal Microscopy?**

Optical Microscopy is the traditional method of microscopy that uses visible light to view the sample or the object. It uses a series of lenses that allow the magnification of the sample or the object so that it can be seen by the naked eye.

- Confocal Microscopy is a branch of Optical Microscopy, but Confocal Microscopy equips the use of a pinhole to remove the out of focus light, hence only light focused at the pinhole passes through it. This process is known as spatial filtering.



How is Laser used in Confocal Microscopy?

- Lasers are highly focused in nature, coherent, high intensity and monochromatic in nature. The rate of expansion is very low. These lasers are used to illuminate the sample or the object. Lasers are more functional in Confocal Microscopy because lasers have high intensity and are tight beamed, which is exactly what confocal Microscopy needs. So, the pinhole can be eliminated because the light source is a laser.
- The intensity of the laser light is adjusted using neutral density filters then a mirror is tilted in such a way that the laser focuses on the sample. If the sample is fluorescent then a part of the light is reflected back into the objective lens. Then the light is made to pass through a polarizer due to which the light with a different polarization angle will pass through.
- This light is of low intensity which is then made to pass through a Photomultiplier Tube (Also called PMT; PMT utilizes the multiplication of electrons by secondary emission, then it amplifies the light signal with low intensity into a signal with higher intensity. The PMT converts the analogue light signal into a digital light signal which is then displayed on the computer, which can amplify light signal and converts it from analogue to digital signal in the computer, then displays it on the monitor.

Components of Confocal Microscopy

1. Laser: The laser can be a gas or a crystal laser, the purpose of the laser is to provide illumination.
2. Scanner: A set of 2 or more mirrors that focuses the beam on the specimen.
3. Objective Lens: This lens allows optical image formation and is responsible for the resolution of the sample image.
4. PMT: This is responsible for the amplification of the light signal.
5. Pinhole: The pinhole helps to remove the out of focus light.

Lasers used in Confocal Microscopy

1. **Gas Lasers:** Gas Lasers used maybe Argon-Krypton laser, Krypton-ion laser or Helium-Neon laser. Argon-Krypton lasers are preferred to the other lasers because they release a stable output compared to other lasers.
2. **Crystal Lasers:** Nd:Yag (Neodymium: yttrium aluminum garnet), Nd:Ylf (Neodymium: Yttrium Lithium Fluoride) are the commonly used crystal lasers in CLSM.

Basic Safety Measures opted by the Government Agencies are:

Eye Safety

Laser safe eye protection of appropriate wavelength and density should be worn by the health care workers in the room.

Patients' eyes must also be covered with eye protection or moistened eye pads to prevent radiation. The windows in the room must be provided with adequate protection to prevent the radiation from venturing outside.

Laser Safety operation

For safe operation, the personnel are to be well trained in the use of lasers. The patient should be well informed on the procedures that are to be conducted for their well-being.The laser should never be directed at a person; only dull or non-reflective anodized instruments should be kept near the laser site.

Credential of the Physicians

Only the surgeons or physicians who have been granted privileges are permitted to perform the surgery. A list of physicians who have these granted privileges must be maintained.

Care and Maintenance

After the laser procedure, the laser parts should be safely stored.
After the procedure, the laser used should be wiped down with an antimicrobial solution.

Documentation:

Cases that require the laser should always be scheduled and in case of any malfunction during the procedure should be reported.

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MODERN PHYSICS AND MEDICAL DIAGNOSTICS

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Physics has contributed to health since the advent of medicine nearly 5000 years ago. Scientists have used physics to understand the nature of living systems (Physiology) during the 17th century, but have applied physics to identify the philosophy of life itself since the 18th century. Early findings led directly to the creation of new specialties such as electrophysiology, biomechanics, ophthalmology, etc. Physical-based medical technology developed rapidly during the 19th century, but radioactivity-based advances ended the 20th century with a renaissance in this field. The post-genomic tailoring of medicine is on the borderline of a new revolution, and techniques based on physics will once again be at the forefront.

USE OF ULTRASOUND AS A DIAGNOSTIC TOOL

Sonography or diagnostic medical sonography uses high-frequency sound waves to create images of structures in the body. Imaging can contribute to the detection and diagnosis of many diseases. The revolutionary scientific phenomenon of Piezoelectricity was discovered by Pierre and Paul-Jacques Curie in 1880. It was Paul Langevin who developed piezoelectric materials capable of producing high-frequency mechanical vibrations (Ultrasound). The navy division of the army of different countries used ultrasound to locate enemy submarines during WW1. At this time, ultrasound was used more as a therapeutic rather than as a diagnostic tool. A highly powerful ultrasound was discovered in the 1930s by Paul Langevin. As a result of his discovery, high-power ultrasound was used to treat a wide variety of diseases in the 1950s, including Ménière disease, Parkinson's disease, etc. As a diagnostic tool, ultrasound was made possible by the association of physicians and SONAR (Sound Navigation Ranging) engineers. The limitations of ultrasound technology at the time made clinical applications impossible until the mid-1960s. In 1966, B-scanners first became available for obstetric use.1976 was the year when the first ultrasound machines with Doppler measurements were sold. Since then, teams from around the world have worked tirelessly to define and improve ultrasound imaging applications in regional anesthesia.

Following is a brief history of ultrasound:

- A crystal's piezoelectric properties are discovered by Jacques Curie and Pierre Curie in 1880.
- It was in the year 1915 that the navy started using ultrasound for submarine detection.
- Paul Langevin made use of extremely powerful ultrasonic waves to break up animal tissues through his invention.
- Karl and Freidrich Dussik explained about ultrasound as a diagnostic tool in 1942.
- In the 1950s, procedures involving ultrasounds were introduced for treating patients with Parkinson's disease, rheumatoid arthritis and Meniere disease.
- An article on the use of ultrasound for placement of nerve blocks was published in 1978 by La Grange.

WORKING OF ULTRASOUND WAVES

The back-and-forth motion of a particle in sound travels parallel to the direction the wave travels. An Ultrasound is a high-frequency sound wave constituting of vibrations that are more than 20 kHz. The human ear is able to detect sounds between 20 Hz and 20 kHz. Diagnostic ultrasound is commonly

performed at frequencies between 2 and 15 MHz Frequencies above 100 kHz are not found naturally. Only human-made devices can generate and detect ultrasounds.

Piezoelectric Effect

Piezoelectric materials are capable of generating ultrasound waves. Piezoelectricity is a phenomenon in which an electric charge is generated when a mechanical force (a squeeze or stretch) is applied to certain materials. Conversely, the piezoelectric effect produces mechanical deformation by applying an electric field to such materials. The phenomenon of piezoelectricity can be demonstrated by both natural and man-made materials, including quartz crystals and ceramics. Piezoelectric materials like lead zirconate titanate have recently been used for medical imaging. A piezoelectric material produces very little energy. Transducers can convert electrical energy more efficiently into mechanical oscillations by stacking piezoelectric elements in layers. There is a production of electricity from these mechanical oscillations.

Ultrasound Terminology

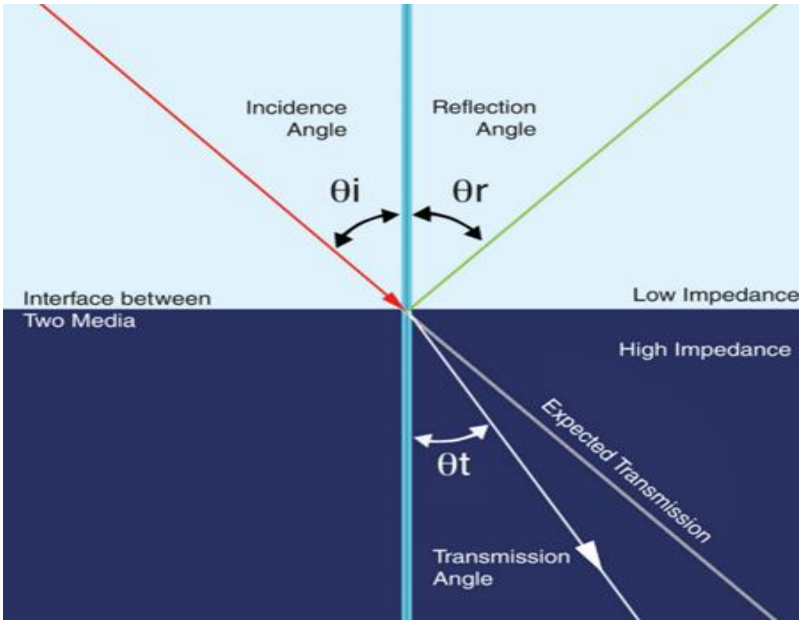
In sound waves, a period measures how much time has been passed between two consequent sound waves. A period is measured in microseconds (μs). The wavelength is determined by the distance travelled during the beginning and end of one cycle. Frequency represents how many cycles repeat each second. It is measured in 'hertz' (Hz) Acoustic Velocity measures how quickly sound travels through a medium. Acoustic Velocity = Wavelength (λ) * Frequency. Speed 'c' is denoted by the density 'ρ' and stiffness 'κ' of the medium ($c = (\kappa/\rho)^{1/2}$). It is the concentration of a medium that determines its density. A material's stiffness is its resistance to compression. Increasing stiffness or decreasing density increases propagation speed. It is calculated that the average propagation speed in soft tissues is 1540 m/s (ranges from 1400 to 1640 m/s). Ultrasound, however, cannot penetrate lung or bone tissues. An acoustic impedance 'z' indicates how difficult it is for a sound wave to travel through a medium; it is equal to density 'ρ' * acoustic velocity 'c' ($z = \rho c$). The acoustic impedance of the medium increases when the propagation speed or the density of the medium increases. Attenuation coefficients measure the decrease of ultrasound intensity in certain media. An increase in frequency results in a greater attenuation coefficient. Additionally, there is a decrease in the amount of penetration as and when there is an increase in frequency. After travelling for a particular distance in an ultrasonic field, the ultrasound beam narrows itself down due to its self-focusing properties. There is a transition/change in between the far-field and the near-field at this level. At this stage, the beam-width is equal to half the transducer's diameter. After reaching a distance two times the length of the near-field, the width of the beam reaches the transducer's diameter. An ultrasound image's spatial resolution can be divided into two types: axial and lateral. Axial spatial resolution is the minimum separation of two planes above and below the beam axis. This factor is determined by spatial pulse length, which is equal to the product of wavelength and the number of cycles in each pulse. It can be presented in the following formula: Axial resolution = Wavelength 'λ' × Number of cycles per pulse 'n' ÷ 2 A pulse's cycle length depends on the transducer's damping characteristics. In most machines, the frequency of pulses is commonly between 2-4 cycles. Ultrasounds that have higher frequencies detect smaller objects with greater accuracy and tend to produce a clearer image for constant acoustic velocity. Currently, ultrasound systems have an axial resolution between 0.05 mm and 0.5 mm. There is also a lateral resolution parameter, which describes the distance between two objects side-by-side. Ultrasound frequency and beam width are both important factors. High frequencies provide sharper axial and lateral resolution as well as a narrower focus. Focusing can also improve lateral resolution by reducing beam width. The ability to observe moving objects like blood vessels and hearts also requires high temporal resolution. For an ultrasound image to appear continuous, it needs to be updated at a rate of approximately 25 times a second or higher. Increased frame rates will, however,

compromise imaging resolution. The ratio of resolution to frame rate has to be optimized to achieve the best image.

INTERACTIONS OF ULTRASOUND WITH TISSUES

An ultrasound wave undergoes a number of interactions as it travels through tissues. Following are a few of the main characteristics: • Reflection • Scattering • Absorption

While travelling through different media, ultrasound undergoes fragmentary transmission and reflection. By the reflection angle 'θr' and the transmission angle 'θt' we can determine the directions of reflection and transmission.



The Reflection of sound waves is similar to that of optical reflection. It returns some of its energy to the medium from which it originated. True reflections require angles of reflection θr and θi to be equal to each other. Reflection strength at an interface varies depending on the difference of impedances between two affinitive media and the incident angle at the boundary. An interface between soft tissues and lung or bone, for example, results in a significant change in acoustic impedance that creates echoes. Similarly, the intensity of this reflection depends a lot on the angle. The ultrasound transducer must be positioned perpendicular to the target nerve in order to visualize it clearly. When sound crosses a boundary, its direction changes. This process is widely known to us as refraction. The refraction angle (θR) is lesser/smaller than the incident angle (θI) if the speed of propagation through the second medium is slower than that of the first medium. The artefacts underneath large vessels in the image can be caused by refraction. To displace air from the transducer-skin interface, a coupling medium must be used between the transducer and the skin. For this purpose, a variety of gels and oils are used. Moreover, they can serve as lubricants to make scanning smoother. Reflected waves will be diffused if the boundary dimensions are less than the wavelength or if the boundary is not smooth. Essentially, scattering is the redirection of sound in any direction as it travels through rough surfaces or heterogeneous media. The scattering intensity is usually much lower than the intensity of mirror-like reflections and is relatively independent of the direction of the incident sound wave, so the detection of the target nerve is not greatly affected by nearby scatterings. The process by which sound energy is directly converted into heat energy is known as absorption. Basically, ultrasound generates heat within the tissue. A higher frequency is absorbed faster than that of a lower frequency. An increased scanning frequency, however, provides better axial resolution. Ultrasound frequencies may be selected at lower frequencies to increase penetration of the structures

of interest if the penetration is insufficient to visualize them. When a longer wavelength (lower frequency) is used for ultrasound imaging, the resolution is lower because ultrasound resolution is proportional to the wavelength of the imaging wave. Most clinical applications do not use frequencies less than 2 MHz or more than 15 MHz because of insufficient resolution or penetration depth.

ULTRASOUND IMAGE MODES

A-Mode

A-mode ultrasound was invented in 1930 and is the oldest form of ultrasound. A pulse of ultrasound is emitted from the transducer into the medium. After the striking of ultrasound beams on the tissue boundary, a collection of vertical peaks appears on the single-dimensional ultrasound image. The measurement of the distance between the echoed spikes can be made by dividing the ultrasound speed of about 1540 m/s by half of the time passed, but it does not tell us about their spatial arrangement/structure. Therefore, A-mode ultrasounds cannot be used for regional anaesthesia.

B-mode

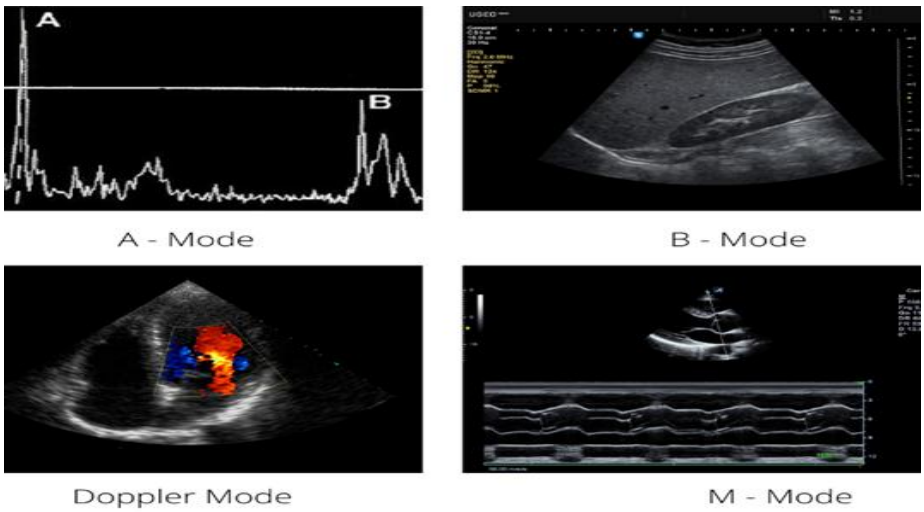
In B-mode, a two-dimensional (2D) image is created rather than a single image as in A-mode by scanning 100–300 piezoelectric elements in a linear array. B-mode imaging converts the amplitude of the echo from a series of A-scans into dots of different intensities of brightness. Tissue distances are represented by the vertical and horizontal dimensions whereas, echo strength is represented by the grayscale intensity. B-mode (primary mode) is used in regional anaesthesia and gives us a cross-sectional image of the specified area.

Doppler Mode

Physicist Johann Christian Doppler is accredited with the discovery of the Doppler effect. This term refers to a change in frequency or wavelength of a sound wave due to the relative movement between a sound source and a sound receiver. In other words, the sound frequency will remain the same at a stationary position. The sound waves must be squeezed toward the sound receiver in order for a high-pitched sound to be heard (positive Doppler shift), whereas the waves must be stretched in order for the received sound to be lower pitch (negative Doppler shift). The magnitude of the Doppler shift is determined by the incident angle between the direction of the ultrasound beam and the moving reflectors. Doppler shift doesn't occur with a 90° angle. An angle of 0° or 180° will indicate the largest Doppler shift. Usually, Doppler shifts in medical settings are audible. Doppler colour maps are created by superimposing a colour-coded Doppler shift map on top of a B-mode ultrasound image. The direction of the flow of blood depends on if the transducer is moving towards or away from the flow of blood. Red and blue colours are chosen by convention to show blood flow direction and velocity. To determine if blood vessels (arteries and veins) are present in an area of interest during an ultrasound-guided peripheral nerve block, colour Doppler may be used. Based on this convention, the colour of arterial flow transforms from blue to red when the ultrasound beam changes direction. Power Doppler can detect the flow of blood up to five times better than colour Doppler, and it is less affected by the angles of scanning. Therefore, power Doppler can more reliably identify the smaller blood vessels. The disadvantage is that power Doppler does not tell you how fast and in which direction the blood is flowing.

M-Mode

It is possible to produce images with a motion signal in an ultrasound scan, in which a structure such as a heart valve is represented as a wave. Despite the extensive use of M-Mode in cardiac imaging, it is rarely used in regional anesthesia.



ULTRA SOUND INSTRUMENTS

On an ultrasound screen, the dots that are formed by the echoes received by the transducer are displayed as anatomic images. Grayscale images are produced when the brightness of each dot corresponds to the echo strength. A linear or curved scan transducer is used in regional anesthesia. Linear transducers can produce parallel scan lines and rectangular displays, whereas curved transducers produce curved scans and arc-shaped images. A layer of air between a transducer and skin virtually reflects all ultrasound waves, preventing them from penetrating into the tissue. In this case, a watery gel coupling medium is applied between the skin and the transducer to remove the layer of air. Machines that can produce 3D images have recently been created to replace the traditional 2D ultrasound machines being used for regional anesthesia. Three-dimensional ultrasound imaging in theory should be helpful for determining how anaesthetics spread over anatomical structures. There are three techniques of 3D imaging ultrasounds: (1) Freehand 3D is obtained by sweeping the transducer across a region of interest to obtain a set of ultrasound images for the 2D view of the area under examination/evaluation. (2) Volume 3D is a transducer that provides 3D volumetric images. Sonographers do not need to manually move the transducer elements to sweep through regions of interest during scanning. (3) Real-time 3D lets the sonographer observe a 3D model moving in real-time by capturing multiple images from different angles. On average, 3D imaging has a spatial resolution of about 0.34–0.5 mm. As of now, 3D imaging systems are far from being as practical in regional anesthesia as 2D imaging systems, so their application is limited.


Ultrasound Machine

APPLICATIONS OF ULTRASOUND SCANS

• For pregnancy, ultrasound is used for the imaging and examination of the unborn baby. Also, it is used to observe the uterus and ovaries during pregnancy.

• During an abdominal ultrasound, abdominal organs and tissues are examined.

• When a woman has dense breast tissue, breast ultrasound screening can help detect breast cancer.

• An ultrasound of the heart allows for assessment of heart function overall through an echocardiogram. Doppler ultrasound visualizes the blood flow through blood vessels and organs and is commonly performed in conjunction with echocardiograms.

• Biopsies can be helped by ultrasound.

• Ophthalmic ultrasound examines eye structures.

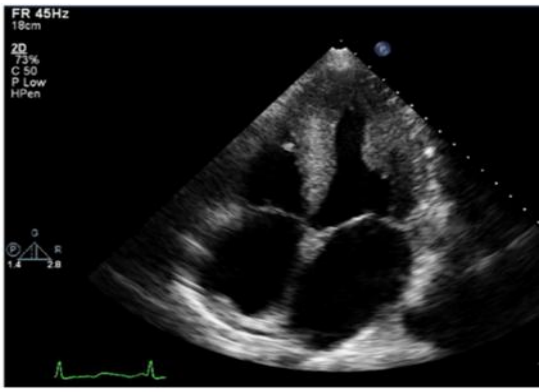
• Inflammation of joints can be assessed with ultrasound.

• Diagnostic ultrasound allows us to treat the cause of swelling, infections, etc. within the body.

• The use of ultrasound imaging can be used to figure out if an organ has been damaged after an illness or not.

• Problems of the Prostate gland and Genitalia can be detected with ultrasound.

Pregnancy Ultrasound Scan



Heart Ultrasound Scan

BASIC SAFETY MEASURES ISSUED BY THE GOVERNMENT FOR ULTRASOUND LABS

1) It is necessary to register, at least 3 months in advance, all the places where a USG machine will be used, whether it be a black and white or colour Doppler machine. This includes nursing homes, intensive cardiac care units, and everywhere else USGs will be used. This registration is required regardless of whether the machine will be used to perform pregnancy scans, abdominal scans, or only 2D echocardiograms. For all centres, proper accredited registration is required.

2) Radiologists, sonologists, and other physicians using USG machines shall be listed on their PC-PNDT certificates. Their degree must show that they hold the certification required for performing ultrasound procedures.

3) A machine present in that particular centre may only be used by doctors registered there. It is only after notifying the appropriate authority (AA) that other qualified doctors may use the machine at that Centre.

4) A USG machine cannot be shifted from one centre to another. Multiple USG machines can be registered in one centre, but the manufacturer's name, model number, etc. should all be noted on the PC-PNDT registration document (included on the document or attached separately).

5) A 30-day notice should be given by the AA if any changes are to be made to the centre (For example, change in location/machines). It should be informed to the AA within 30 days if the operating doctor is changed.

MODERN PHYSICS AND MEDICAL DIAGNOSTICS

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Key Word: Laser

Introduction

Physics has always been used in medicine and medical diagnostics since time immemorial. From the early period of time when we were hunter gatherers to the modern age. Various methods and discoveries in physics were and still used by doctors around the globe. From the making of optical lenses for people with eye problems to the use of computers and electromagnetic radiation to scan our brains. However, it is only in recent times, that the theories and proofs discovered by the spectacular and weird modern physics have been put to use in medicine. Modern physics encompasses what we know today as quantum mechanics, special relativity, general relativity, solid state physics and so on. Many remarkable medical technologies, diagnostic tools, and treatment methods have emerged as a result of modern physics discoveries in the last century—including X-rays, radiation treatment, laser surgery, high- resolution ultrasound scans, computerized tomography (CT) scans and magnetic resonance imaging. In this essay today we will try to summarize and understand the basic principles of lasers and its uses in medicine.

What is laser?

Laser or l.a.s.e.r can be defined as a device that stimulates atoms or molecules to emit light at particular wavelengths and amplify that light typically resulting in a narrow beam of radiation. Its emission generally covers an extremely limited range of visible, infrared or ultraviolet wavelengths. The term l.a.s.e.r stands for "light amplification by the stimulated emission of radiation."

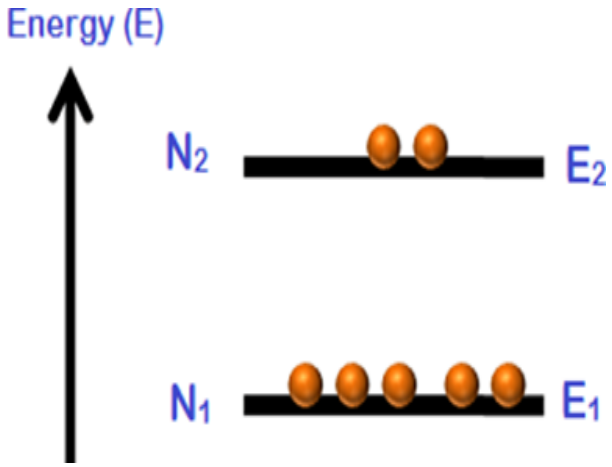
History of laser

Historically, it is believed that the concept of laser was first suggested by Einstein in 1916. He hypothesized that under the right circumstances, atoms could release excess energy as light when stimulated in certain ways. But it was only in 1953 that the first prototype of what was to become laser were beginning to be produced in labs. The device which was made called maser and it generated stimulated emission at microwave frequencies. During this era, on the other side of the globe, Russian physicists Aleksandar Mikhaylovich Prokhorov and Nikolay Gennadiyevich Basov had independently developed and described the theory of maser operation. All three of them were awarded the Noble Prize for Physics in 1964 for their work on masers. Following this discovery, many maser research projects were conceived and funded in the mid-1950s. However, masers were limited to few practical applications such as low-noise microwave amplifiers and atomic clocks. Townes along with his brother in law, Arthur L. Schawlow published their ideas for an "optical Maser" in December 15, 1958 and it is believed to be the first paper on what we know today as lasers. At the same time, Gordon Gould, a graduate student of Columbia University, also developed and published his own independent ideas on lasers and it is still hotly debated today to who should be credited as the "inventor" of laser.

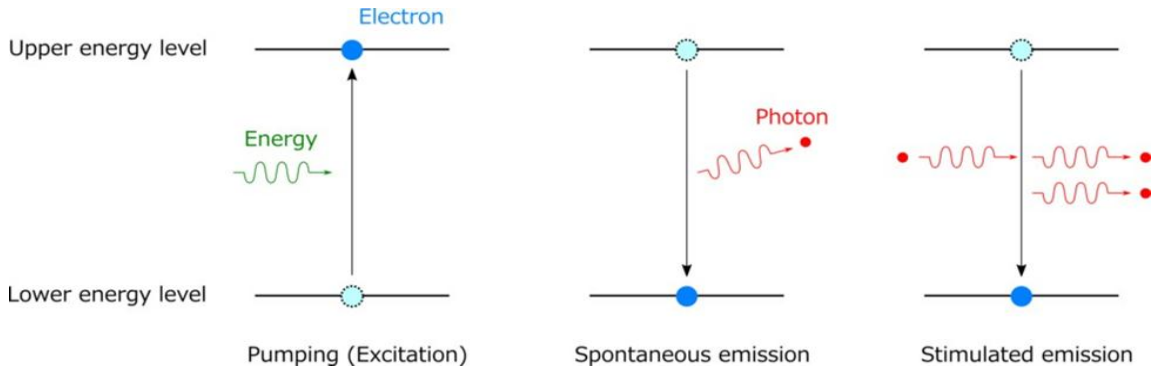
Basic principles of laser

The emission of laser is shaped by the rules of Quantum Mechanics. According to Quantum Mechanics, atoms and molecules have a limit on the discrete amounts of stored energy and this depends on the nature of the atom or the molecule. An individual atom is at its lowest energy level when its electrons are all in the nearest possible orbits to its nucleus. This state is called the ground state. If one or more of the electron absorb energy, they move to outer orbits and the atom is excited. Generally, these excited states are not stable and as the electrons drop from higher energy to lower energy levels, they emit the leftover energy as light. It can be said that laser is amplifier of these emitted light waves.

In lasers, the photons are interacted in three ways with the atoms i.e Absorption of radiation, spontaneous emission and Stimulated emission. During absorption of radiation, electrons in the ground state absorb energy from the photons to jump to higher energy level. The electrons in the lower energy level need some extra energy to jump into the higher energy level and this extra energy is generally provided by heat, electric field or light. Now, let us consider two energy levels (E1 and E2) of electrons. E1 is the ground state or lower energy state of electrons and E2 is the excited state or higher energy state of electrons. In order to jump to higher energy state, the electrons needed sufficient energy and when photons equal to the energy difference of the two energy levels (E2 – E1) is incident on the atom, the ground state electrons gains sufficient energy and jumps from ground state (E1) to the excited state (E2).



During Spontaneous emission, the electrons in the excited state return to the ground state by emitting photons. The electrons in the excited state can stay only for a short period of time and the time up to which it can stay a higher energy state is known as the lifetime of excited electrons. Therefore, after the short lifetime of the excited electrons, they return to the lower energy state by releasing energy in the form of photons. However, the photons emitted during this process constitute ordinary incoherent light. Incoherent light is a beam of photons with with frequent and random changes of phase between them and thus the photons emitted do not flow in the same direction of incident photons.

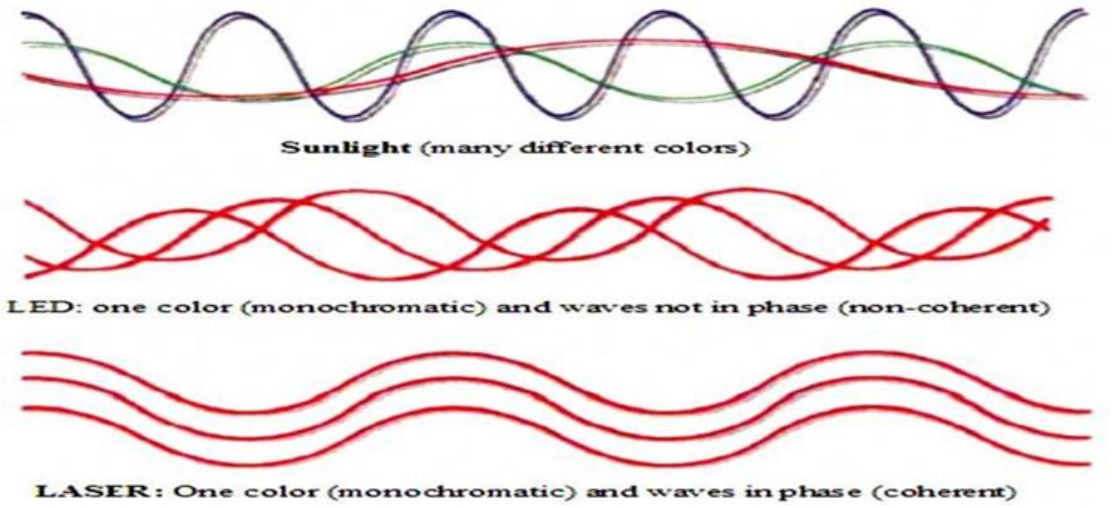


Stimulated emission is the process by which the incident photons interacts with the excited state and forces it to return to ground state. It is an artificial process. In stimulated emission, the electrons are forcefully returned from the excited state to ground state before completion of their lifetime. In stimulated emission, photons are incident on the excited electron which compels them to release energy in the form of light while falling to the ground state. Thus, two photons are emitted during stimulated emission, one due to the incident photon and the other due to the energy release of excited electron. All the photons emitted during this process have the same energy, frequency and are in phase. Therefore, the number of photons emitted depends on the number of electrons in the higher energy and the incident light. Mathematically, it can be written as Np = Ne+I, where Np is the number of photons emitted, Ne is the number of electrons in excited state and I is the intensity of the light incident on the electrons. Further, amplifying the photons emitted during the stimulated emission process using different techniques, we obtain laser.

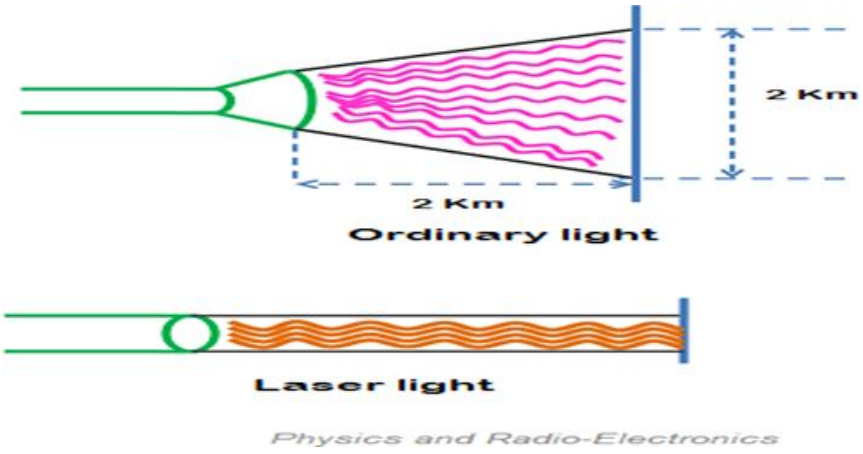
Properties of Laser

Though both light and laser are made up of photons, laser light has some distinct properties which makes it different from a normal light. Broadly categorizing the differences, it has been divided into four major characters. They are - Coherence, Directionality, Monochromatic and High Intensity.

In ordinary light sources, the electron transition i.e the moving of electrons from higher to lower energy state or vice versa is random in time. The photons emitted from ordinary light sources usually have different energies, frequencies, wavelengths and colors. Thus the photons emitted are generally out of phase and we define them as being incoherent. However, in laser, the electron transition occurs in specific time and all the photons emitted have the same energy, frequency or wavelength. Therefore, the wavelengths of laser light are in the phase in space and time and we define them as being coherent. Due to this, a large amount of power can be concentrated in a narrow space.



Emission of photons by ordinary light sources generally travel in random directions. However, in laser all photons travel in the same direction and the light emitted is only in one direction. This property is called the directionality of laser light. The width of the laser light is extremely narrow and hence, they can travel to long distances without randomly spreading.



While ordinary light beams which we observe are made up of different colors or wavelength, a laser light is made up of only one color or wavelength. Thus, a laser light is monochromatic.

It is known that the intensity of a wave is the energy per unit time flowing through a unit normal area. In an ordinary light source, the light spreads out uniformly in all directions. For example, if a person looks at a 100 Watt lamp filament from a distance of 30cm, the power entering their eyes is less than 1/1000 of a watt. This means that the intensity of an ordinary light beam is very low, but in lasers, the light spreads in small region of space with a small wavelength and it is, therefore, concluded that lasers have higher intensity than ordinary light beams.

Obtaining lasers in labs

Usually, to obtain lasers in a lab, a process known as population inversion is used. Population inversion is the process of achieving greater population of higher energy state as compared to the lower energy state. This technique is usually used for light amplification.

Consider a group of electrons with two energy levels E_1 and E_2. E_1 is the lower energy state and E_2 is the higher energy state.N_1 is the number of electrons in the energy state E_1.N_2 is the number of electrons in the energy state E_2. The number of electrons per unit volume in an energy state is the population of that energy state. Population inversion cannot be achieved in a two energy level system. Under normal conditions, the number of electrons (N_1) in the lower energy state (E_1) is always greater as compared to the number of electrons (N_2) in the higher energy state (E_2).

$N_1 > N_2$

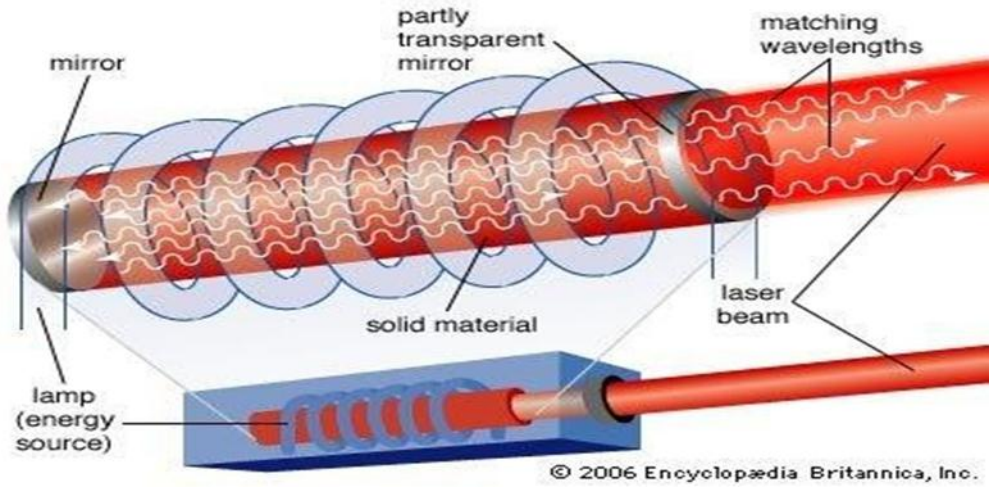
When temperature increases, the population of higher energy state (N_2) also increases. However, the population of higher energy state (N_2) will never exceed the population of lower energy state (N_1). At best an equal population of the two states can be achieved which results in no optical gain.

$N_1 = N_2$

Therefore, we need 3 or more energy states to achieve population inversion. The greater is the number of energy states the greater is the optical gain.

Unfortunately, the three-level laser works only if the ground state is depopulated. When atoms or molecules emit light, they accumulate in the ground state, where they absorb the stimulated emission and shut down. However, this is not the case with the four level laser, where an extra transition state is located between the metastable and ground states. This allows it to emit a steady beam for a long time, sometimes even days.

Population inversion can be produced in a gas, liquid, or solid but most laser media are gases or solids. Generally, laser gases are contained in cylindrical tubes and excited by an electric current or external light source.



Typically, optical resonator is required to build up the light energy in the beam. It is formed by placing a pair of mirrors facing each other so that light emitted along the line between the mirrors is reflected back and forth. When a population inversion is created in the medium, light reflected back and forth increases in intensity with each pass through the laser medium. This combination of laser medium and resonant cavity forms what often is called a laser.

Applications of lasers in medicine

Since its inception, lasers have been used for various medical procedures which include dermatology, plastic surgery, wound healings, nerve stimulation and many other surgical procedures. Some of them have been described in brief below.

The earliest medical applications for lasers were in ophthalmology and dermatology. Just a year after the invention of the laser in 1960, Leon Goldman demonstrated how a ruby laser, which emits red light, could be used to remove port wine stains, a type of birthmark, and melanomas from the skin. This process relies on the ability of lasers to operate at a specific wavelength. Later, ophthalmologists used argon lasers (which emit green-wavelength light) to treat detached retinas. This application uses the properties of the eye itself—specifically the lens—to focus the laser beam onto the area where the retina has become detached. The highly-localized power from the laser causes the retina to reattach. Another medical approach, also with argon lasers, is used to stop internal bleeding in patients. Green light is selectively absorbed by hemoglobin, the pigment in red blood cells, in order to seal off bleeding blood vessels. This can also be used in cancer treatment to destroy blood vessels entering a tumor and deprive it of nutrients. Both ophthalmology and dermatology have also benefitted highly from lasers. Recently, these lasers have become widely used to reshape corneas so that patients no longer need to wear glasses.

Lasers have a major role to play in the early detection of cancer as well as many other diseases.

PDT can destroy just cancer cells and leave most healthy cells alone. It is used to treat certain cancer tumors. PDT is also called photo-radiation therapy or photo-chemotherapy. It uses a combination of a light source and a photosensitizing medicine activated by light. The medicine is often injected into the blood. It collects more in cancer cells than in normal cells. When the laser's light is focused directly on the tumor, the cancer cells absorb the light. A chemical reaction occurs that kills the cancer cells.

An emerging area of usage of lasers in medical applications is scanning near-field optical microscopy, which can produce images with a resolution much greater than that obtained from standard optical microscopes. This technique is based on optical fibers that have been etched at their tips at a smaller scale than the wavelength of the laser. This enables sub-wavelength imaging and paves the way for imaging biological cells.

Harmful effects of lasers

Improperly used laser devices are potentially dangerous. Effects can range from mild skin burns to irreversible injury to the skin and eye. The biological damage caused by lasers is produced through thermal, acoustical and photochemical processes. Lasers can cause a wide range of hazards which include both direct beam hazards such as tissue burns, eye damage, endotracheal tube fire, drape fire, and explosion of gases, or non-beam hazards (those that are secondary to the actual beam interaction) such as laser generated airborne contaminants (surgical plume), **electrical damage**, toxic dyes, and system failures.

For example; a photo thermal wavelength of 10,600 nm (Carbon Dioxide), creates enough heat to cause flammability hazards. Users of such a laser would need to follow procedures to prevent fire, including eliminating dry materials or alcohol containing solutions from the target zone, correctly placing an appropriate fire extinguisher, having an open container of water available, preventing reflections, observing the path of the beam for interference of any kind, evacuating surgical plume, and removing free sources of oxygen or other flammable gases from the field.

Basic safety measures for potential laser hazard

Various safety measures and precautions for the usage and study of lasers either in scientific labs or hospitals have been drafted by Government agencies around the world. While each of them may differ slightly, an international standard for prevention and control measures for laser has been been adopted by many countries and institutions. Some of them are described below.

With the significant damage lasers can cause to your eyes, it is imperative that you are wearing the correct laser safety glasses. Selecting laser glasses is foremost and should directly correspond with the laser you are using. You can find the laser information in the instruction manual. The wavelength range (in nanometers) and optical density measurements are imprinted on the glasses to help you match with your laser. Laser glasses should be worn throughout the entire procedure, taking them off during any laser application can lead to harmful effects.

ANSI (American National Standards Institute) requires health care facilities to follow their laser safety standards and regulations. Many facilities are required to comply with ANSI Z136.3 standards, which are intended for those working with high-powered Class 3B and Class 4 lasers and laser systems. If you’re not sure if your facility is following ANSI standards or state regulations, consult with your Laser Safety Officer for information.

An individual working around high-powered lasers is required to have had proper training and education. Accidents can easily occur in laser procedures resulting in the loss or damage of vision.

Well trained personnel will significantly reduce the risk of accidental laser exposure. A trained laser operator will know how to align the laser correctly, making sure to position the laser beam above or below the normal eye levels of seated and standing personnel. The initial machine alignment can take as little as 15 minutes but should be carefully done to ensure the highest safety measures.

Safety and warning signs can help your medical staff and patients be aware of caution areas in your facility. Throughout your controlled laser areas, easy-to-read signs should be posted in appropriate locations. (i.e. entrance of procedure rooms). You also will want to consider posting signs that indicate the type of reflective gear to avoid wearing during laser procedures. Some of these items include reflective identification badges, jewelry and tools.

MODERN PHYSICS AND MEDICAL DIAGNOSTICS

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Key words: X-rays, CT scan, Radiation, Crompton scattering, Photoelectric absorption.

Introduction

Modern Physics plays a very vital role in medical diagnostics. X-rays, computed tomography or CT scan, positron emission tomography or PET scanning, magnetic resonance imaging or MRI, laser therapy, radiation therapy, Radioimmunoassay, nuclear medicines all these are the contributions of modern physics. Many other remarkable medical technologies have evolved as a result of new discoveries in modern physics. One of its example is Intensity Modulated Radiation Therapy or IMRT, which has enhanced the ability of delivery maximum dose of radiation to the tumor while minimizing the dose to the surrounding healthy tissues and thus efficiently killing the cancerous cells to stop the tumor's growth. Thus advancement in the medical technologies, diagnostic tools, therapies due to the contributions of modern physics have made it possible to save thousands of lives.

Medical Diagnostic Tools: X-rays & CT scan

What are X-rays? : X ray is a type of electromagnetic radiation. It has very short wavelength and high frequency. The wavelength ranges from 0.01 nm to 10 nm and corresponding frequency from 10^16 to 10^20 Hz. The X-ray wavelengths are shorter than that of UV rays and typically longer than the gamma rays. Because of the high frequency the X-rays possess high energy which ranges from 124 eV to 124 keV.

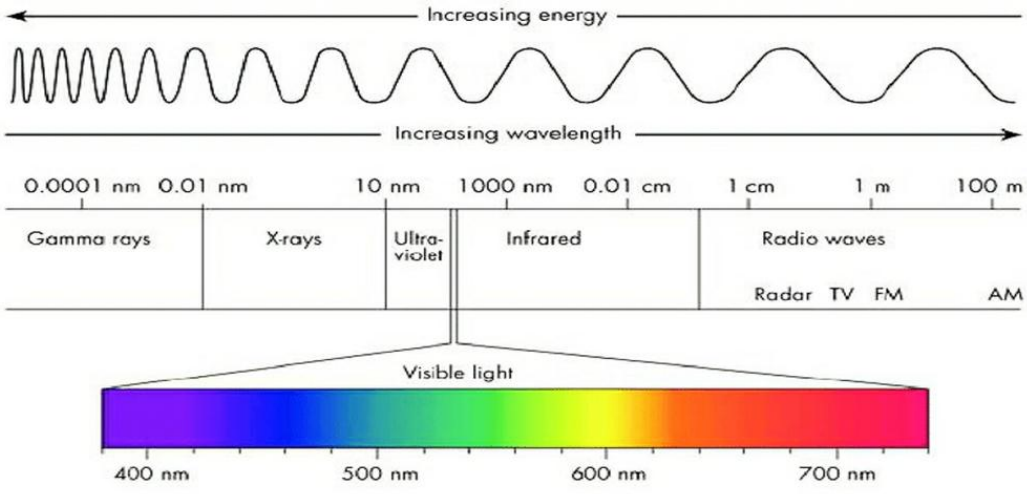

Figure1: Electromagnetic Spectrum

X-rays which have high photon energy above 5-10 keV are called Hard X-rays and those with lower energies are called Soft X-rays. The X-rays with intermediate range of photon energy are called Tender X-rays. Because of the high penetrating ability the hard X-rays are used for imaging in medical radiography, airport security etc.

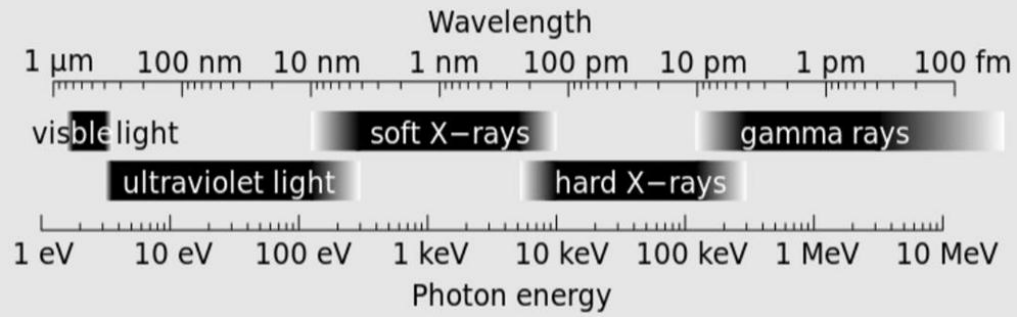

Figure 2: Hard and Soft X-rays

Production of X-rays: X-rays are produced by the conversion of the kinetic energy of electrons into electromagnetic radiation with the help of a dedicated apparatus known as X-ray tube.

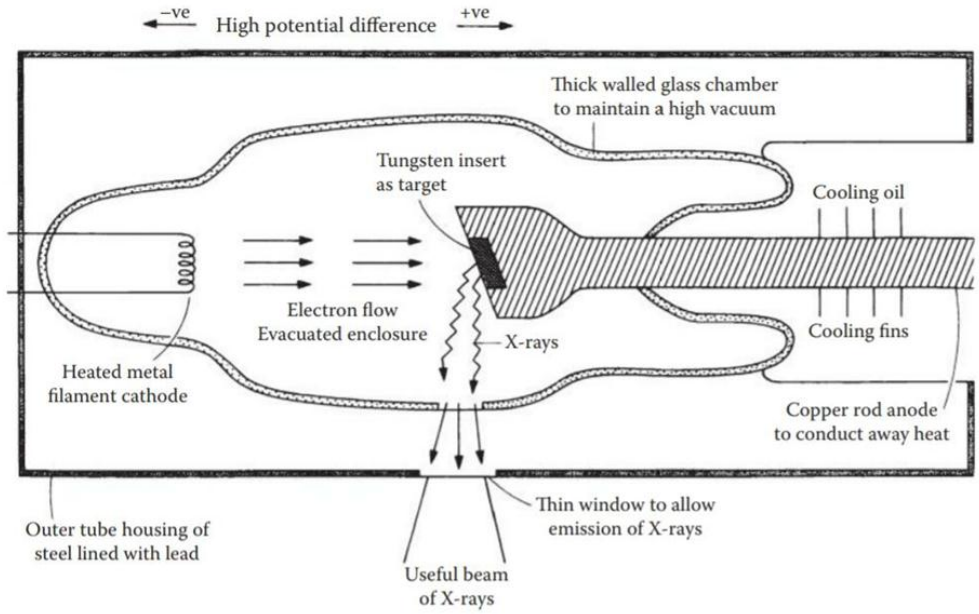

Figure 3: Basic Structure of a X-ray Tube

Basic functions of an X-ray tube

1. A heated filament acts as cathode and supply electrons through thermionic emission.
2. A metal anode (usually Tungsten), also called the 'target' converts the kinetic energy of electrons into X-ray photons.
3. An evacuated chamber along which a high potential difference is applied between the electrodes to drive the electrons from cathode (source) to anode (target).

The thick walled glass chamber which maintains a high vacuum in the X-ray tube is usually made up of borosilicate glass, which contains boron trioxide(B_2O_3) allowing it to have a very low coefficient of thermal expansion. Hence it can withstand extreme temperatures changes during X-ray production. The whole tube is evacuated to avoid energy of electrons due to collision with air molecules during their passage from source to target. The cathode which is a wired filament is heated to white heat so that it emits electrons. Tungsten (Z=74) is used as thermionic emitter in the X-ray tubes. Though Tungsten has a relatively high work function (4.52 eV), but because of its high melting point

(3422°C) and high mechanical strength it's used as a thermionic emitter. The thermionic emission temperature of Tungsten is 2200°C.

The high voltage applied between the electrodes accelerate the electrons emitted from the source to the target.

$$\Delta K.E = eV$$

$$\Rightarrow \frac{1}{2}mv^2 = eV$$

$$\Rightarrow v = \sqrt{\frac{2eV}{m}}$$

The kinetic energy (ΔK.E.) thus acquired by the electrons is given by the product of charge (e) and accelerating voltage (V) applied between the electrodes. Hence, when an x-ray imaging system operates at 70 kVp , the electrons arrive at the target anode with an energy of 70 keV or (70 keV) (1.6 × 10−16 J/keV) = 1.12 × 10−14 J and a velocity v = 1.6 ×108 m/s . The projectile electrons on hitting the heavy metal atoms at the target, interacts with the orbital electrons or the nuclear field of the atoms. This electron-target interaction converts the kinetic energy of the projectile electrons into thermal energy(99%) and X-radiation(1%). The projectile electrons on losing their K.E. get slowed down and conducted through the anode into the associated circuitryThe kinetic energy (ΔK.E.) thus acquired by the electrons is given by the product of charge (e) and accelerating voltage (V) applied between the electrodes. Hence, when an x-ray imaging system operates at 70 kV_p , the electrons arrive at the target anode with an energy of 70 keV or (70 keV) (1.6 × 10−16 J/keV) = 1.12 × 10−14 J and a velocity v = 1.6 $\times 10^8$ m/s . The projectile electrons on hitting the heavy metal atoms at the target, interacts with the orbital electrons or the nuclear field of the atoms. This electron-target interaction converts the kinetic energy of the projectile electrons into thermal energy(99%) and X-radiation(1%). The projectile electrons on losing their K.E. get slowed down and conducted through the anode into the associated circuitry. The focal spot at the target anode where the projectile electrons hit the target, is usually made up of tungsten or tungsten rhenium alloy (90% tungsten and 10% rhenium). Addition of rhenium to tungsten makes it tougher to which state and extreme stresses caused by heating. The maximum energy (E max) of the X-ray is given by the product of electronic charge (e) and the accelerating voltage (V) applied between the electrodes. This maximum energy (E max) corresponds to maximum frequency (f max) and minimum wavelength (λ min) of the X-rays produced.

Plank's quantum equation,

$$E = hf = hc/\lambda$$

$$E_{max} = hf_{max} = hc/\lambda_{min}$$

$$\Rightarrow eV = hc/\lambda_{min}$$

$$\Rightarrow \lambda_{min} = \frac{hc}{eV}$$

Anode Heat: Most of the kinetic energy of the projectile electrons which hit the target anode is converted to thermal energy due to the collision with outer shell electrons of the target atoms. The kinetic energy of the projected electrons transferred to the target atoms causes excitation rather than ionization. The excited electrons on coming down to the ground state releases infrared radiation.

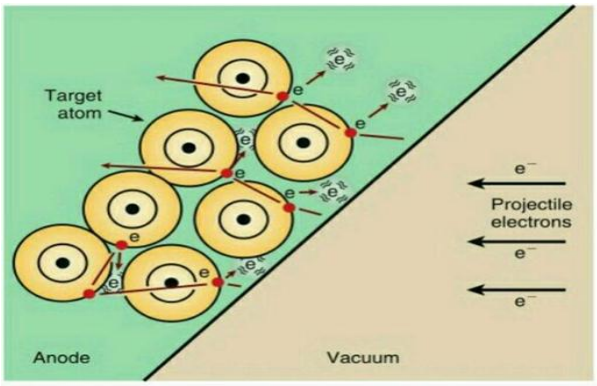

Figure 4

Characteristic Radiation: When the projectile electron ionizes the target atom through removal of an inner shell electron, a void is produced which is filled up by an outer shell electron. This transition from outer shell to inner shell releases energy in form of X-Ray. The energy thus released is equal to the difference of the binding energies of the inner and outer shell electrons.

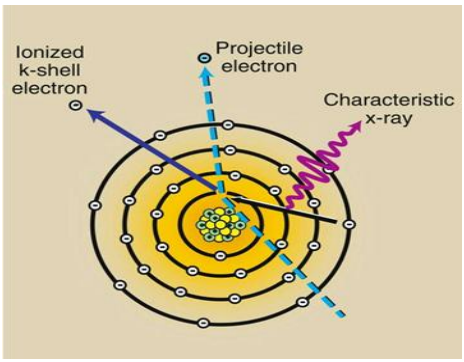

Figure 5: Characteristic Radiation

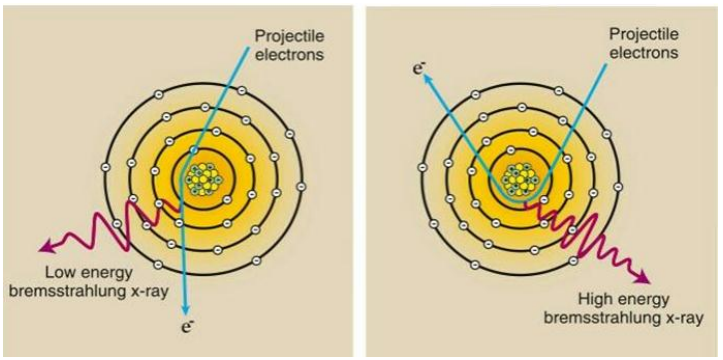

Figure 6: Bremsstrahlung Radiation

The K X-rays have the highest energy among all other characteristic radiation as the binding energy of K shell electrons is highest (Table-01) and so K characteristic X-rays of Tungsten are useful for imaging. Since the binding energies of the electrons are different for different elements, the energy of the characteristic x- radiation also varies with the target element. With increasing atomic number of the target element, the effective energy of the characteristic X- radiation also increases.

Bremsstrahlung Radiation: When a projectile electron avoiding all the orbital electrons to the target atom comes very close to the nucleus of the atom its speed and trajectory is influenced by the nuclear field, which results in the reduction of its speed as well as change of its trajectory. The reduced kinetic energy of the project electrons is released in form of X- radiation, which is called Bremsstrahlung Radiation. Closer the projectile electron passes by the nucleus more it is influenced and more energy is released. Bremsstrahlung radiation plays a major role in diagnostic imaging.

Shells	Principal quantum no. (n)	No. of electrons	Approx. Binding energy (keV)
K	1	2	69
L	2	10	12
M	3	18	3
N	4	32	1
O	5	12	0.1
P	6	2	

Table 1: Binding energies of electrons of different shells of Tungsten (Z=74)

X-ray Spectrum: In case of Bremsstrahlung Radiation, the projectile electrons can lose any amount of its kinetic energy and so, in a x-ray imaging system operating at 70 kVp, the X-rays produced in Bremsstrahlung interaction can possess energy

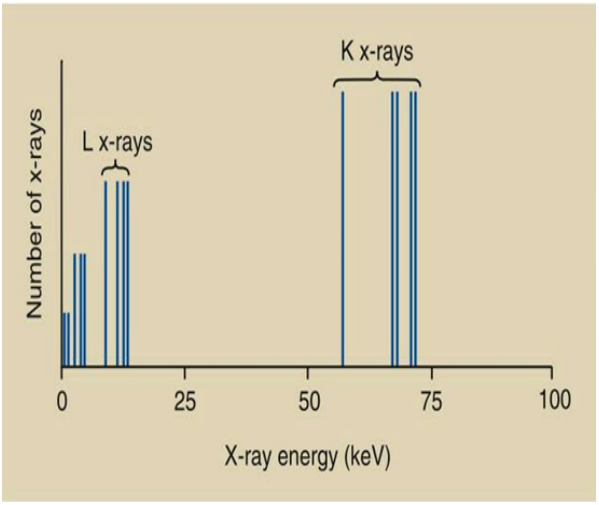

Figure 7: Characteristic X-ray emission spectrum

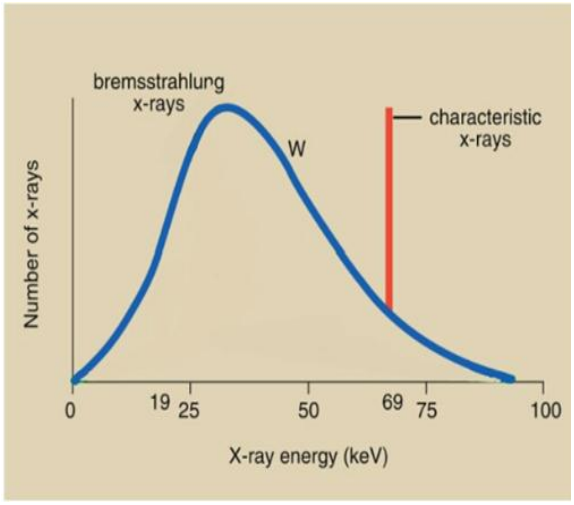

Figure 8: X-ray emission spectrum

up to 70 keV. That's why the spectrum of Bremsstrahlung radiation is continuous.

On the other hand, the characteristic radiation can only have a certain numbers of discrete energy values as the binding energies of electrons of different shells are also discrete. Hence the corresponding spectrum is discrete. The Bremsstrahlung radiation can take place at any kVp, whereas the characteristic X-radiation requires at least 69 kVp. So at low kVp, the X-radiation mainly consists of Bremsstrahlung radiation.

X-ray Interaction with Matter and Image Formation: X-rays interact with matter through five ways: coherent scattering, Compton scattering, photoelectric absorption, pair production and photodisintegration. The coherent scattering occurs below approximately 10 keV. The pair production and photodisintegration occur in case of X-rays having energies greater than 1.02 keV and 10 keV respectively. Hence only Compton scattering and photoelectric absorption play important role in diagnostic radiology.

Compton Scattering: Compton scattering occurs when X rays with moderate energy level interact with outer shell electrons and cause ionization of the target atoms. This results into the scattering of X-rays as well as change in the wavelength and thus change in the energy of the X-rays. The energy of the incident x-ray (Ei) equals the sum of the energy of the scattered x-ray (E_s), the binding energy (E_b) and $\mathbf{E_i = Es + E_b + E_{K.E.}}$ Kinetic energy (EK.E.) of the Compton electron.

Photoelectric Absorption: Photoelectric absorption occurs when the incident X ray is completely absorbed by the target atom causing ionization of the atom through removal of an inner shell electron called photoelectron. The energy of the incident x-ray (Ei) equals the sum of the binding energy (Eb) and kinetic energy $\mathbf{E_i = E_b + E_{K.E.}}$ ($E_{K.E.}$) of the photoelectron.

Dependence on Atomic Number: Compton scattering doesn't depend upon atomic number of the atom and so the atoms of bone and soft tissue both have the same chance that the incident X-ray will undergo Compton scattering. But the probability of photoelectric absorption is directly proportional to the third power of the atomic number of the absorbing material. That's why in comparison to the soft tissue atoms (usually C, O, N, H), the atoms of bone (like Ca) have more probability that the incident X-ray will undergo photoelectric absorption. This difference between X-rays absorbed photoelectrically in the patient and transmitted to the image receptor is called Differential absorption and it's responsible for the formation of X-ray image. The anatomical structures, through which X-rays are transmitted to the receptor, are called radiolucent structure and anatomical structures which undergo X-ray absorption, are called radiopaque. The darker region in a radiographic image refers to the radiolucent parts and the lighter parts in the image represents the radiopaque structures. The Compton scattering doesn't convey any useful information to the image rather it causes noise to the image. On the other hand, the difference in photoelectric absorption of X-ray in different anatomical structures conveys useful information about the respective anatomical structures.

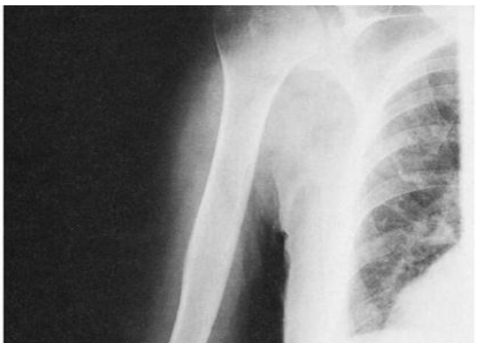

Figure 9: Radiograph of bone structures

Dependence on Mass Density: As the mass density increases, the probability of absorption and

scattering also increases. Hence other than the Z-dependent photoelectric absorption, the difference in mass density between different anatomical structures also helps in the formation of the radiographic image of the respective structures. In this case, the denser regions absorb more X-radiation and appears lighter in the radiograph.

- **Computed Tomography or CT Scan:** Computed tomography are CT scan takes a series of X-ray images taken from different angles and with the help of computer it combines them to generate cross-sectional images of different anatomical structures like brain, spine, heart, lungs etc. Usually in a computed tomography, the X-ray imaging system rotates around the central axis of the region being scanned and thus takes a series of X-ray images to generate a 3D image

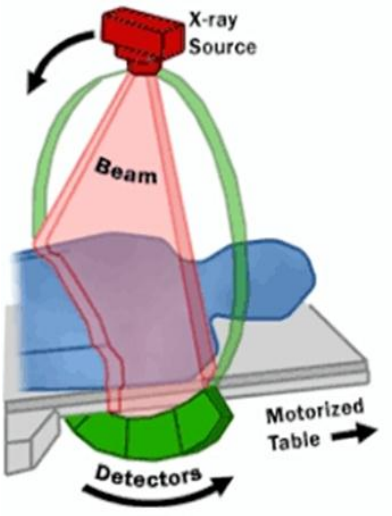

Figure 10: CT scan

- **Use of X-rays and CT scan:** X-rays and CT scans are used to diagnose a number of diseases and health conditions, which includes bone cancer, breast tumors, osteoporosis, arthritis, fractures, tooth decay, gastrointestinal issues, lungs diseases etc. Chest CT scans have been playing a very vital role in the diagnosis, detection and prognostication of the covid-19 disease.

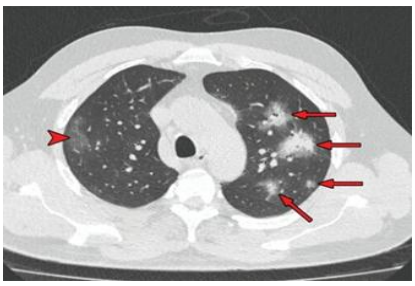

Figure 11: Chest CT scan of a 55 years old COVID-19 positive patient.

- **Basic Safety Measures:** Exposure to X-radiation puts both the radiation workers and the patients at a risk and if not dealt properly, then it can give rise to many serious health complications. The Atomic Energy Regulatory Board (AERB) has issued safety code which must be followed by the labs during conducting the tests. Some of the safety measures are:

1. The rooms housing the diagnostic x-ray equipment must be located in an isolated area far from areas of high occupancy.
2. There should be appropriate structural shielding for the walls, doors, windows, ceilings and floors of the X-ray room.
3. The number of doors for entry in the X-ray room should be kept minimum.
4. The unshielded openings for ventilation should be located above a height of 2 m from the finished floor outside the X-ray room.
5. Waiting area should be provided far from the X-ray room.
6. No person other than associated staff should stay in the room.
7. The room must be kept closed during radiation exposure.
8. In no case the film for x ray tube be held by bare hands.
9. Radiation exposure can be very harmful for the foetus and so examination of women who are pregnant must be given special consideration.
10. Gonad Shields should be used to protect the reproductive organs of the patients unless it is interfering with the desired information. Eye shields, thyroid shields can also be used when necessary.
11. The radiation workers must use appropriate personal radiation monitoring devices like personal dosimeters.
12. To ensure minimum possible dose to the patient the field size should be minimized in accordance with the diagnostic requirement.

TEACHERS' ESSAYS CATEGORY (B)

YEAR 2019

Physics of your city, community and surroundings

YEAR 2020

Pollution in our community, measurements and Physical insights

YEAR 2021

Modern Physics and Medical Diagnostics

Starting on the next pages...

PHYSICS OF YOUR CITY, COMMUNITY AND SURROUNDINGS

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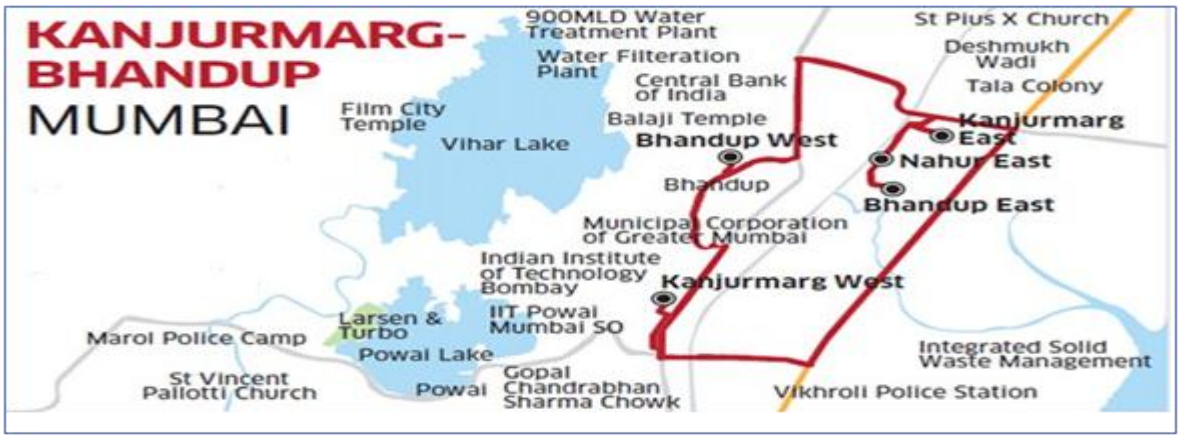
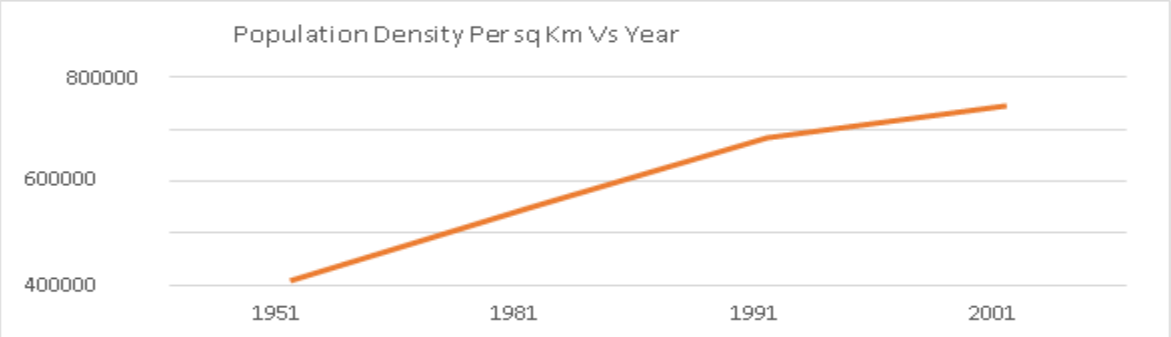
Key Words: Bhandup, Solar Power, Gravity, Conservation, Biodiversity, IITB.

Introduction

Bhandup is a suburb of Mumbai very vibrant in its culture lying on the central railway line. Map of Bhandup with latitude and longitude 19.14 Degree North 72.93 Degree East
Rough area in Sq. Km: 37.80



Rainfall and Temperature Ranges: Average yearly temperatures vary between 25°C and 35°C Average rainfall is 400 mm with instances of 600 mm sometimes.
Population Density Per sq. Km is 6,91,227 according to 2001 census.



Means and consumption of Electrical Power: Electricity is supplied by Maharashtra Rajya Vidyut Vitran Company limited. There is also Tata Power Sub Station towards Lake Road.
Many big Societies have Gas pipeline connections
Means and Consumption of Water: Bhandup Pumping Station, Largest water treatment plant in Asia.
Transport particularly public BEST buses from LBS road go to Western and Eastern Suburbs and also to Worli, Mulund and Thane.
Fast and Slow local train services are available. The second corridor to go out of Bhandup west station is now in full swing to reduce the load of one extreme end use of corridor.
The metro rail above the famous LBS road will shortly connect Thane to Wadala (near Dadar)

Bhandup name comes from Bhandupeshwar another name of Lord Shiva after whom a temple is located near Sonapur Signal south of Dockyard Colony. It has been a historic place since it was part of Salsatte island famous and developed by British in early eighteenth Century. Parsi Framjee Cowasjee Banaji (owning large estates here) had many agricultural experiments at Powai. His salt works near Bhandup yielded good results.

The Missionary Weekly Newspaper Bombay Guardian of 25th January 1890 (Page 11) gives the following information Bhandup a small station 17 miles up the Great Indian Peninsula Railway line in the vicinity of the Vehar (Vihar) and Toolsee (Tulsi) lakes was the spot chosen by the Fort Methodist Episcopical Sunday School for their annual picnic. The picnickers after breakfast walked to the Vehar Lake. The children were called together and joined in singing "What a friend we have in Jesus." This information shows how this place was a picnic spot, and today also the Powai Lake is a loved spot for morning and evening walkers and also youngsters especially from the I I T campus.

The Municipal Garden named Baden Powell located near the Powai Lake has rare flora and is a lung space for elderly and nature walk lovers. It is located inside the Municipal Garden adjacent to the Powai lake. It has variety of flowers.

The Bombay Government Gazette of August 19, 1954(Page 1067), 23rd September 1954(page 1210), 30th September 1954 (page 1238), 7th October 1954 (Page 1285) shows Bhandup's population by the Census of 1951 as 15,787. But in last twenty years its population has risen like mercury

Today Bhandup is one of the oldest suburbs of Mumbai within S-ward administration of Municipal Corporation of Greater Mumbai as is visible from the history above. It is Mumbai North East Lok Sabha Constituency very much a residential community though earlier it had many industries like Lambrata Scooter factory, GKW factory which produced safety pins and now closed down, Ceat tyers now closed down and the area is commercially developed etc.

Activities I witness on a daily basis

The Bhandup West area outside station is very crowded in Working hours especially 8 to 10 in morning and 5 to 10 in evening, which shows that the working population inside Bhandup predominantly uses local train as a mode of communication. Best Buses and shared Autorickshaw help commuters from Shivaji Talao, Nardas Nagar, Jungle Mangal Road, Bhattipada, Punjabi Chawl, etc areas to come to the Station.

Fresh Nira Drink used to be available outside the station when I came here to stay in 2016, proving the availability to tad trees around, but now it has disappeared. There are also monkeys in the vicinity of Bhandup since the Borivali Sanjay Gandhi National park is not far off.

Solar Power and Gravity based Water Supply System

The Chief lakes Powai and Tulsi around Bhandup geographically lie on higher planes than the city as a result, there is no derth of ground water in the city. It enjoys supply of bore-well throughout the year. The Tulsi – Vihar Lake has capacity of 35,000 million liters of water. The city also has many small lakes which too have water throughout the year. The Bhandup water treatment plant is India's largest and oldest in Asia. It is estimated that 460 MGD of clean water is treated at Bhandup Water Power Station. Last year BMC upgraded this plant with solar power unit (2.5 MW) on an area of 26,000 sq. mts. It created history as it was the first time in our country that solar power was used in such a large scale for water treatment. The Bhandup pumping station treats 2300 MLD of water daily requiring 45 lakhs of power monthly at the cost of Rs. 3.5 crores. The solar power unit will cover 30% of the energy demand. It has proved to be cost effective as well helps in reducing carbon in the

environment. The water reservoirs in Mumbai are mainly situated on hills like those of Powai and Bhandup; as a result water can be transported easily via pipes with comparatively little power.

Scientific Waste Disposal Ground

I am a resident of Dheeraj Dreams Society Bhandup for the last three years. The 66 Hectare Kanjur Dumping Ground is nearby handling 80% of Mumbai's Garbage. Segregation at source is simply the best way to manage the gargantuan garbage generated so our Dreams Society conscientiously follows the wet and dry waste segregation using two bins- Green for compostable organic waste and Blue for all the rest. Since our Society is very big BMC decided to ask large Municipal Solid Waste (MSW) generators like our society to make their own composing arrangements. We have in all 7 Dreams Societies as well as DCHSA, and BMC stopped sending its daily compactor garbage pick-up vans to our campus from 1st January 2019. Urgent negotiations with BMC approved outsourced- composting vendors by paying Rs 3500 per day for the entire Dreams Residential Complex to a Navi- Mumbai vendor (so Rs 50 is charged per flat per month)

Garbage disposal at Kanjurmarg- Bhandup has capacity to handle 3000 tons of garbage a day. This is far beyond the waste generated in nearby areas. New scientific methods like Anaerobic digestion is used to treat the garbage with byproduct methane (source of clean energy) and remaining solid waste as fertilizer. Our Prime Minister has called for involvement of all in managing and treating our own waste.

City's Largest Solar Panels

Our Society building has installed solar panels generating 800 KWh power per day on the terrace (25,000 sq. ft. area) of 20 storey building, and the electricity generated is used effectively for lift and corridor lights, water pumps etc. It covers approximately 70% of the power needs of our society. This is said to be the possibly the largest renewable energy system used in a residential complex in suburbs of Mumbai. Extra electricity given to Maharastra State Electricity distribution board and the electric charges are adjusted against the consumption by the society. There is a facility to send the extra power generated back to the grid. It is estimated that this setup will help save 309.5 tonnes of Carbon dioxide emissions over next 25 years. The cost of the project /installation is deemed to be covered in 30 months' time and the cost of electricity generation is estimated at Rs 2.71 per units against Rs14 per unit normally. This project was granted a subsidy of Rs 36 lakhs from the government. The society is proud to have moved away from pollution.

World Renowned Scientific Institution

I I T Mumbai (IITB) is the most renowned scientific institution which came up with the help of USSR's collaboration after independence. IIT campus has a school, residences and innovation centres. It has two gates viz the main gate and market gate. Due to its proximity to Sanjay Gandhi National Park (Borivali) it has presence of leopard. The scenic beauty of IIT is enhanced by the lush green campus and close vicinity to Powai Lake and Hiranandani Complex. The campus conducts Mood - Indigo yearly event which is popular with students all over the world. During this festival students display the innovative projects developed by them and they have opportunity to interact with scientists as well as visit the campus.

The innovative Center for environment science and engineering at IITB helps in promoting cleaner technologies, prevention of Industrial pollution, biomedical waste management etc. and conducts regular training programs.

IITB provides all scientific facilities for research to the neighboring institutions/ industries needed for promotion of research. It has state of art facilities in many of its centers like Center for research in nanotechnology and science. Well known researchers and scientists in the IITB campus make India Proud.

The Naval Civilian Housing Colony

The Naval Institute is located in Kanjurmarg- Powai. There is also big Naval Civilian colony area with lot of greenery. It is a housing colony for officers families with all amenities. This colony has innovative water treatment process (SBT System) installed with the help from IIT Mumbai. Raw waste water is passed through several layers of soil, sand, gravels. Suspended solids can be removed periodically from the top. The resulting water for reuse is promisingly clean.

Conservation of Mangroves: The life line of Coastal Mumbai

Coastal and Marine Biodiversity Centre is located in close proximity of Bhandup in Airoli. It was developed as a Indo-German (GIZ) project for conservation and sustainable management of Marine areas. A sought of protected zone for conservation. This Marine Mangrove institute is an innovative timely action taken by the Government of Maharashtra to prevent the precious mangroves to Thane creek stationed at Airoli very close to Bhandup. The tour begins with an explanation to a wide variety of birds, crabs and other sea creatures which help in preserving the environment. This is followed by a visit to a museum which displays the role played by mangroves in preservation of environment with the help of state of art interactive features. The visitors are excited after hearing the sounds of whales, flamingoes etc. There are also shows of 40 minutes on why mangroves need to be protected in Marathi and English. The chief attraction is the Flamingo boat ride that is most popular from October to June months, which is a much awaited ride for bird lovers. The center has many divisions like

coastal biodiversity that exhibits the mangroves and aquatic life and the marine biodiversity with exhibits on whales, dolphins etc. Right now a carcass of a young whale can be seen under installation. In all 600 marine species are expected to be displayed. The center provides altogether new experience of life forms (animals and plants) in a marine ecology system which is so closely related to the environment setup especially to coastal city like Mumbai.

PHYSICS OF YOUR CITY, COMMUNITY AND SURROUNDINGS

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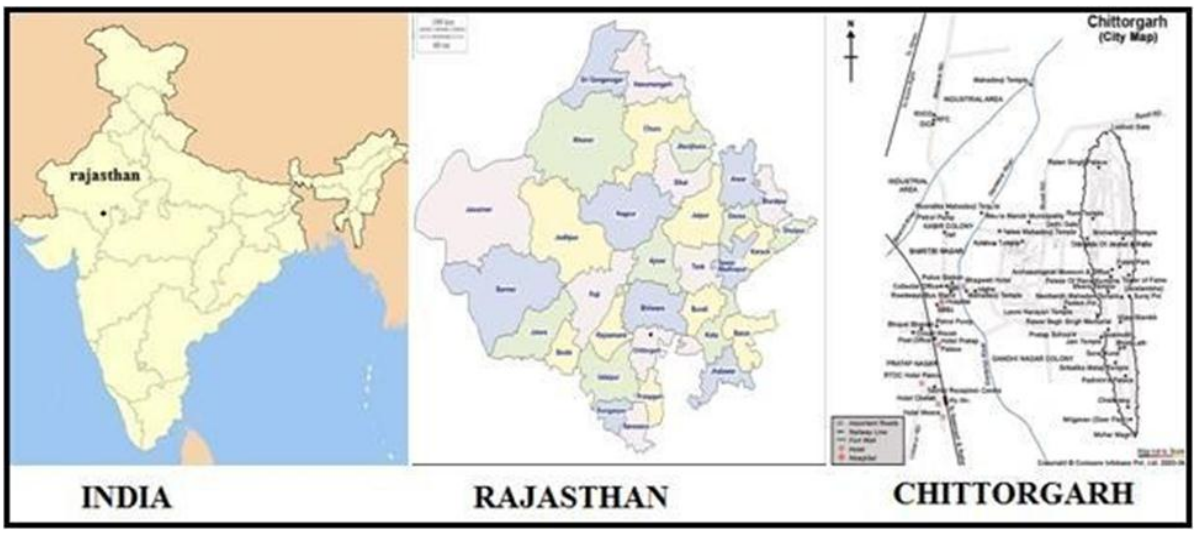
ABOUT THE CITY - CHITTORGARH
THE FIRST PART

The heritage & history of place Chittorgarh has unique place in the world. It is known for SHORYA and BHAKTI KI DHARTI. It is remembered and known for fighting for independence, not surrendering against Muslim attackers. The place is known for all time legend Maharana Pratap, Chetak horse, Rani Padmini Johar, etc. Apart from Meerabai, it is also known for Panna Dai. This place has unlimited number of stories of bravery, sacrifice and Rajputana AAN-BAAN & SHAN.

Chittorgarh is a major city in Rajasthan a state of north western India. The city of Chittorgarh is located on the bank of river Gambhiri and Berach. Berach River is a tributary of Banas. Chittorgarh is administrative headquarter of Chittorgarh district and a former capital of Sisodia Rajput dynasty of Mewar.



Chittorgarh is home to the Chittor fort the largest fort in India and Asia. It was the site of three major sieges (1303, 1535, and 1567- 1568) by Muslim invaders, and its Hindu rulers fought fiercely to maintain their independence. Chittor also has been a land of worship for Meera. It is also known for Panna Dai and Jauhar many times specially by Rani Sahiba Padmini.

The completed golden quadrilateral highway system passes through Chittorgarh, connecting it to much of the rest of India. The East-West Corridor (Express Highway) also crosses it. Chittorgarh is situated on National Highway No. 76 & 79. National Highway 76 connects to Kota with a driving time of 2 hours.

Chittorgarh Junction is a busy junction of Western Railway of Indian Railways, Ratlam Division. Chittorgarh is well connected to all parts of India by roads. The Golden Quadrilateral Road Project and North-South-East-West corridor expressways pass through Chittorgarh City.

The bus stand (bus depot) of Chittorgarh is located between the old and new cities. There are good bus services (private as well as state-owned) available for Delhi, Mumbai, Ahmedabad, Ajmer, Bundi, Kota, Udaipur, and other major cities.

Rajasthan roadways (RSRTC) provide a service for visiting areas around Chittorgarh. Rajasthan Roadways also has premier services called Pink Line, Silver line and Sleeper Coaches (Grey Line).

The nearest airport is Udaipur (Dabok Airport). The airport is located 70 kilometers from Chittorgarh and linked by daily air service from New Delhi, Jaipur, Jodhpur, Ahmedabad, Chennai, and Mumbai.

Chittorgarh is located at 24.88°N 74.63°E. It has an average elevation of 394 meters (1292 ft). Chittorgarh is located in the southern part of the state of Rajasthan, in the northwestern part of India. It is located beside a high hill near the Gambheri River. Chittorgarh is located between 23° 32' and 25° 13' north latitudes and between 74° 12' and 75° 49' east longitudes in the southeastern part of Rajasthan state. The district encompasses 10,856 square km (3.17 per cent of the Rajasthan State) area of land.

The city population of Chittorgarh is approximately 1.5 lakhs. The average rainfall is 90 cms per year and temperature ranges from 12 degree min. in winter to 42 degree in summer. The electric power is supplied from atomic reactor situated at Rawatbhata. The sources of water supply are natural and tube well. The ground water level is quite good because of rivers and dams in the surroundings.

Now a days, it is also known for one of the largest zinc-lead smelting complex in the world at Chanderiya near to Chittorgarh, nuclear reactor at Rawatbhata, one of the largest cement factory project in India, biggest coaching city Kota in its nearby. Large number of colleges of all streams affiliated to Sukhadia University Udaipur are there in the city for advance education.

PHYSICS OF MY COMMUNITY

People of my city are science loving, they live science in every walk of life even in playing, walking, cooking, farming, etc. Some examples from their daily life are:

1. When asked to drive within safe limit at circle or curved road they agreed and now most of the youth is following my advice. I convinced them that if we go beyond $v = \sqrt{gR}$ on a curved road. It is fatal to life.
2. Avoid use of too much plane sleepers in bathroom and kitchen or outside home in rainy season. They listened me and changed their sleepers to avoid accidents as new sleepers from bottom are rough shape sufficient to stop unwanted motion by interlocking between grooves of sleepers and ground.
3. When cricket loving children were asked to lower their hand while taking catch, first they were hesitant but when explained by impulse-momentum theorem, they got that by use.
4. My community people are also aware that wearing two thin shirt is better than to wear a thick shirt for preventing from winter.
5. Touching live wire with wet stick, doing electric household work without insulating from earth may become fatal to life.

THE SECOND PART

KEYWORDS – REFLECTION, UP HILL, STEEL SPIKE GATES, PRESSURE, NOTCHED PARAPETS, POINTED ARCHES, CURVED MOTION, MOTION ON VERY LARGE INCLINED PLANE

One of the UNESCO world heritages with its grand walls, standing tall and built on a hill the world's famous glorious Chittorgarh fort is known for Rajputana Shaurya, long story of courage, determination, sacrifice, worship and fighting battle untiredly for freedom. Positioned on elevated hill of 180 metre near the Gambhiri river, it extends 3 km in length and 13 km in peripheral length covering total area of 700 acres. It looks like fish when viewed from above. This largest fort in India is at top of 590 foot tall hill, with towers and walls that have stood since many years of the Maurya empire rulers who built it.

The largest fort in India and Asia Chittorgarh fort has withstand three major Muslim invasions starting from Alauddin khilji, Akbar and Bahadur shah but never for once seen as a Muslim bastion and always regarded as the hallmark of the Rajput amour prosper and its scientific architect. One world heritage site, this fort was capital of MEWAR and presently in Chittorgarh of Rajasthan state. The fort precinct has several historical palaces, temples, gates and two prominent commemorative towers called Vijay Stambh (tower of victory) and Kirti Stambh (tower of fame).

The ascent of the fort passes through seven gateways, sharp turn road, partly flanked by hexagonal or octagonal towers including Vijay stambh and Kirti stambh, Rani Sahiba Padmini palace, Hindu Jain temple and many more are protected by enclosing defensive walls.

For water supply management and storing capacity for emergency was made by originally 84 water bodies built within the 700 hectares of the fort area of which 22 still sustained. Together the water bodies can store up to 4 billion litres of water which is sufficient for an entire year that can quench the thirst for 50,000 lives for a span of 4 years.

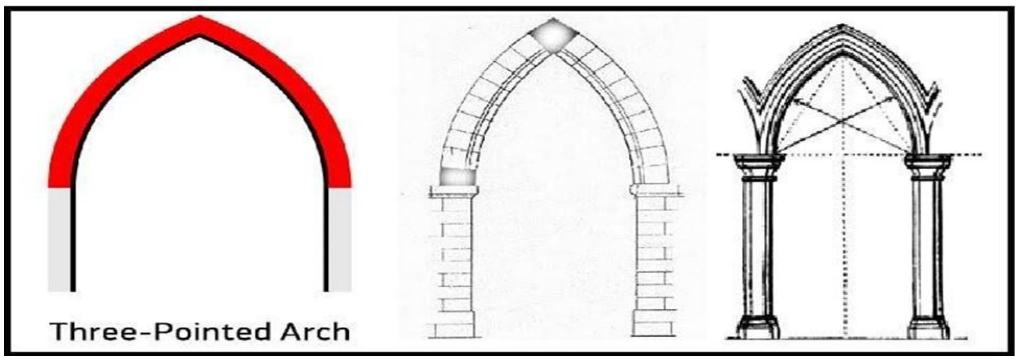
There are seven gates safe guarding all the entrances. Seven gates out of which one was built in 5th century and rest were built in the 15th century. These gates in order are namely Padan pol, Bharon pol, Hanuman pol, Ganesh pol, Jodala pol, Laxman pol and lastly Ram pol named on the ancestors of the king of Mewar. They were the descend out of lord Rama. These gates were built to protect the fort from the enemy attack. The arches were built against the elephants entering the fort. The walls are made of lime mortar and rise up.

Padan pole is the first gate and its name is derived from the rajasthani word "PATWI" which means eldest or first. There is a legend which says that after Alauddin Khilji made a siege a buffalo kid named PADA was brought down with force so it was named as PADA.

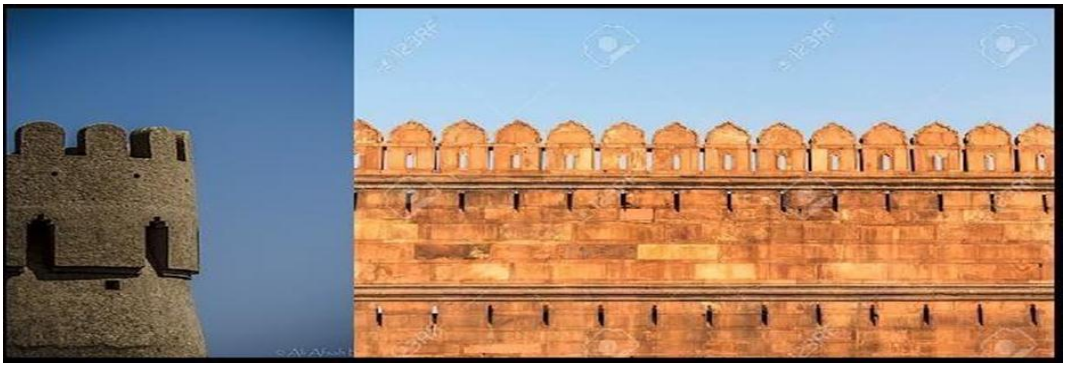
SCIENTIFIC FEATURES IN THE FORT

1. SCIENCE IN THE GATES

All the gates of this colossal fort were built scientifically for security purpose and not surprisingly the gates have special architectural designs. All the seven gates of the fort are nothing but massive strong structure aimed at providing maximum security from the potential threat of enemy. The gates have pointed arches to make sure that it provides extra protection during attack by enemy.



Notched parapets were built on the top of the gate, enables soldiers to shoot arrows at the enemy army. These defensive low wall between chest-height and head in which gaps or indentations occur at interval to allow for the launch of arrows or other projectiles from within the defenses. These have large area of influence, large field of view at low expected loss.



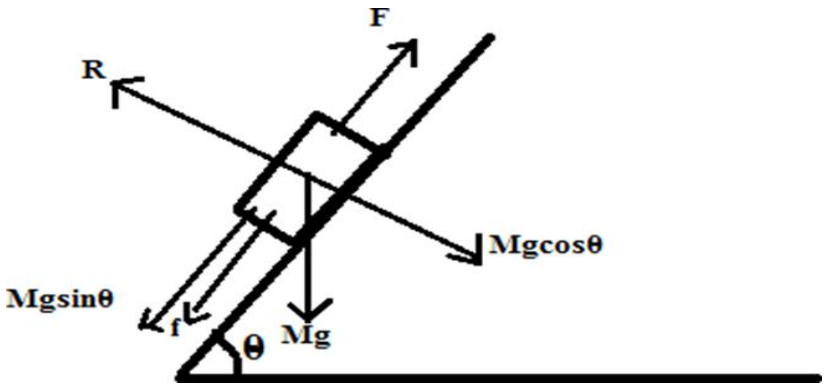
The gates were made in such a way that they provide full security to the fort from invasion. They were built with heavy stones and pointed steel arches. The steel arches were pointed so that the elephant of the enemy cannot push the gates and enter into the fort as they gets badly wounded in pushing gates covered with pointed and javelin type of structure.

PRESSURE= FORCE/AREA

As area of pointed end is small pressure is large, it injured the elephant and therefore elephant cannot push the gate.

2. SCIENCE IN WALL STRUCTURE

The massive Chittorgarh fort with its grand walls standing tall and above built on a hill. Some where the walls were rough having irregular inclination so that one cannot climb up easily and uniformly. These walls are made of lime mortar and rise up almost vertically to 500 meter above the ground level. To climb up for an enemy to such a vertical height on wall without support against gravity and fiction is impossible task.



The force required to move up hill on a vertical wall is

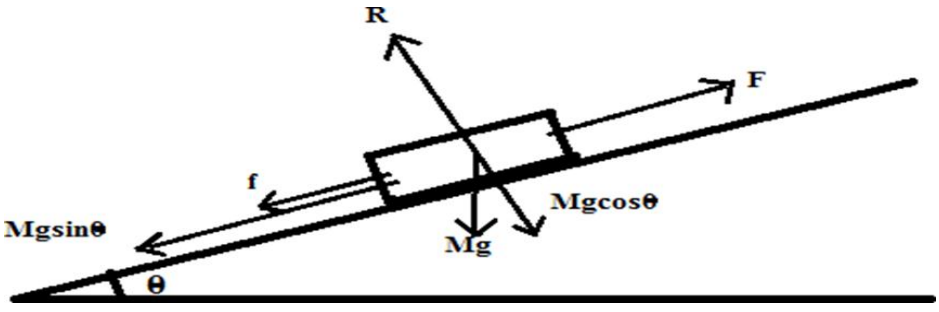
F= f + MgsinΘ

As Θ is almost 90 degree. Hence sinΘ is maximum. Therefore maximum force is required. Because of this reason although the fort was attacked 3 times and every time it got saved by the daring heroism of the Rajput warriors and scientific built of the fort.

The walls of the fort are often looked higher from the outside then the inside. It helped insiders of the fort to look outside easily and difficult for outsiders to climb up. The walls of the fort are very thick and stone is most important material with lime paste for building forts.

3. SCIENCE OF ROAD INSIDE THE FORT

There is a mile long common road that runs inside the fort connecting all the gates. Climbing up hill with sharp turn against gravity and friction by overcoming seven protective gates was so impossible that Khilaji army waited for months to enter into fort and finally got failed every time because of scientific structure of the fort.



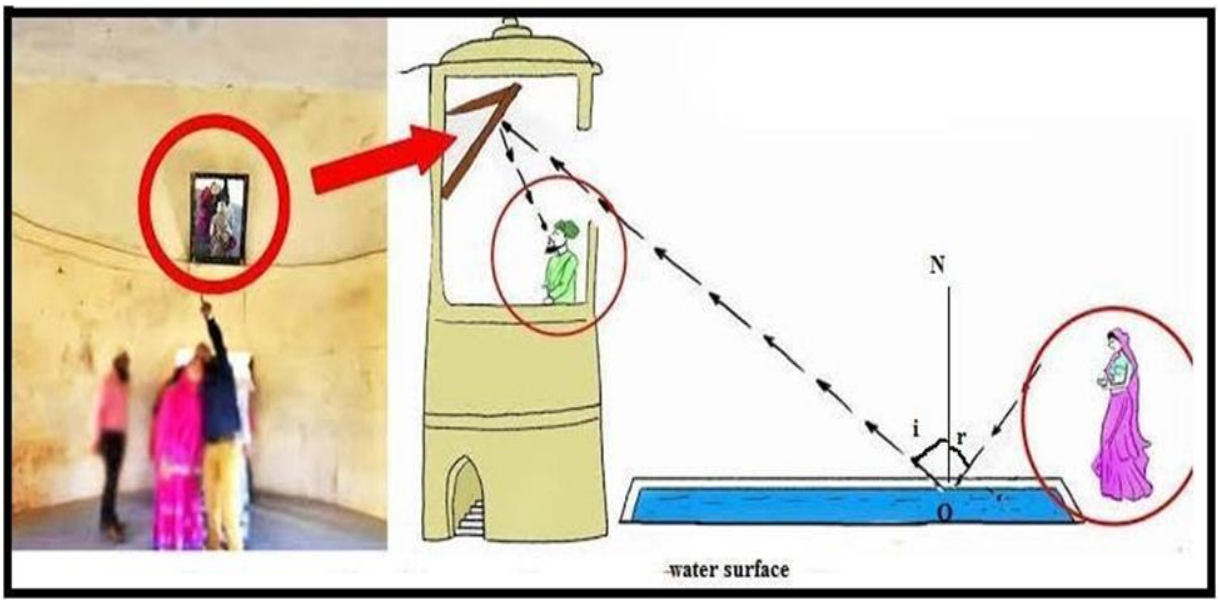
WORK= FORCE×DISPLACEMENT

WORK = (f + MgsinΘ)S

As inclination increases sinΘ also increases and hence more work has to be done.

4. REFLECTION OF LIGHT AS LEGEND OF MAHARANI PADMINI JI

The fort defenders sallied forth to change the attacking enemy but yet not able to succeed. Among all the three attack, the first one becomes an unforgettable which gave a huge example of women empowerment. Queen Padmini was aware of the brutalities caused by the foreign invaders and refused to meet. On request from Khilji and unfavorable condition it was decided to let him see her reflection only. There were arrangements made and mirrors were set in such a way that Khilji could only see her reflection. Thus Khilji saw her from the fort on the left, while she stood on staircase of Padmini Mahal. Many ambitious filmmakers distorted the real history and presented in wrong way against feelings of the local people that caused dispute.



Hence the entire fort is built scientifically in such a way that it makes it almost impregnable for the enemies to enter making life in the fort to survive safely for long without external supply.

PHYSICS OF YOUR CITY, COMMUNITY AND SURROUNDINGS

Mihir Pal
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Introduction

There is a famous quote that- "If you can't clean your surroundings then don't make it dirty". As far as our environment and surrounding is concerned, we should be a part of solution of our environmental problem and not a part of environmental pollution. We all are the product of nature – we have originated from nature, brought up in nature and will terminate in the nature and so to make our surroundings sustainable, is an essential and prime task of us for our existence and also for our future generation. Nature is the only place of our origin and existence but since birth how much our activity has become eco-friendly? Rather in most cases we are threatening our environment through our activities. Even Einstein told in his tenure of life that- "We shall require a substantially new manner of thinking if mankind is to survive". Physics is very much helpful for designing any city full of energy, water, food and minerals resources and its successful implementation will certainly improve the sustainable nature of people's lives as well as of our planet also. More than fifty percent of world's population resides in different cities and thereby exerting increased stress on our earth and more than 70 percent of global carbon dioxide emissions come out from urban areas. So, cities are the key issue which decides whether the sustainable nature of our planet is maintained or not and in this regard designing of any city, community and surroundings in eco-friendly manner has got highest importance. Physics may be used in diverse manner for development of any city, its community and surrounding; but always effort should be given to make these issues in more sustainable manner. Keeping in view all these issues, a case study has been carried out on the city Agartala, the second largest city of northeastern India and on its community and surroundings from the frame of Physics .Considering the geographic location along with climatic condition of the city, application of diverse technology guided by principles of physics is very much helpful to improve the scenario of electrical power consumption, water consumption, transport condition etc. of the city. Using Physics principles, generating the scientific awareness and spreading all these in the entire communities of this city is also a challenging task of the physicists for overall development of the human resources of the city. Development of the society may be accelerated if peoples can be made scientifically literate in micro level and physicists of this city have to play a vital role in various manners, in this regard. It is based on the theories of Artificial Neuron Network (ANN) that Physicists Luis Bettencourt, Geoffrey West, and co-workers can be able to successfully explain several macroscopic aspects of cities. In this era of digitization, physicists can also exercise the combined studies of computing power and computational techniques based on commercial and governmental records to get the insight view of the urban structure and its dynamics properly.

Sustainability of City

The word sustainability means "the quality of causing little or no damage to the environment and therefore able to continue for a long time". Long-term ecological balance is the main criteria for any city to be sustainable. Planning of any city with the help of Physics principles can make the city more and more sustainable. In order to maintain sustainability of any city proper management and governance of resilience is to be adopted. Sustainable and social-ecological system may be achieved

by governance perspective on climate change. Effective implementation and monitoring of plans are needed to ensure the sustainability of the city area. Unsustainable practices followed by the stakeholders of urban areas should be restricted by social media and by other means. Physics can play a crucial role in various manners for sustainability of any city. Geographic Information System (GIS) can be used to form a linkage between ecological scenarios gathered from the analysis of satellite photograph and management policies adopted for sustainability of the city. For boosting the sustainability of the city area integrated management plan is to be implemented and in order to increase sustainability of the city the following issues have to be considered with top priority.

Use of sustainable energy source

Most of our daily energy requirements like as in transportation, lighting, cooking etc. are based on conventional energy sources and these energies are again based on fossil fuels like coal, petrol, diesel, kerosene and natural gases. All the fossil fuels are carbon based and as a result combustion of these items releases CO_2 gas in the atmosphere. This CO_2 absorbs the infrared part of radiation reflected from earth surface and then reradiates it back to the earth, creating the 'greenhouse' effect. The average global temperature of earth is increasing day by day due to this effect. Due to human activities other released greenhouse gases like CH_4, N_2O, CFC are giving threaten to the average global temperature. This increased global temperature results several environmental imbalance like erratic weather patterns, floods, droughts etc. Moreover health hazard due to combustion of fossil foils are also threatening the life-span of human beings. More and more uses of sustainable energy sources rather than conventional energy sources can make the city more resilience and thereby reducing the vulnerability of eco-system. The choice of clean and sustainable energy source is obviously the sun's energy, which is also abundant. This energy source is a nature's gift; source of energy in the sun is the fusion reaction but due to its large distance of 149,600,000 km away from earth surface we are almost safe from its nuclear radiation. This has been estimated that the solar energy that received by earth surface in one second is equivalent to 4 trillion 100-watt light bulbs. So this source of energy puts the signature of only solution for energy crisis of any city in sustainable manner. Physics is playing a vital role for developing more and more cost- effective solar energy conversion technologies in this regard. Suitable strategic plans are to be adopted by any developed city for availing the facility and charm of this beautiful green energy resource.

Solid Waste Management

Undisciplined lifestyle and bad habits of the stakeholders of urban areas increases the solid waste generation. Mainly a large communities and industries of a city are generating hazardous solid waste affecting the environment of the city. Even a large section of people drop their solid waste in open land like on the roads, stairs and in various public places. Solid waste generated due to such kind of activity and there after their unscientific collection may cause viral fever, headache etc. Moreover deposition of solid waste may hamper the aquatic lives of inhabitants. Increase of harmful insects, growth of mosquitoes, bacteria etc. are also due to lack of scientific management of solid waste. Solid waste may also cause the release of methane and environmental degradation due to its toxic materials. So, it is essential for any healthy city to have facility of scientifically strong solid waste management system. Organic solid waste may be easily decomposed to produce so called compost fertilizer. But the challenging task for any city to control its environmental degradation is the management of solid waste arising due to plastic materials. Increased rate of use of plastic materials is one of the major environmental concerns for any city. Moreover, these materials are remained intact in environment even more than hundreds of years and thereby releasing their toxicity effect directly or indirectly in environment gradually. One of the best solutions of this problem for any city

is to recycle these waste materials by using them as cost-effective construction materials without disturbing the strength of construction. Physics can also be used to explore new and innovative techniques of recycling such materials in more environmental friendly manner.

Ground water recharge

Ground water is the most important and comparatively safest source of fresh water .In fact the topography and geology of any city has an impact on natural ground water flows in its drainage basins. This type of water flow may be classified as unconfined and confined. Ground water can also be discharged naturally into rivers, lakes, reservoirs or directly into the ocean in case of coastal areas. Moreover ground water level can also be lowered due to upward movement of water from the water table through capillary fringes. So ground water recharging is the only solution for restricting the depletion of an aquifer.

For our future generation, ground water is a valuable resource and this must be protected with highest priority for drinking – water supply of any sustainable city. This is the only source of water which is less costly than distribution of surface water after treatment. The ground water availability over different part of our country is not uniform. In urban areas recharge of ground water can be enhanced by conserving roof top rain water and this mechanism has a great potentiality in this regard. For any sustainable city development, there should be some master plans which are to be implemented for rain water harvesting.

Proper drainage system

In order to keep the city environment well drained and free of waste materials, there should be proper drainage system which ensures the transportation of waste water and sewage to the disposal points of city. Construction of high rise building in any city without proper drainage system cannot be the signature of real infrastructural development. Improper and unscientific drainage system causes obstruction to the free flow of water in rainy season and this may cause damage in various ways to the private and public properties of city by flooding. Poor drainage system can also be the cause of foundation damage to a building or home. Structural failures of roads in city area may also be the result of poor drainage system.

Improper drainage system causes erosion problems in city area. Moreover the gathering of stagnant water welcomes the breeding of mosquitoes responsible for the cause of diseases like malaria; dengue etc. Several waterborne diseases may also be spread while the environment becomes polluted by stagnant water.

General description of study area

Agartala is the capital of north-eastern state Tripura and has been chosen as study site. The city is located in the western zone of state. In the year of 1940, after returning from UK tour Tripura's Maharaja Bir Bikram Kishore Manikya Bahadur had started to implement his plan of designing Agartala city as mini UK and since then he has been considered as the founder of the planned city of Agartala. This is the 2nd largest city in north-east India after Guwahati. Majority city dwellers are of Bengali community and so Bengali cultures and language predominate in the city. The city is the hub of all administrative, Business, industrial, Educational and Health Centre of the entire state. Agartala is the only state capital having a unique feature that its municipality area has common boundary with a foreign country-Bangladesh.

Earthquake, flood and cyclone are the three natural threats which are vulnerable for this city. During last 50 years till 1997, Agartala has experienced 42 numbers of large and small earthquakes. The average Richter scale of these earth quacks were 4.40. Out of these, the largest earth quack of Agartala happened in the year 1885, when the Royal palace of Maharaja of Tripura was destroyed. The city had experienced largest flood during the year 1956 due to severe damage in the bank of river Howrah and the entire Agartala city was then remained flooded for 5 days.

Location of study site

Agartala is located at latitude $23^0 49' 45.556''$ N and longitude of $91^0 16' 40.2492''$ E. Altitude of this city is 16 m above the sea level. This city lies on the bank of river Houra which has been originated in "Baramura Hills" and ultimately merges into the "Titas River" across the Bangladesh border. Surroundings of the city are of higher elevation, giving the city a saucer like shape. Area of this city is about 76.504 km^2.

Fig 1: Map of Agartala city area
Source: Department of Town planning

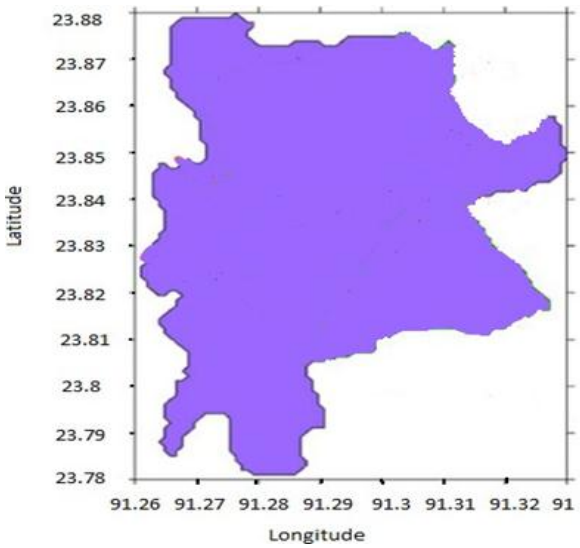

Fig 2: Agartala city area displaying latitude and longitude

Climate of study site

The climatic condition of this city is humid sub-tropical and it is in temperate climatic zone. Three distinct seasons such as summer (Mar to Jun), monsoon (July to Sep) and winter (Oct to Feb) have been observed here. The climate warms up generally from the middle of March and this condition persists up to May. Generally the average maximum temperature is 35^0 C whereas average minimum temperature is 10^0C. The average annual rainfall recorded is about 261cm. Humidity is generally high throughout the year. In the summer season relative humidity is in between 50% to 74% whereas in the rainy season it is over 85%. For most of the time winds flowing over the city are from the south-to-south–east direction. Average velocity of wind varies from 4 km/hour to 9 km / hour.

Topography of the city

Altitude of the Agartala city is 12.8 metres above the sea level. The central part of the city is located in an area lower than the surroundings having saucer like shape and this shape is very much vulnerable towards flooding of the city in monsoon period. Moreover, central part of the city is bounded by rivers Katakhal in north and Howrah in the south. The city is located in earth- quake porn zone which falls under seismic zone- V of seismic hazard map. Laterite and lateritic types of

soils are generally seen in the city area, whereas in some areas red and alluvial soils are also found.

Population growth in city area

Population density of the city is 6,831/km^2 according to Agartala city census report 2011. From the year 1991 to 2001 population of this city has increased by 32,640 whereas in next 10 years population was increased by 209,690 according to data collected from Census report, Govt. of India. Such types of rapid population growth might have diverse effect on the scenario of increased demand for jobs, food, energy, drinking water, transportation and also on various social issues.

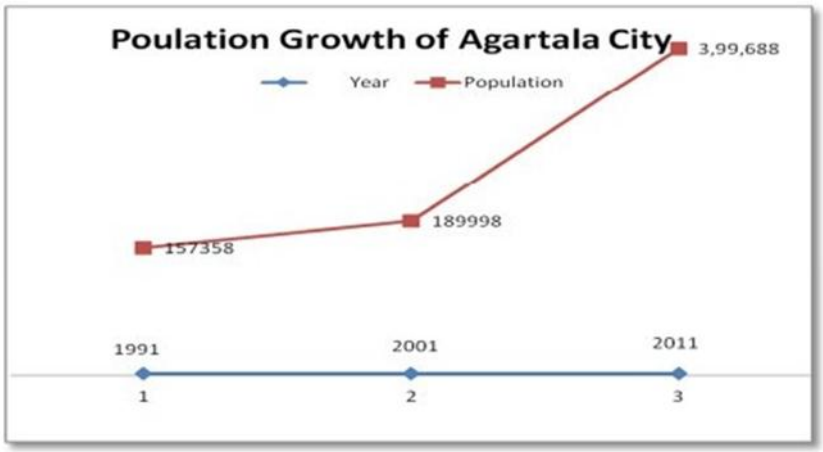

Fig 3: Graph showing population growth of the city
(Source: Census report, Govt. of India)

Sustainable solution is very essential for challenging the burden of population growth of the city. The upward trend of population growth trajectory of the city also demands the urgent necessity for innovative technologies that is to be implemented to reduce CO_2 emission for sustainable development.

Electrical power consumption scenario of the city

For inclusive development of any city rapid economic improvement in primary, secondary & tertiary sectors is very essential. Electrical power consumption is one of the most important indices that decide the development level of any city. The Government of Tripura is committed to improve the quality of life of its dwellers through higher electricity consumption. The joint initiative of Government of India and Government of Tripura aims to provide each household of the city as well as of entire state access to electricity, round the clock. 79% of the electricity demand of the state is being fulfilled from gas based power stations and balance 21 % from hydro based power stations. The per capita consumption of electricity in urban areas has been increasing in recent years. From financial year (FY) 2011to FY 2015, the per capita electrical power consumption of the state has grown at a compound annual growth rates (CAGR) of 8.09%

Water consumption scenario of the city

The water supply system of Agartala city area mainly depends on Howrah River and on ground water extracted by some deep tube wells. There are two intake sources of water in the River Howrah and 49 numbers of deep tube wells in different regions of the city. As the underground water of the city contains high level of iron (5 to 7 ppm), iron removal plant is very essential before distribution of such water. The entire water circulation process within the city is being done through piped system. Residential water consumption in the city area averages to 78 liters per capita per day

(lpcpd), whereas total consumption is about 90 lpcpd. The salient features of water supply sources in city are shown in table 1.This has been identified that for betterment of water resource scenario of the city stress should be given on- production of ground water, up gradation of existing iron removal plants, installation of more iron removal plants, presence of proper disinfections etc.

Table 1: Salient features of water supply sources of Agartala City

Sr. No.	Particulars	Production capacity (mld)
1	College Tilla water treatment plant	13.5
2	Bardowali water treatment plant	18
3	41 working tube wells	41 x 1.25 = 51.25
	Total	82.75

Infrastructure overview of the city from the frame of transport system

The lifeline of the state Tripura is the National Highway (NH-44), connecting Agartala with Guwahati by road. In order to access with Chittagong port, Agartala railway station is just waiting to start railway service facility with Sabroom, the southern-most part of Tripura near the India-Bangladesh border. This 114-km Agartala-Sabroom railway track will certainly add a new horizon to the transport system of the city shortly. The city is also suitably connected by air to Kolkata, Delhi, Mumbai, Guwahati and other North Eastern cities. The AAI had already started a project work of Rs 438 crore to convert the Agartala airport to the third international airport of northeast India by providing world-class facilities and it is expected that within one year the entire work will be fully completed. Regular passenger bus service between Agartala and Dhaka is another important side of transport system of the city.

TRTC, the public bus transport department of Tripura are giving services to the public by maintaining inter- city and inter-state bus services daily at regular time interval. However number of public service vehicles is much less than the private vehicles. Private transportation is also playing an important role to reach a person in his destination in due time without any hassle arising due to traffic jam by following alternate roads.

Historic places and tourist attraction

The most attractive historic places located in Agartala are –Ujjayanta palace, Maharaja Bir Bikram college etc. These historic constructions have already been renovated feeling the significance of protection of these heritage buildings. Along with these historic places there are some other places of

Fig 4: Front view of Ujjayanta palace

attraction for the tourists like as - MBB stadium, Sukanta Academy, Rabindra Bhaban, Raj Bhaban etc. The tourism industry in Agartala city is also a growing industry. Data available from Tourist Directorate (Table-2) reveals an increase of 67% in the number of tourists arriving in Agartala during the session 2004-05 compared to its five years earlier value.

Table 2: Year wise tourist's arrival record for city visit

Types of Tourists	1999-2000	2000-2001	2001-2002	2002-2003	2003-04	2004-05
Domestic	159730	169929	178697	268529	260403	267023
International	1971	2327	2390	3191	3684	2847
Total	161701	172256	181087	271720	264087	269870

Source: Tourism Directorate, Tripura, Agartala

Infrastructure overview of the city from the frame of academic scenario

The State has one Central University (Tripura University), one private University (ICFAI), one State University (MBB University) and all the three universities are located in Agartala. Out of 24-General Degree Colleges of state, 3 are located in Agartala city area. Two medical colleges, 1-Government Law College, 1-Government Music College, 1-Tribal Folk Music College, 1-Art and Craft College, 1- Agriculture College,1-state Engineering College,1-polytechnic Institute,1-womens polytechnic college,1- veterinary college,1-ITI ,1- National Institute of Technology- all these have strengthen the academic infrastructure of the city. Academic infrastructural development in urban area is another important key factor of increased population load compared to rural areas.

Role of Tripura Renewable Energy development Agency for city development

In order to convert Agartala city as a green city, action plan for solar city development has been taken jointly by Tripura Renewable Energy Development Agency (TREDA) and Agartala Municipal Corporation. In the preliminary stage a Master plan for estimating current energy situation and future demand has been implemented. Moreover this has been afforded to include all stakeholders for successful implementation of solar city plan. A task force has been constituted to accelerate the entire mission and final Master Plan has been submitted to the Ministry of New and Renewable Energy (MNRE) for its approval. Successful implementation of the entire plan will certainly turn this beautiful city more sustainable. Moreover TREDA always remains active for spreading the awareness of using renewable energy sources for the overall benefit of our society and of our future generation. Every year Rajib Gandhi Akshay Urja Diwas are being celebrated on 20th August organized by TREDA and this celebration has been extended throughout the entire state for one month.

Infrastructural development of the city in the field of Internet

Internet is a very powerful communication tool today. The developed form of internet facility available in a city can include a newer dimension of infrastructural development of that city. Moreover, this promises a closer and interactive relationship between a community and its citizen. People can also interact with community development organizations by using social network. Like most of the developed cities investigated, Agartala should also have a variety of initiatives to make the Internet feasible for low- income group people too.

Telecommunication system of the studied city Agartala is being upgraded by implementing optical fiber cable (OFC) network, and connecting the city with other parts of state by strengthening the

internet backbone. Moreover, after Mumbai and Chennai, this city has been turned into country's third International Internet Gateway (IIG). Agartala is now connected with Cox Bazar, Bangladesh through a 10 GB bandwidth of internet broadband line. Due to this connectivity, it is not only the internet and telecommunication system of Agartala, but also the other parts of country are getting benefit for the launching of such additional bandwidth facility.

Role of Physicists in Urban Science and Observatory weakness of the current city in the eye of Physicists

Science of any urban area is very much complicated. Every element of its environment forms complex framework that always interact in time and space for changing atmosphere, condition and people. In the year 1972, Nobel laureate physicist P. W. Anderson developed complexity theory for following the complex clusters of elementary particles. Every stage of complexity can be investigated in terms of newer conceptual structure rather than the individual components of the elementary particles. His theory is equally applicable in case of cities also. Complexity of the system increases as one shifts his outlook from an individual city dweller to the entire city level. Another theoretical physicist Bettencourt had much more fascination with cities and communities. By his interdisciplinary effort he had designed successfully a general theory of urbanization which can explain cities quantitatively.

In the eye of a Physicists, the existing weaknesses of the city Agartala those have been identified and obviously a challenging task for Government are-Road Encroachment and Poor Traffic Management, very poor drainage system, poor solid waste management, inadequate public conveniences, high population density within AMC area, lack of awareness among the people towards heritage conservation, absence of sewerage network, vulnerability due to poor drainage etc. Presence of large number of tillas in different areas, presence of international boundary with Bangladesh along the western part of the city, saucer like shape topography of the city etc. have been identified as the major constraint conditions for future development of the city.

Summary

Development of any city in true sense may be a complex issue with full of several constraints. Pushing these limits or constraints, operation within the system is the primary job of a physicist. Physicists view before successful implementation of any master plan is very essential as these may be coupled with other system causing retardation to the actual development of our communities as well as our cities. Moreover Physicists can solve complicated problems, can work with interdisciplinary teams and can also show efficiency in experimental and modeling procedures which certainly are very helpful for developing the urban science. For rapid Socio-economic development of the city Agartala, several strategic Plans for key sectors such as Road, Civil Aviation, Railways, solid waste management, flood management, Power, Tele- Communication and IT, and Health etc. are in the way of implementation. Feasibility of certain policies for handling with energy demands, pollution control, recycling of waste materials for restricting their generation and sewage treatment of city Agartala, should also be investigated from the frame work of physics. In order to tackle the frequent flooding in monsoon period, first of all depths of river Howrah and kata khal are to be increased. Number of pumps having higher capacity is also to be increased for flood water removal from different points of city area. For strengthening the drainage network of the city, construction of new drains is needed on emergent basis. This city will be no more isolated from the mainstream of other technologically advanced Indian cities if all the technology based master plans adopted can be implemented successfully as early as possible.

POLLUTION IN OUR COMMUNITY, MEASUREMENT AND PHYSICAL INSIGHTS

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Key words: Air, Sound, Physics, Pollution, Measurements.

Pollution has become part and parcel of the modern world we live in. Knowingly or unknowingly we all are exposed to Pollution of various kinds. We are experiencing tremendous growth in Science Technology and Physics have been playing a pivotal role in these advancements. Physics has been helping technology to grow and provide gadgets that a human desire. On the other hand, we are facing the problems such as pollution and waste disposal responsible for pollution. Air Pollution, Industrial Pollution, Sound Pollution, Light Pollution, Water Pollution, Electronic waste, Nuclear waste is harming our Environment 24/7.

Scientific and Technological Growth is the mark of advancement of human life. Science and Technology have made our lives so exciting and full of discoveries which one could not imagined 100 years before. Scientific and technological growth has brought the whole world on our finger tips. We have been continuously striving to control and prevent the negative effects of technology. Instruments/ Technology based on principles of Physics are being used to monitor levels of all types of Pollution. Physics has been helping in detection of degradation of environment, in medical diagnosis, in development of laser source for medicine etc. Sophisticated Instruments used for detection and environment have undergone immense change.

During times of recent Covid -19 pandemic we have been using X-Ray, CT-Scan, Oxy Meters., all of which are gift of Physics and Technology. We get so much of confidence using these sophisticated instruments providing precise measurements. We cannot imagine our life without technology. We have Decibel Meters for sound pollution, Lux Meters for light pollution, AQI – Monitoring Equipment for Air Pollution and Water Quality and Instrument for Water Pollution. We have developed sensors useful in accurate and precise determination of pollutants in air. Satellites are continuously monitoring the environment, thereby sharing the information globally and signaling us to take measures to reduce pollution world over.

Picture: Scientists Speaking in International DW News- German Channel (20th NOV 2020)

Constant Pollution in air has very negative effects on nature and in turn on human health . The photo shows, scientist speaking in international DW news (A German News Channel) yesterday on 20th November 2020 regarding air pollution creating ideal conditions for recent pandemic (Covid-19), which has shaken the whole world. Causes and effects of Pollution are very complex in nature and difficult to solve. It causes global warming, affects climate change, causes acid rain and smog. It causes deterioration of fields and of building materials, extinction of animal species, chemical instability etc. Local quality of air depends indirectly on the climate change and in turn on the environment in which we all live. Humans have been modifying the environment for thousands of years by various activities like emission of pollutants (NASA News, October 23, 2019). Ozone in atmosphere, particulate matter (PM) have either warming or cooling effect on climate. Satellites images have clearly indicated the change in atmosphere by human activities. Based on this data US, Europe and some other nations have reduced pollution by implementing strict environment laws. It further says 'India is getting worse'. Pollutants in air cause various types of allergies and diseases. Inhalation of toxic gases affects our lungs and other respiratory organs causing respiratory diseases of upper tract.

Similar to air pollution in most Cities noise is unavoidable. Levels of noise pollution are growing day by day and due to lack of proper data, laws and civic bodies have failed to take timely steps to control and stop these. Noise rules are flouted especially in crowded cities and during festivals or celebrations. Noise pollution is a serious hazard and is one of the upcoming problem for people and animals. In city areas vehicular traffic, construction work, rock concerts, aero planes, helicopters with loud sounds is causing hearing loss, high blood pressure and stress. Study shows considerable work has been done on air pollution but the data available and awareness for noise pollution is still lacking. This has led to the creation of so called 'Noise Mapping Projects' undertaken by Bombay Municipal corporation with the help of private bodies to track the sources of noise, which will further help them in town planning to segregate between commercial, residential and silent zones.

Advanced nations have started using noise shields with new acoustics meta materials, scientifically developed for this purpose. European Environment Agency recently found that 125 million people reside in noise environment and noise is responsible for nearly 10,000 premature deaths. According to noise pollution – regulation & control rules (2000), maximum noise level is restricted to 55 dB with 50dB in day and 40-45 dB in night for silence zones. Exposure to noise above 80 dB for about 8 hours a day for long period induces permanent deafness. During recent lockdown the noise levels fell to nearly 50 -56 dB as against 85-100 dB in the residential areas in Mumbai. We can learn a lot from this situation and make changes in our lifestyle for future human betterment.

Mumbai is a commercial City and is full of air and sound pollution. Central Pollution Control Board (CPCB) has listed Mumbai as one of the noisiest city of India based on the noise measurements for 3 years in line. This write-up reports the air and sound pollution in city of Mumbai as it is my residential city and I could closely monitor the sound and air quality using the mobile apps. Also there are some running incidences of busiest cities in India and reports around the world.

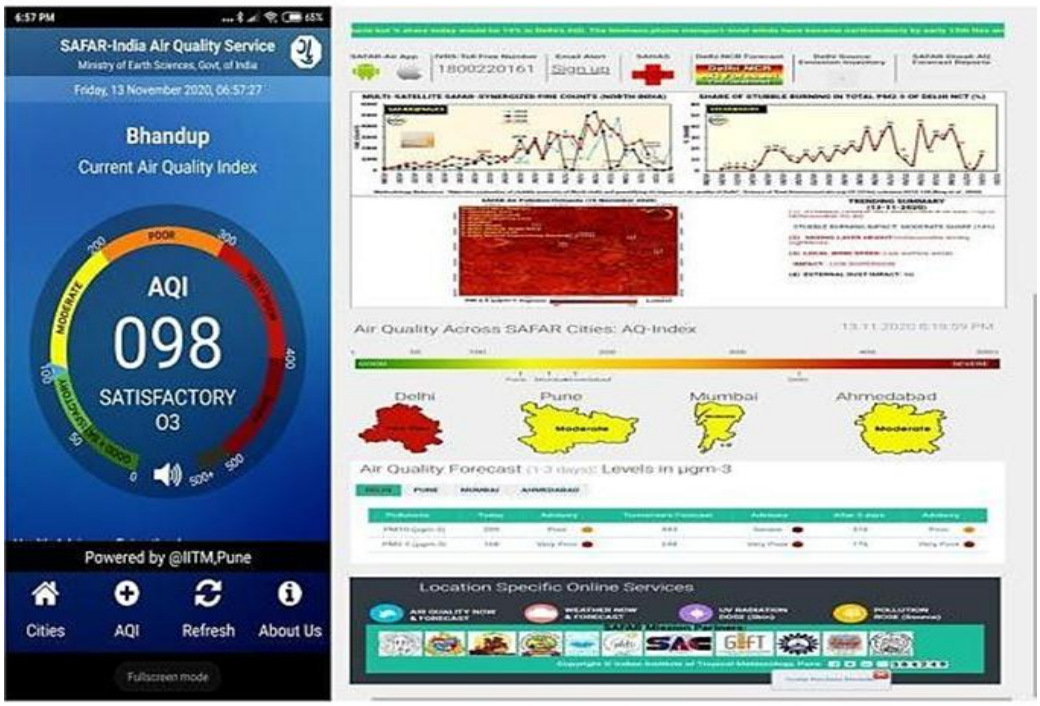
Air Pollution

Scientists have shown direct relation between Covid-19 and the quality of air (DW News, 20th November 2020). More Covid Cases and more deaths have been observed in areas having poor quality of air. It has been recorded that every 1 µg/cubic meter increase in $PM_{2.5}$ particles, the mortality rate increases by 8 % (The Hindu, 13th November 2020) Moreover studies show positive association between other particulate matter (PM_{10}), CO, NO_2, O_3 and Covid-19. WHO limits $PM_{2.5}$ to 10µg/cubic meter annually. Levels beyond 500µg/cubic meter are considered to be extremely high

and are responsible for health deterioration in relation to Covid-19 and beyond. 7 day average of $PM_{2.5}$ in major north Indian Cities around Delhi is approximately between 300 – 400 µg/cubic meter (TOI, October 26, 2020) which is very alarming. Long term exposure to high levels of $PM_{2.5}$ weakens the ability of the lungs to fend off infections, making people more and more susceptible to Covid-19 and related cardiovascular problems.

SAFAR – the online monitoring of Air Pollution in India under Ministry of Earth Sciences, Government of India is supported by the Indian Institute of Tropical Meteorology (IITM) for Air Pollution Mitigation. It is in fact the first type of network which continuously monitors several air pollution parameters together with others and maintains up to date data base with robust quality control and quality assurance. Efforts are made under SAFAR to collect data from diverse micro-environments which is a true representation of city environment. As a result the observational Network of Air Quality Monitoring Stations (AQMS) and Automatic Weather Stations (AWS) have been established within city limits in some selected microenvironments like industrial, residential, background/cleaner, urban complex, agriculture, SEZ zones as per the international guidelines. Air Quality indicators are typically mounted at a height of about 3 m from the ground level with associated online sophisticated instruments operating 24/7 and the record is stored at every 5 minute interval. The pollutants typically monitored include PM_1, $PM_{2.5}$, PM_{10}, Ozone, Co, NOx (NO, NO_2), SO_2, BC, CH_4, Non methane hydrocarbons (NMHC), VoC's, Benzene, Mercury and other metrological ones.

Through SAFAR online App we can see the air pollution in our city / area as shown in the monitoring chart below. The left hand side shows the app as it looks in to a mobile phone and the right hand side shows charts and air quality forecast across the selected cities.



Picture: SAFAR APP and SAFAR – AQI Monitoring Chart

AQICN – The world Air Quality Index Project was established in 2007. Its mission is to promote air pollution awareness to citizens and provide a unified and worldwide air quality information – Air Pollution in Mumbai: Real Time Air Quality Index Visual Map (as shown below). It clearly shows moderate, unhealthy and Hazardous Zones all over our Country.

Using the Safar Air- App, I have collected data for a weeks' time around the Diwali Festival (2020). The graph shows variation of AQI for different cities across Mumbai during Diwali with AQICN generated real time AQI – Visual Map. Out of 10 cities where monitoring is done by SAFAR, Mumbai Overall has 75% PM $_{2.5}$, and 25% PM_{10} followed by Ozone in atmosphere. The graphs show complex variation of AQI and several sources may be responsible for it. Pollution created by crackers, emission from vehicles as the unlock down process has begun as well as from other human activities. Effect of changing climate cannot be ruled out. Winter is setting in and at the same time the human activities are slowly taking pace due to unlock down process. Like when it rained in Delhi during this time which was experiencing all time high (Severe AQI nearing 500) due to stubble burning in the areas /states around, was brought down to (Poor AQI nearing 250) limits bringing much relief to its citizens. Effect of climate can similarly be seen in the cities surrounding Delhi.

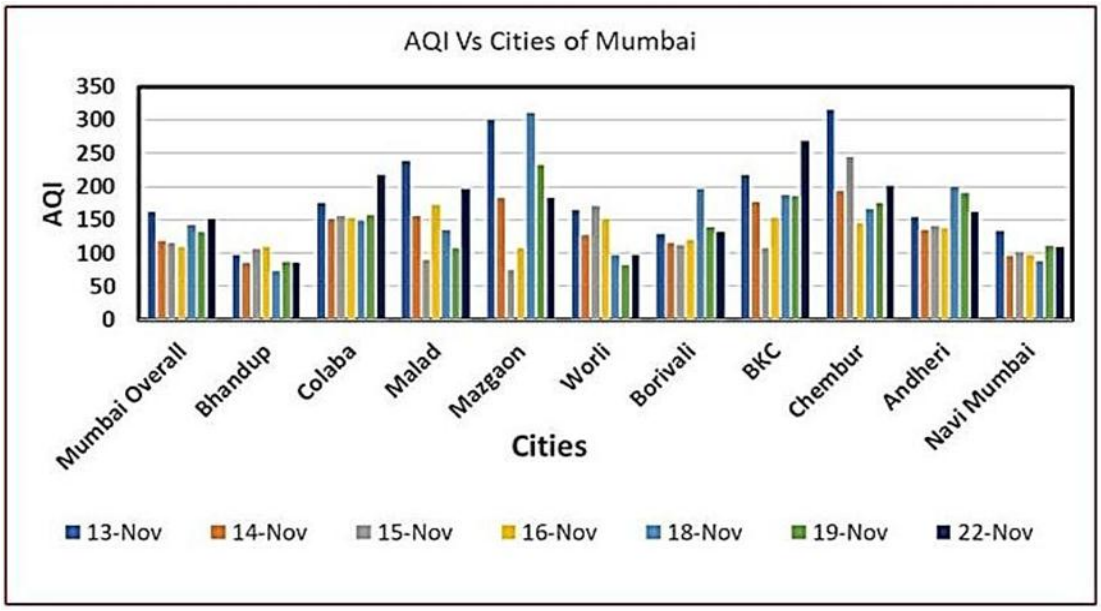


Figure: AQI of Cities across Mumbai Vs Dates (Diwali Festival) and AQICN – real time AQI Visual Map

MPCB – The Maharashtra Pollution Control Board Monitors the quality of air and other pollutions like sound pollution across cities in Maharashtra. CPCB is responsible for the Ambient Air Quality monitoring network in Maharashtra. MPCB has generated table showing the Air Quality Index 2020 as with Green colour for satisfactory zones (green / light green) and moderate (yellow) zones. It clearly shows the variation of the quality of air during various seasons across Maharashtra. AQI in Mumbai is in dark green zone in the month of July (rainy season). This is in contradiction to Navi - Mumbai where from May -September the AQI is very satisfactory, even when it is so near to the city of Mumbai. Moderate AQI can be noted from October -November and January, so during winter season the particulate matter and hence the air pollution is high. Across Mumbai also there is lot of variation in the pollution (AQI) levels as indicated in the Figure above.

Noise Pollution

There was good news on the World Environment Day namely 5th June 2020 (TOI) with air and noise pollution significantly decreasing during lockdown. AQI was seen to be at its best a day after the cyclone Nisarga with Raigad recording lowest AQI of 17 this year. Bombay Municipal Corporation (BMC) affirmed this observation with the help of SAFAR where the levels of pollutants $PM_{2.5}$, PM_{10}, CO and NO_2 levels falling sharply due to lockdown. The data was collected from 10 pollution monitoring stations in Mumbai City. This was clearly due to closure of Vehicular Traffic, Construction sector, Transport and some Industries.

Noise consists of sound waves and hence can pass through Wall. Thick walls are needed to blocking noise but in highly populated / commercial cities we also have to keep in mind high cost of living space. This is related to universal mass-density law which in turn is based on volume mass and friction. Figure below shows weight per area of wall needed to block noise as a function of frequency (Z Yang etal, Phys. Rev Lett 101, 204301, 14th Nov 2008). Decorated membrane Resonators (DMR) having low- transmission and low-reflection are used as dampers for structural vibration.

Noise Shields which are Compact, light-weight and cost-effective 'Resonance Acoustic Meta Materials' have been developed commercially. A centimeter thick easily mountable noise shields on existing home walls helps to block noise over 40dB in entire 100 -1500 Hz range. These noise shields combine the benefits of thick walls blocking high frequency noise and the noise shields blocking low-frequency noise. Also, flexible standalone panels designed to mimic human hearing curve with average transmission of 35 dB are in use. These flexible sheets (curtains) can cover noisy power generators / air compressors or during construction work.

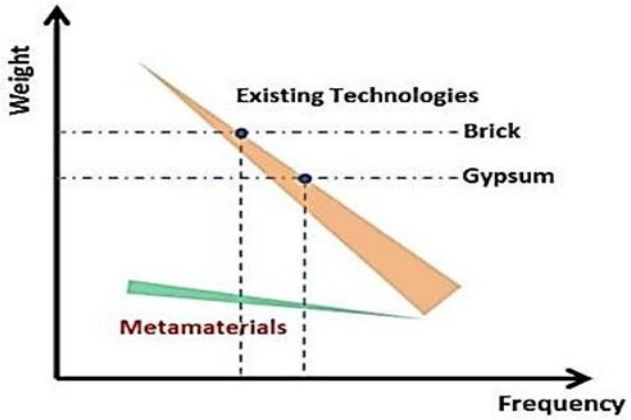


Figure: Weight per area of wall needed to block noise Vs Sound Frequency

Noise Standards are set according to the rules laid down in noise pollution (Regulation & Control, 2000). Noise Mapping Project has been undertaken to classify different city zones according to noise levels. Levels of Noise are compared with ideal levels using sound level meter. Nitesh Joshi etal has carried out Noise Mapping in Mumbai City and reported it in a Research Article. We must be aware of noise pollution around us and discuss the issues on various platforms as it may be a salient killer.

Bombay Municipal Corporation **(BMC)** measured sound levels at 740 of its 1200 locations across the city (HT, September 25, 2016). With the help of private bodies, noise levels at 50 places across 24 municipal wards were monitored. The continuous mapping showed that most locations in Mumbai are crossing safe limit set for noise pollution. The noise levels for residential/ salient zones were found to lie at 65dB (night time) and 75 dB (day time). Bombay high court made it mandatory for all authorities to carry our noise mapping in given time frame all over Maharashtra. It is said that before the mapping process, Maharashtra Regional Planning Act was not taken seriously. It was essential to identify the primary causes of noise for integration in to development and city planning.

Maharashtra Pollution Control Board **(MPCB)** has been developing Ambient Noise Protocol - Monitoring Network in India. It also has responsibility to establish Committee for Noise Pollution Control. Central Pollution Control Board **(CPCB)** has already declared Mumbai as India's noisiest city. Excessive Noise is directly affecting human health – hearing loss, high blood pressure, mental health problems. Exposure to excessive noise is also known to cause heart and mind cancer.

Variation of average sound over the week: changes with construction work on roads and blowing of horns by vehicles, monitored using Sound Mobile App as shown below.

The graph shows variation in noise levels (dB) at different times during the day in Bhandup West residential zone (Mumbai). During lockdown these figures look good but as we are heading slowly towards un lockdown process, these levels will be further enhanced.

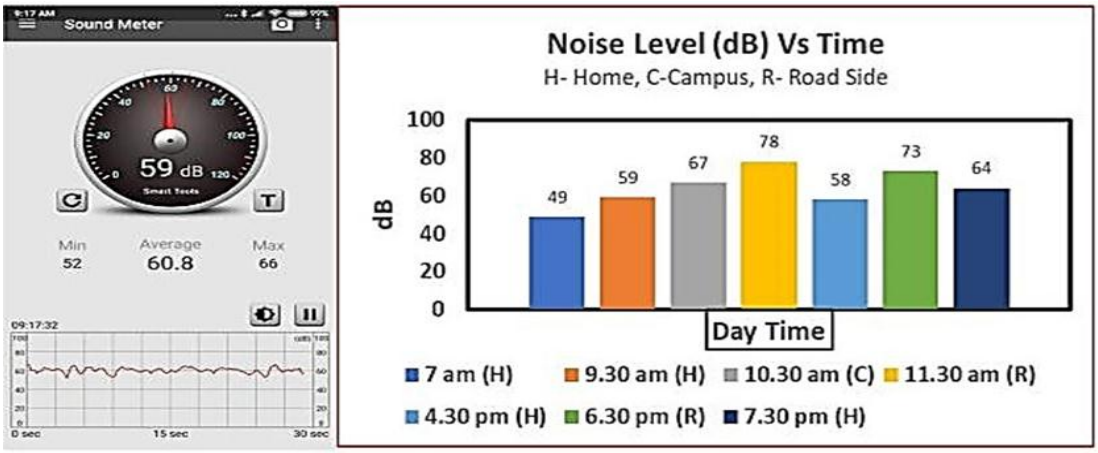


Figure: Sound Mobile App and Variation in noise levels (dB) at different times in Bhandup (Mumbai)

High frequency noise generated by construction work, moving vehicles, aero planes/ helicopters and low frequency noise due to human steps, music, highway traffic, trains, air conditioners, factories and power plants are harming human and animal lives.

Awaaz NGO Foundation conducts Awareness Campaigns. During recent current lock down the noise levels were noted to be good and satisfactory in residential areas. Various Environment protection groups have now launched a campaign 'Saalbhar 60' putting pressure on the government to make environment laws more stricter, implement them to control and reduce the pollution levels in City.

The importance of pollution control especially during recent Covid Pandemic has taught us a very hard lesson. Bad weather due to air pollution created favorable conditions for Covid indicating that there was direct relation between pollution and Covid, that may bring many other lung diseases in future. SAFAR, AQICN, CPCB are clearly showing we are exposed to very severe pollution and vulnerable to so many cardiovascular diseases. Particulate Matter (PM) is wide spread and is major cause of pollution in air affecting human health compared to all others. PM is approximately caused by traffic (5%), Industrial activities (15%), domestic fuel (20%), natural dust and salt (18%) and unspecified sources of human origin (22%). Majority of the cities around Delhi and Mumbai have PM2.5 and that around Ahmedabad have PM10.

Happily, World Environment Day (5th June 2020) saw significant reduction in air and noise pollution due to recent lockdown. However, there was some concern about the rising levels of O_3 in the Mumbai City. It came as surprise to MPCB which analyses and endorses the data collected. The Mumbai Metropolitan Region (MMR) from Greater Mumbai extending up to suburban Kalyan saw a hike of 24.8 % in ground- level Ozone (GLO) in the analysis carried out by National Clean Air Program (NCAP) tracker comprising of Mumbai based quality research group 'Respirer Living Sciences (RLS)' and 'Climate Trends' a Delhi based communications initiative (HT, 28 May 2020). 50 % rise in O_3 levels have been recorded in the MMR region compared to last year.

The safe average limit for ozone is placed at 80μg/m^3 per day. Many cities across India recorded ozone concentration between 64 -70 μg /m^3 per day. Surface Ozone is formed by reaction between organic compounds and NOx in presence of heat and sunlight. GLO is said to aggravate Asthama,

Cardiovascular and other related ailments. One cannot imagine all these, when the spread of Corona was at its peak and affected the lungs of people. This clearly shows the atmosphere around us was favorable for the spread of Covid-19. Which primarily shows that air pollution is a complex process than what we thought or know.

The rise in ground – level O_3 during lockdown is in fact related to NO_2 levels (caused due to coal burning and vehicular exhaust), which fell down by 50 – 58 % for Mumbai -Thane Region. Photochemical production of ozone is enhanced by low NO_2 in presence of heat during Summer as analyzed by MPCB authorities. MPCB Chief Scientist said ground – level O_3 may be secondary pollutant as a result of reduction process from other major pollutants (industries). Hence more scientific investigation is needed to identify the source of ground – level O_3. As a part of NCAP, Cities across Maharashtra want to reduce various pollutants at least by 20 -30 % in coming four years. New challenges like rise in ground level ozone at the time of already existing health crisis calls for more serious efforts to identify the impact of other pollutants apart from Particulate Matter. China too is said to have witnessed rise in Ozone and has already being putting efforts to control it. So now onwards in months of summer, we need to consider precursors for Ozone in addition to adopting measures to control other pollutants.

The lesson we learned this year was the factors which we can control to reduce air and noise pollution in the city. It is possible!.. Climate greatly affects the atmosphere around us. Delhi has severe AQI crossing 500+ level during winter (Diwali) on account of particles caused due to burning of crops after yield. Sudden rains this Year in Month of November on 15th November 2020, the air quality was enhanced from severe to poor (228 overall, moderate). So the timely rain was actually a boon to the citizens of Delhi. During same period an improvement in quality of air was noted in Ahmedabad (SAFAR- India data).

SEZ Zone and proximity to Sanjay Gandhi National park, possible results in satisfactory API for Bhandup city near Powai, Mumbai. This can be clearly seen in AQI graph of various cities across Mumbai (discussed before), which clearly shows the number of trees (Green Zones) and open places restricted for human activities have a major role to play together with climatic rains. As if our natural environment is supporting us in a big way. But we must realise this and take immediate measures to prevent pollution of Mother Nature thus benefitting each other in the process.

Green and Pollution free Environment is the dream of whole world. We need to have more salient zones like the initiative of Mumbai International Airport. Urban and Planning Development can make it mandatory to use noise shields around our homes / commercial setups. Our modern society must be more aware of dangers of salient killer “noise” and take timely actions. The Mumbai Metropolitan Regional Development Authority (MMRDA) and its partners have been undertaking several massive projects like Metro-Rail, Sea Link, Express Highways, Trans-Harbour Sea Links which passes through the residential parts of the Mumbai cities and has already been a matter of concern for noise pollution. MMRDA has promised to carry out partial mapping through the noise mapping project.

What is all this telling us? To live a contended life, manufacture only that which is actually needed and not exploit nature. It is very difficult for the government and NGO’s alone to control pollution. We have many festivals throughout the year and music is inseparable part of the same. During these festivals, people are in jovial mood and not in position to listen to the law makers. We as a society

must be responsible to take our part and think scientifically and environmentally. We need to think of old people and small children around us while playing high pitch music (DJ) at our home. Children's living near noisy airports have been found to suffer from stress, memory impairment, disturbed attention

levels and reading skills. We have seen in spite of so many laws available to curb Pollution, it has failed to control the situation.

We forget about the nature around us, the birds, the wild animals who too are badly affected by loud noise. Loud noise causes death of tender just born birds, caterpillars' hearts to beat faster, birds to have fewer chicks etc. Some animals use sound to navigate, trace food, attract their mates, and avoid predators. Noise pollution impairs all these tasks and in turn affects their ability to survive. In our Sea's too, movement of Ships, Oil drills, sonar devices create noise adversely impacting sea life. activities Making laws stricter would surely go long way. Every one of us must be aware of the pollution and take oath to use only those things which are nature friendly and really needed.

We have to develop and adopt and plan for the new technology which takes care of pollution (Green Technology). Our research must be focused in that direction. We have advanced instruments for research to help us to do that through new ways like Delhi government's initiative to use bio decomposers with the help of IIAR Pusa, New Delhi to take care of burning stubbles in and around Delhi causing severe air pollution with good soil fertility. We can slowly start to use electric vehicles and shift to solar energy (even in villages) thereby preventing burning of wood for food or hot water. This is a real challenge for every one of us; time is not far when our honorable Prime Minister would float the idea of "Pollution Free Bharat."

POLLUTION IN OUR COMMUNITY, MEASUREMENT AND PHYSICAL INSIGHTS

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"We are the last generation with a real opportunity to save the world" - Laurence Overmire

I. Introduction

Pollution of our environment indicates the contamination of soil, water, and the atmosphere due to the emission of pollutants. Air and water are two important fluids of our nature. When these two fluids get polluted then our nature itself will become unhealthy and vulnerable to all living species even from the regional level to the global level. A large section of human resources has been lost worldwide every year, due to the victim of a polluted environment. Even this has been come out from research at various levels, that gene-environment interactions are the causes of several incurable life-threatening diseases of human beings like cancer and many others. So as long as we are increasing the environmental risk factor by polluting our surroundings, we are throwing our future generation towards a void space of the living world. On the other hand water resource is also very vital for life sustainability and all other developmental activities of any society. According to United Nations declaration-"Water is critical for sustainable development, including environmental integrity and the alleviation of poverty and hunger, and is indispensable for human health and well-being". Actually water may be considered as the driver of our nature. Sandra Postel, the director and founder of the Global Water Policy Project correctly commented in her Project that "Water is the basis of life and the blue arteries of the earth". About the significance of water someone had suitably commented that "In every drop of water, there is a story of life". So from very beginning people were realized the immense role of pure water. Slovakian Proverb regarding significance of pure water is that "Pure water is the world's first and foremost medicine". Now a day's access to safe water drinking is an emergent issue, but this has often threatened by pollution of water both in urban and rural areas. According to the India National Family Health Survey, nearly 40 per cent people living in extreme poverty conditions are using unimproved and untreated drinking water. This has been found that major parts of rural households and even some urban households still depend completely on untreated surface and groundwater globally which causes several water borne diseases every year .The quality level of the natural air we breathe, the water we drink –is lowering day by day in different regional and global areas. So continuous monitoring along with fruitful protection strategy for these two valuable resources are the primary needs of all countries for their sustainable development.

II. Air Pollution

Pollution has now become a major global problem threatening the climate change issue for our healthy existence. Among all types of environmental pollution, like air pollution, water pollution, soil pollution, noise pollution, light pollution, thermal pollution etc. air pollution is the most dangerous one.

A. Sources of Air Pollution

Both natural disasters and manmade activities are responsible for air pollution and this cause's even death of many organisms including humans directly or indirectly every year globally. In the air pollution mechanism, three factors involving in the system are- the sources of pollution, a means of transport, and receptors. Apart from natural sources like wildfires, volcanoes, wind-blown dust, etc.;

manmade activities are also very much vulnerable for polluting the air. Manmade air pollution sources may be of three types like mobile sources, stationary sources, and area sources. Cars, buses, trains, planes, etc. are the mobile sources; while power plants, factories, oil refineries, etc are the stationary sources. Agricultural areas, cities, wood-burning fireplaces, etc. are the main area sources of air pollution. In the transport mechanism of the pollutant from source to receptors, climatology and topography of any region play the key role; where the receptors are the human beings, plants, different animals, and other living and nonliving organisms. Air pollutants may be classified as primary and secondary pollutants. There are diverse hazardous effects of air pollution on our environment. Several critical diseases, global warming ,acid rain, ozone layer depletion etc are now very alarming issues generated by polluted air.

B. Components in polluted air

In various region of earth surface this has been identified that in every year, the number of deaths above expected average death rate is mainly due to increase of pollutants in the surrounding atmosphere. Table 1 explores the comparative study of components present in pure air and typical polluted atmosphere. In case of the typical polluted atmosphere, the highest amount of pollutant that remains present in a suspended state in the air is the particulate matter (PM) which is nothing but a mixture of aerosols and liquid particles. The PM with a diameter from 0.1 to 1 μm can exist in the air for many days and weeks and also able to transit long distances in air. Components of PM may vary from location to location, though it is a mixture of physical and chemical characteristics. Out of these, the most common components of PM are sulfates, nitrates, ammonia, and other inorganic ions such as sodium, potassium, calcium, magnesium, and chloride ions, organic and elemental carbon, minerals, crust associated water, particles, metals, and polycyclic aromatic hydrocarbons (PAHs). Aerosol particles can change the microstructure of cloud particles and thereby influencing the regional clouding and precipitation processes. These particles can affect the transfer processes of solar and thermal radiation in the atmosphere and also the temperature regime of the Earth's climate system. Moreover, these particles can scatter and absorb solar and thermal radiation, and thus radiation balance of the atmosphere and the underlying surface are greatly affected.

Table 1: Comparison of pure air and polluted atmosphere

Component	Pure Air	Typical Polluted Atmosphere
Particulate matter	10-20μg/m^3	260-3200 μg/m^3
Sulfur dioxide	0.001-0.01 ppm	0.02-3.2 ppm
Carbon dioxide	300-330 ppm	350-700 ppm
Carbon monoxide	1 ppm	2-300 ppm
Oxides of Nitrogen	0.001-0.01ppm	0.30-3.5 ppm
Total hydrocarbons	1 ppm	1-20 ppm
Total oxidant	0.01 ppm	0.01-1.0 ppm

This type of effect can ultimately put a significant amount of pressure on the energy balance of the Earth's climate system. The risk of morbidity and mortality rate in both developing and developed countries are greatly stimulated by both short-term and long-term exposure of PM. This has been identified that particulate matter particles having diameter of less than 10 μm (PM_{10}) and less than

2.5 μm ($PM_{2.5}$) can penetrate deep into the respiratory system. In the year 2008 Beelen, R and his group had published a paper entitled "Long-term effects of traffic-related air pollution on mortality in a Dutch cohort" in the journal Environmental Health Perspectives; and shown that each increase of PM concentration to 10 $\mu g/m^3$ is associated with an increase of cardiopulmonary mortality risk to 6–13%.From literature survey of reputed medical journals this also has been explored that while we breathed in, PM disperses through the alveoli and diffuses through the blood-air boundary into the fundamental flow, actuating foundational oxidative pressure and irritation in the heart, liver, cerebrum, and lungs. These PMs collect in the lung parenchyma and can intensify a few aspiratory illnesses, including irresistible sicknesses and incessant obstructive pneumonic infection, and lessen lung work. Constant monitoring of air-quality, mainly in urban areas is very much essential to reduce the health hazard issues.

C. Air –quality monitoring system

Block diagram of a general continuous air-quality monitoring system may be represented schematically by fig 1. In order to pull air sample inside the monitoring device there must be a primary air-moving device just like as vacuum pump. Flow-control, pollutant detection, automatic reagent addition, transducing of primary signal in the form suitable for recording and telemetering etc are some essential features of such air-quality monitoring device.

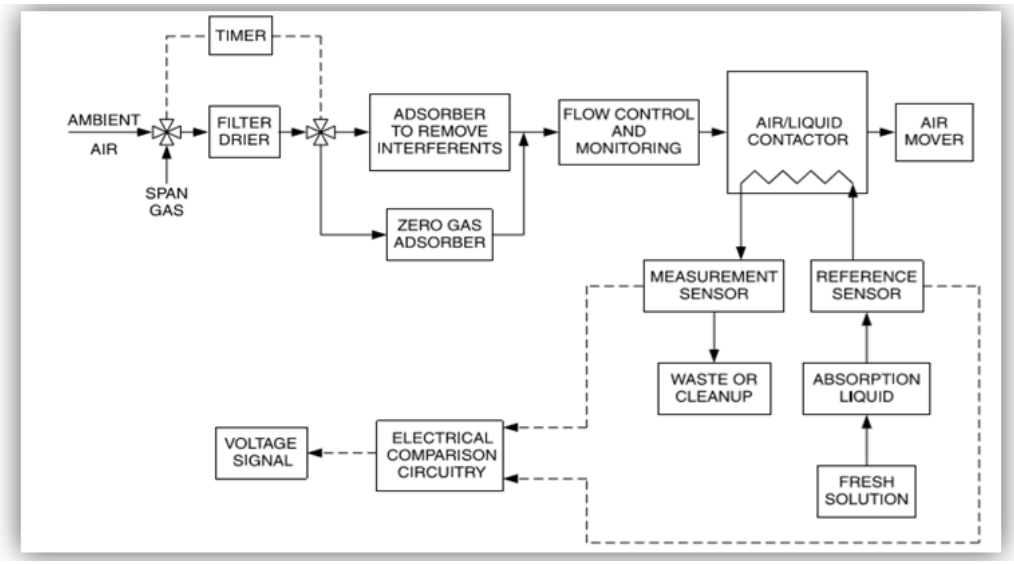

Fig 1 Block diagram of a general continuous air-quality monitoring system

However for proper monitoring of air pollution, online GPRS sensors array system has been widely used in different air-quality monitoring system. Nowadays wireless sensor network also has vital role in this field. The features like low cost, easier setup technique etc. have made this wireless monitoring system more popular by providing a real time pollutant data. Web based monitoring of air pollution may be more beneficial in this regard.

III. Water pollution

The amount of water contained in the atmosphere is surprisingly small. It is estimated to be less than 1% of total mass of the atmosphere, but plays a very important role in climatic fluctuations. Global freshwater resources are unevenly distributed throughout the entire world. The accessibility to water well suited for human usage along with utilization is limited in the earth's hydrosphere. About 0.62% of the total water is available as freshwater and out of this nearly one-half lies below a depth of 800 m and therefore remains beyond reach for human's use. The freshwater in lakes, rivers and groundwater is only 0.3% of the total freshwater source of planet. These indispensable resources are

being exhausted day by day in very faster rate. Population growth, increased trend of urbanization, large-scale industrialization and environmental concerns etc. are the main causes of lowering of fresh water stock level. The shortage of affordable fresh water compels an estimated 1.2 billion people worldwide to drink unclean water today. This causes various water-related diseases that kill 5 million people every year. This has been found that even rainwater, nature's way of water purification, is not always pure due to its contamination caused by various pollutants that have been exposed to our atmosphere. From India's census report this has been found that India has 17 percent of the world's population though India has only 2.45 percent of the world's land areas. According to projections by the UN, India's urban population is expected to rise to 50% of the total population by 2050. As a result the demand of fresh water in Indian perspective is very much high and increasing day by day. But India has only 4 percent of world's freshwater resources. Pollution of such fresh water resources are making the situation more complicated day by day. Regular monitoring, analysis of water quality and different remedial action plan implementation are very essential to survive the Indians from different water- related diseases.

A. Sources of water pollution

Storm-water runoff, domestic discharges, industrial discharges, accidental spills, utilization of water control structures, e.g., dams and so on are the most well-known reason for water contamination. Storm-water runoff ordinarily contains numerous toxins. Spillover from streets and parking garages frequently contains oil, gas, and other vehicle liquids. Spillover from ranch fields may incorporate pesticides, composts, animal squanders, and so forth, while overflow from forested territories may have soil, vegetation, and different trash in it. Tempest water spillover from greens may contain pesticides and manures. Modern locales may create spillover containing mechanical synthetic concoctions. Spillover from development or different regions where the land is being upset frequently contains disintegrated soils, broke up minerals, and flotsam and jetsam. Tempest water spillover conveying these toxins enters storm canals, channels, and jettison—and at last our waterways, streams, and lakes. These wellsprings of tempest water contamination, alone and joined, have brought about genuine water contamination issues. Tempest water releases from farming fields, for example, have polluted waterways with natural material and microorganisms from animal waste. Tempest water releases containing phosphorus have added to the unfortunate development of huge quantities of green growth in lakes and waterways. Tempest water releases containing dissolved soils have harmed fish producing beds and other amphibian natural surroundings. A large portion of the sources causing storm-water related contamination are alluded to as nonpoint sources since they originate from expansive regions as opposed to single purposes of inception. Nonpoint sources of contamination are the main source of water contamination in several areas of India today. Nonpoint contamination from agribusiness, specifically, has been referred to as a significant reason for the corruption of these waters. Other sources of contamination are alluded to as point sources since they originate from single points of discharge, such as the ends of pipes. Domestic discharges are the point sources of water contamination in this regard.

B. Contamination of drinking water sources

Drinking water gracefully in maximum communities originates from ground and surface water sources. In some communities, surface water is utilized as their essential wellspring of drinking water and groundwater is being utilized as their reinforcement source. High quality drinking water can be acquired from groundwater sources as these sources are shielded from surface pollution by the soil mantle above them. Groundwater sources may be enriched of minerals; in any case, since they are continually in contact with rocks and soil, and a portion of the minerals in the stones and soil disintegrate into the water. Since drinking water from groundwater sources is by and large of top notch, water suppliers may require just to purify the water preceding conveyance and use by people

in general. Watersheds undermine the nature of our drinking water flexibly and are source-related concerns. Logging, street building, mining and different exercises that include delving into the dirt or evacuating vegetation can be especially hurtful in the event that they are not done cautiously. Storm-water running over these upset territories can get sand, residue, dirt, and different contaminants and convey them into our drinking water flexibly. It is to be noticed that both our surface water and groundwater supplies are taken care of by precipitation falling into our watersheds. The danger of groundwater contamination is right now, also a matter of worry in several urban areas all around.

C. Effect of contaminated drinking water:

As indicated by World Health Organization (WHO), in excess of 80 percent of human illnesses are identified with drinking water issue. The contamination of drinking water by microorganisms is a genuine health concern around the world. Microscopic organisms, infections, and protozoans are altogether microorganisms fit for sullying our drinking water and causing malady. For example, microscopic organisms are liable for typhoid, paratyphoid, salmonellosis, shegellosis, bacillary looseness of the bowels, and Asiatic cholera. Infections are liable for irresistible hepatitis and poliomyelitis. Protozoans are liable for amebic looseness of the bowels and Giardiasis. Typhoid fever is brought about by the bacterium Salmonella typhi. Typhoid fever causes a high fever, looseness of the bowels, and ulceration of the small digestive system. It is exceptionally infectious.

IV Study Area:

In order to investigate the water pollution and air pollution status of an urban area, the Agartala city has been chosen as our study site. Agartala is the capital of the state Tripura and is the 2nd largest city of North- East India and has now become the top ranked among the 10 smart cities of the Northeast zone of India. It is now India's third global internet gateway after Mumbai and Chennai. GPS coordinates of this city are 23° 49' 45.5556" N and 91° 16' 40.2492" E and its elevation is 12.8 m above the sea level. The geographical area of this city is 76.51 km² .The population density of the city of Agartala is around 10,000 people per square kilometer. The population growth of the city is presently about 3%. From a survey this has been found that on average, every year the population of this city increases by nearly 20,000. So maintaining the city as less polluted smart city, this has become a challenging task under the increased pressure of population growth.

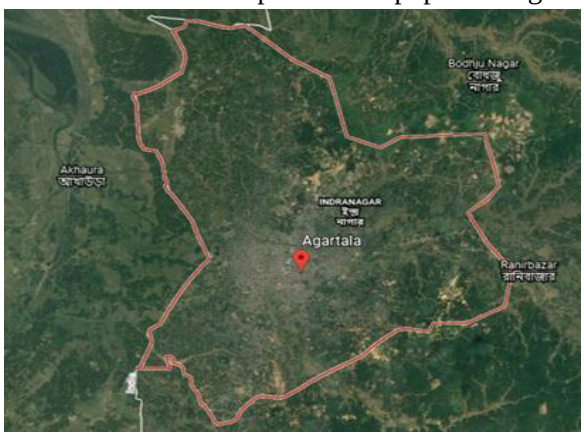

Fig2. Agartala City location (source: Google Earth)

A. Air pollution status of study site

In Agartala, there is no such big industrial area built till today and so industrial pollution is quite less as compared to other big cities. Motor vehicles and road side deforestation are major sources of air pollution in Agartala. Fig3. represents a road of Agartala city area displaying air pollution caused by motor vehicles. Some ambient Respirable dust sampler for PM_{10} and Fine particle sampler for $PM_{2.5}$ have been installed in different busy areas of Agartala city for monitoring the local pollution level.

Fig4. is representing such device, installed near footpath of a busy road of Agartala city area. The process of measuring $PM_{2.5}$ is almost similar as PM_{10} measurement. Weighing procedures for $PM_{2.5}$ are more conservative than for $PM_{10-2.5}$.

Fig3. Air pollution in a typical Agartala city road

Fig4. Respirable dust sampler for PM_{10} and Fine particle sample for $PM_{2.5}$ installed in Agartala City

Air quality index of Agartala city area are being monitored by satellite based data. No ground level stations for monitoring air quality are available in this city area till now. Both temporal and spatial variation of air pollutants in any city area can be easily investigated from AQI data obtained from IQAir. Air quality data of any city area may be obtained from IQAir, a Swiss air quality technology company. Data obtained from IQAir for Agartala city area has enabled to identify day wise variation of AQI and Air pollutant concentration during this month which is shown in fig.5 and fig.6 respectively. This has also been identified from their monitoring that air pollution level of this city is good or moderate throughout the entire current month. The main air Pollutant that has been recorded during this period is mainly $PM_{2.5}$

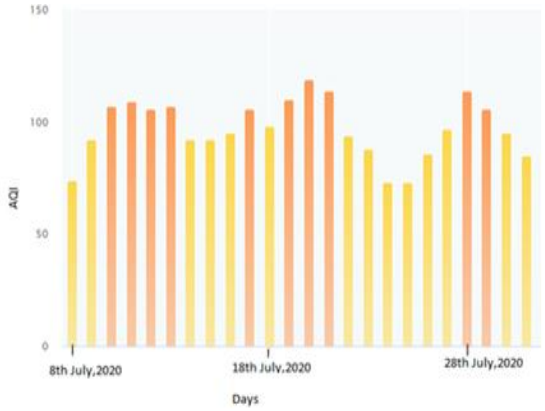

Fig5. Day wise AQI variation in Agartala City area

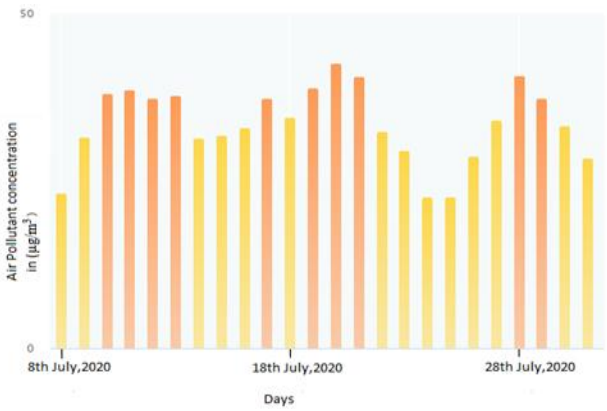

Fig 6. Day wise air pollutant concentration variation in Agartala city area

If we investigate the air Quality data of this city area before COVID-19 pandemic then it is also found that air quality during this pandemic period has been improved a lot from its earlier air quality.

B. Water Pollution status of study site

Drinking water circulation among the community of this urban area is mainly from surface water sources and from ground water sources. The two surface water treatment plants are located in Collegetilla and Bardowali area of Agartala city. Howrah river is the only source of surface water of this two water treatment plants.

Fig 7. Clariflocculator system in Collegetila water treatment plan

Fig 8. Clariflocculator system in Bardowali water treatment plan

Agartala Municipal Council and Public Health Engineering Department are engaged for monitoring the issue. In order to supply potable water from both the surface water treatment plants, clariflocculation system has been installed which is very helpful for the water treatment of surface water, industrial and municipal wastewater treatment, filtration pre-treatment and also in Reverse Osmosis process. Actually the clariflocculation process can remove organic compounds, sedimenting particles and heavy metals from processing water. Several overhead water storage tanks have already been installed in different high land areas of the city to get the larger speed of the circulated drinking water.

Fig 9. Overhead tank (INTZ type) in Colegetila area

Fig 10. Overhead tank (INTZ type) in Gandhi School area

Due to the maximum surface water collection from Howrah river for water distribution among the community of the state, Howrah river is considered as lifeline of Tripura .But its pollution level is gradually moving towards the critical value day by day. The main sources of this river water

pollution, those have been identified during field survey are the-garbage's dumping into the river, cleaning of clothes, bathing of cattle immersion of idols during several traditional festivals etc. In spite of absence of major industries, the river water is being polluted continuously due to the contamination of human waste (septage) .Direct connection of overflow pipes of septic tanks into storm water drain, presence of large numbers of kachha drains adjacent to river banks has also been identified during field survey. Increased amount of toxins, chemicals and other dangerous bacteria present in the river water are threatening the sustainability of entire community and immediate implementation of some remedial action plan can only resist this trend of deterioration of water quality of this lifeline of the state.

Fig 11.Brick field wastes

Fig 12. Drain outlets

Fig 13.Idle emersion

Fig14: market garbage

Fig15: Animals dead body within river water

Fig16: kachha latrine outlet in river

Some typical pictures displaying the cause of river water pollution have been explored from **fig 11 to fig 16**. Each case is representing the fact that pollution in this river water is caused by human activity.

Conclusion

Development of the human civilization is solely based on technological advancement but majority of the inventions are not eco-friendly and directly or indirectly causing health hazard by polluting our surroundings. So this is now a very emergent issue for science and technology to convert all these previously invented devices and adopted technologies in eco-friendly manner for sustainability of our nature. Violating the sustainability of environment no technological development can be considered as a development in true sense. All the fossil foil based technologies have to be converted solar based to resist further degradation of our environment and also for sustainability. We have always thought only about our newly comfort generated by newer technology rather than thinking towards sustainability of our nature. But it is now the time for thinking about the impact on nature 1st and then the implementation of any technological issues. Moreover as water shapes a center of the presence of human and other living things, its conservation and economical accessibility can't be overemphasized. The accessibility of clean water is extraordinarily undermined by different human exercises and of intrigue is contamination which influences the biological system and causes different climatic changes. While different wastewater treatment techniques are being investigated by businesses and different treatment plants, untreated wastewater is as yet being released into the water bodies by certain ventures. Consequently, viable ecological insurance strategies consistence drive will be of massive advantage to the earth and by augmentation to human. Considering these natural assurance arrangements into the objectives and targets of different on-screen characters associated with ecological crumbling will help approaches execution. This will fill in as a stage forward toward improving water contamination and leading us towards a healthy and beautiful world for our future generations.

POLLUTION IN OUR COMMUNITY: MEASUREMENT AND PHYSICAL INSIGHTS

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Introduction

Have you ever experienced that if we walk in crowded city streets or with heavy traffic road sometimes we feel that our eyes irritate or we start sneezing otherwise feeling of uneasiness in throat comes at once. Many times passing on the vehicle through the industrial sectors we may cough. Why this happens? The reason is when we enter the environment which is uncomfortable or different than our sensory organs used to tolerate or we find an abnormal surroundings. The atmospheric constituents in excess present in the surroundings are the primary cause for such symptoms. It is utmost necessary to monitor changes taking place in the quality of the environment for initiating efforts to control it. Pollution is a resource that we are not harvesting. We allow it to disperse because we have been ignorant to its value.

Pollution is the insertion of excessive impurities within the environment which causes dangerous effect. According to dictionary [1], Pollution is the presence in or introduction into the environment of a substance which has harmful or poisonous effects. The polluting components can be foreign substances / energies or natural contaminants. Air, water, light, plastic, noise, thermal, soil or littering are types of pollution. In general, reasons of pollution are natural – being the result of abrupt variation in temperature, seasonal variations, or regular cycles, other type is man-made or the result of undisciplined human behavior. The air pollution effect on our planet is exponentially increasing, especially those that result from human activity, are of great concern to all as they give the long-term ill effect.

Air Pollution

As we know Nitrogen (78%), oxygen (21%), and other gases like argon and carbon dioxide (CO_2) composition makes Earth's atmosphere. All living beings on this Earth need this in well balanced composition. The imbalance due to introduction of any pollutants causes a profound damaging effect. Carbon monoxide (CO), CO_2, sulfur dioxide (SO_2), methane or toxic chemicals can cause Air pollution. In India air pollution is reason for serious health issues because in 2019, 21 cities of India were among most polluted cities out of 30 in the world [2]. Air pollution can be divided into Primary and Secondary types of pollutants. Primary pollutants are caused by the industrial emissions or volcanic eruptions while Secondary pollutants are caused because of combinations or reactions with primary pollutants viz. carbon emissions and water vapors which create smog. In India 51% of pollution is caused by the industrial pollution, 27% by vehicles, 17% by crop burning and 5% by fireworks. According to the World Economic Forum, air pollution alone kills 1.25 million people in India annually. State of Global Air 2020 report identifies that air pollution is fourth highest cause of death among all health risks ranking just below high BP, tobacco and poor diet.

Natural causes

The naturally-occurring phenomena cause Natural pollution. It happens because of natural periodic activities, being more common under certain conditions and less common under others. They are sustainable over long periods of time.

Wind one of the natural pollutants. It can spread dust storms in areas of open land with little or no vegetation. This particulate matter, when mixed with air, causes health hazards because of warming

effect. Natural vegetation regions can also be affected by obstruction in photosynthesis because of Particulate matter.

Wildfires are caused due to prolonged dry periods which occur in forest areas. It is because of lack of precipitation and season change. The smoke and CO_2 generated from these fires contribute increase carbon levels in the atmosphere. This in turn allows greater warming causing a Greenhouse effect.

Volcanic eruptions are source of natural air pollution. When this eruption takes place, it produces excess amounts of sulfur, chlorine, and ash products. These are dispersed into the atmosphere to be picked up by winds and hence get spread over wide areas.

Man-made causes

In recent times many human activities contribute to air pollution. The human dependency on fossil fuels and heavy industry is ever lasting. It can also be due to the accumulation of garbage, modernization of agriculture, and other man-made processes.

Fossil-Fuel Emissions: The major cause of air pollution is combustion of fossil fuels or petroleum and other factory combustibles. Generally these fuels are used in power plants or vehicles and factory wastes or other fuel-burning devices. Excess of electricity used in Air conditioning and different home appliances in turn leads to more emissions.

Waste

Major greenhouse gas, generated from methane is having potential hazard of highly flammability and suffocation. This is dependent on rise in population and urbanization. This causes proportional waste production and generates need for dumping sites that are far from urban environments. A significant source of methane production are these sites, the best example is Mt. Pirana in Ahmadabad. We the human beings are adding harmful pollutants to the air faster. This causes acid rain, global warming or different health problems.

The 21 days lockdown intended to fight corona virus has brought breaking halt in the country. With vehicles and industries totally off in their functioning, pollution level throughout the India has observed a drastic fall. Many cities saw the drastic atmospheric freshness compared to that of before lock down conditions because of negligible vehicles on the roads and factories which was totally shut off. News regarding such conditions is reported as:

Jalandhar residents wake up to view of Himalaya range as Covid 19 lockdown leaves air cleaner. (News18, April 6 2020). According to Washington Post, air pollution in New Delhi dropped by almost 60% within just few days of the beginning of the lockdown. CNN in 2019 described that air in India's capital as a toxic, throat-searing cloud of brown smog. It reports that smog is mainly caused by transportation emissions, industry and power generation and construction dust in New Delhi.

Looking to news reports of lockdown period- means that restricted use or no use of vehicles or non-liberating industrial gases keeps the atmosphere natural and healthy which is proved during complete lockdown.

Air Pollution Measurements

Air Quality Index or AQI is the measure of outdoor air pollution, which rates condition of air across the country based on concentrations of five major pollutants: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Some of these pollutants contribute to pollute indoor air, which includes cigarette smoke or volatile organic compounds (VOCs) like substances.

Particulate matter (PM) consists of fine particles, which are smaller than 2.5 microns in size. This size is enough to penetrate people's lungs and bloodstream. PM pollution can be the reason for heart failure or lung cancer.

Sulfur dioxide, Nitrogen dioxide both are emitted from industries outcomes or vehicles. They can worsen respiratory disorder like asthma. If the exposure is of high level it can disturb lung function permanently.

Carbon monoxide is released by the incomplete combustion of fossil fuels into the air. Carbon monoxide is colorless and odorless, and when inhaled in large amounts it can easily lead to confusion, dizziness, and death.

Ozone pollution causes smog which comes from the emission of VOCs. When VOCs interact with sunlight it forms ground-level ozone. Ozone pollution can cause irritation of eyes, nose, or throat.

The Air Quality Index shows the measure of pollutants present by assigning the air, some grades in a particular geographic area [3]. It depends on level of atmospheric air pollutants present in that area. Each grade has a corresponding number value as well as a color as mentioned in table 1.

Grade	Range	Quality	Color
1	0-50	Good	Green
2	51-100	Satisfactory	Light Green
3	101-150	Moderate	Yellow
4	151-200	Poor	Orange
5	201-300	Very Poor	Red
6	301- above	Severe	Dark Red

Table 1 – Grading of AQI

The basic objectives of AQI are: Resource Allocation, Ranking of Locations, Enforcement of Standards, Trend Analysis, Public Information, and Scientific Research. This objective enables the contribution of individual pollutants and sources to overall air quality. Such objectives become useful when utilized in conjunction with local sources. Based on AQI observations a case study is presented here.

Case Study

The four random locations were selected for the monitoring AQI and pollutant levels. The AQI India mobile application was used for this purpose. This application provides limited location data. Among that I have selected to monitor Vatava GIDC Phase 4, Gandhinagar Sector 10, Ankleshwar GIDC, Vapi GIDC Phase 1. With respect to air pollution consideration, these all are sensitive zones. The following table 2 shows different AQI date recorded for the months of July to October 2020. The AQI observations taken were of post lockdown duration. Initially stable but there were few drastic surge observed in the AQI because increase in pollutants.

Selected areas are all Industrial sectors - GIDC areas hence there is obvious possibility of air pollution. The interesting observation is about Vapi GIDC Phase 1, which showed AQI 100 constant till end of July though the levels of particulate matters varied daily, also the NO_2, SO_2, & CO were quite stable in this area. After that AQI reduced to satisfactorily level from August first week to October first week and was under control. But from second week it increased severely and reached to Orange level on 20th Oct. PM_{10} caused this change in Vapi as it reached up to 141 $\mu g/m^3$. The temperature was min 27^o C and max 34^o C during this period of observation. Gandhinagar Sector 10 was consistent initially in green zone except once in yellow. PM_{10} was found to be increased up to 102$\mu g/m^3$ on 24^{th} July, while during Sept-Oct it slightly increased while the temperature varied from 26^0C to 37^0C. Ankleshwar GIDC was comparatively stable with AQI data except the drastic surge in dark red zone on 14th. It was found that NO_2 level heavily increased up to 349 $\mu g/m^3$ as there are

many Nitrate manufacturing companies which may be the cause for this jerk. PM_2 level was almost 0 while SO_2 levels varied frequently having the temperature difference of just 3^o C during these days.

After Aug second week, PM_{10} was increased up to 218 $\mu g/m^3$ on a day which in turn increasedAQI to yellow level which than continued up to Oct. Among all these locations Vatava GIDC is highly vibrant in AQI level and it has observed every colour of strip reaching upto red zone on 23rd July. Each constituent except CO was varied on daily basis in Vatva GIDC, PM_{10} was increased to reach up to 115 $\mu g/m^3$ to push it in red zone. Later from Aug it increased and remained in yellow zone till Oct. Particles size range of this type contributes to a good amount of dust which can be drawn into the lungs. Larger particles are trapped in the nose, mouth and throat. In general, monitoring all these cities common observation is that the months in which the lockdown was enforced pollution was minimized. But as soon as unlocking process started and industries open up their functioning with transportation for goods and other requirements caused the rise in pollution level.

Date	Vatva GIDC Phase- 4 (AQI)	Gandhinagar Sector 10 (AQI)	Ankleshwar GIDC (AQI)	Vapi GIDC Phase 1 (AQI)
07-12 Jul	57 avg	46 avg	51avg	100 avg
13-Jul	56	48	106	100
14-Jul	85	59	358	100
15-Jul	100	59	50	100
16-22Jul	100 avg	49 avg	50avg	100 avg
23-Jul	260	58	51	120
24-Jul	160	102	55	100
25-Jul	81	60	50	100
26-30Jul	89 avg	57 avg	50 avg	100avg
20-Aug	103	38	103	34
21-30 -Aug	93 avg	42 avg	51 avg	26 avg
1-Sep	108	57	106	50
2-14-Sep	105avg	57avg	108avg	73avg
17-24-Sep	108avg	68avg	99avg	43avg
25-29Sep	116 avg	67 avg	135 avg	59 avg
30-Sep	117	52	133	44
5 Oct	106	60	112	68
6 -8 Oct	102 avg	60 avg	230 avg	92 avg
9-13 Oct	92 avg	64 avg	125 avg	127 avg
19-20 -Oct	104avg	74avg	140 avg	157 avg

Table 2 – AQI observation of four cities

Thus representative sampling of pollutant concentration at the point of discharge or in the environment requires an understanding of pollutant characteristics. During the periods of high precipitation or high speed winds, emissions from city are swept away and do not have an impact on concentrations. On the other hand during the winter months when temperatures and inversion heights are low, there is greater impact of emissions on pollution concentrations. However, low temperatures also affect behavior through the need for space and water heating – which in turn increases emissions.

Water Pollution

Water being unique matter, it can naturally renew and cleanse itself. This is possible by allowing pollutants to break down or settle down. It may dilute the pollutants to a point of no harm. However, this is natural process and takes time as well as it is difficult when excessive quantities of harmful contaminants are added to the water. Water pollution can come from different sources. The water can enter directly, through legal drains or illegal drains from factories because of improper treatment

plants. Drops and leaks from oil pipelines or hydraulic cracks can degrade water supplies. Wind, storms, and littering especially of plastic waste can also mix garbage into waterways.
Water pollution results in human health problems or poisoned wildlife and can damage ecosystem. When agriculture and sectors from industry drain excess nutrients like nitrogen or phosphorus, they allow algae to bloom which create voids. Sometimes in such conditions low-oxygen areas are created in which fish or other aquatic life can no longer thrive. There are two main sources of water pollution, viz Point source and Non-point source.

Point sources include waste water treatment plants, septic systems, factories, etc. which discharge pollutants in water reservoirs. Non-point source include overflow of chemicals from factories, fertilizer from farm or otherwise animal wastes, sediments from construction sites or mines. Construction mining and sorting operations can cause great amounts of residues to pollute lakes and streams. When pollutants are carried through the ground by rain or melted snow such drains can carry fertilizers, pesticides, and herbicides from farms and homes, oil and toxic chemicals from roads and industry, bacteria from livestock, pet waste, and other pollutants. In water pollution excess of nitrates can harm to infants by disturbing their ability to carry oxygen to tissues.

Every individual is responsible for many non-point sources of pollution like when we flush the toilet, we tend to forget about it or we throw garbage. Because none realize how much we are contributing to pollution. To point the finger at industrial and mining operations is easy. According to Environmental Protection Agency (EPA) of USA, Water pollution is categorized as follow:

Biodegradable waste includes mainly of human waste or animal waste. Energy source for bacteria in water is biodegradable waste. In this process organic carbon turns to CO_2 and is the cause of atmospheric pollution or acid rain. This is problematic than other form of pollution.

Plant nutrients like nitrates or phosphates may enter water through drains or fertilizers overflow. These nutrients are also found in factory wastes. Excess of nitrogen or phosphorus in water allows algae to grow and smell bad with greenish colour while weeds grow and bacteria spreads.

Heat can be one of the pollution sources in water. With increase in water temperature dissolved oxygen amount decreases. It can be naturally occurring or man-made, through cooling tower discharges in power plants or any other equipment. Because of thermal pollution, aquatic life in the water reduces since they require certain oxygen levels and temperatures to survive.

Sediment is also a water pollution source. Washed or drained solid matter or mineral from land goes into water sources. Sediment comes from non-point sources and can cause large problems as it is difficult to identify. It can block water systems or increase turbidity of water. Turbid water can tend to increase thermal pollution, because it absorbs higher solar radiation.

Hazardous and toxic chemicals are man-made materials which if improperly disposed cause pollution. Mainly, chemical pollution comes from factory discharges or oil leakages - part of Point sources. Non-point sources include excess flow from roads or from farms. It is our thought that industries are source of chemical pollution. But personal use of chemicals can be party to chemical pollution such as household cleaners and solvents are toxic. Dyes, paints also can accumulate when drained in the toilet or poured somewhere else. Radioactive pollutants are especially through wastewater from hospitals or nuclear reactors. Natural isotopes are other sources of radioactive pollutants like radon, which can be harmful to the human beings.

Government Measures

To protect the environment and control the pollution of water, Government of Gujarat constituted the Gujarat Pollution Control Board (GPCB) [4]. This has prominent place in progress of industrial development in the country. The main functions being performed by this body, includes monitoring air quality and water, effluent sampling and analysis, inspection of effluent treatment plants for efficient performance and air pollution control. Guidance to the industry and other agencies is also provided by inspecting sites proposed for new industrial projects for its suitability from the environmental point of view. Among few agencies in Gujarat, Sophisticated Instrumentation Centre for Applied Research & Testing (SICART) in Vallabh Vidyanagar has entrusted the responsibility for pollution monitoring and auditing. The special mobile van facilitated with pollutant sensors move around to audit periodically for pollution levels in different parts of Industrial estates in Gujarat and certifies accordingly. This keeps restrictions on Industrial sectors for air pollution at surrounding sites.

While the ministry of road transports and highways keep track of PUC from vehicles. PUC law states about checking the vehicle emissions having potential to pollute the environment with smoke. This provides rules to monitor the emission levels to determine how safe they are for particular vehicle. PUC test for obtaining the Certificate was made compulsory by the Central Motor Vehicle Rule, 1989. "Pollution under Control" is a certification given for the vehicle which is within the range of stipulated standards. Validity of PUC for different vehicle is different e.g. 1 year for new car from its registration date. PUC Certificate confirms the percentage of carbon emission, which your vehicle may contribute to pollution. Thus emissions are kept under control.

Under the Graded Response Action Plan (GRAP) recently, Delhi Government has banned use of electricity generators, except those needed for essential or emergency services, in the national capital as anti-pollution measures. They had also implemented odd and even number vehicle utilization on road to restrict the use to control emissions from polluting vehicles.

Looking globally, last year, the UN General Assembly approved the decision to observe an International Day of Clean Air for blue skies [5] and invited the UN Environment Programme (UNEP) to arrange the observance of International Day collaboratively with other organizations. Following this the first International Day of Clean Air for blue skies was held on 7th September 2020. The objective behind this is to;

- Raise awareness among public—individual, community and government about clean air and its importance for better health, environment, productivity and economy.
- Demonstrate the link with other environmental / developmental challenges of quality air.
- Promote and make possible solutions to improve quality of air by sharing knowledge and bestpractices / innovations.
- Provide platform to diverse international working groups on this topic and form an alliance to strategically obtain momentum for intensive approaches for air quality management effectively at national and international levels.

Possible solutions to avoid Pollution

Three different things that can help to tackle the problem are — education (awareness), laws (severe penalties), and economics (concern to utilize resources in proper manner) and all they work togetheras a team to prevent pollution.

- Conserve water, if water utilization is less, drain out will also reduce.
- For fertilization of gardens use compost.
- Use detergents with less phosphate, as sewage plant only remove 30% of phosphate fromwaste.

- People can prevent indoor air pollution by sufficient ventilation, using exhaust fans in kitchenand bathroom and by avoiding smoking.
- To control global warming replace fueled cars with zero-emissions vehicles such as electricones or add renewable energy resources.

Around the world different countries are handling different types of air pollution. California has been leading to improve air quality standard and setting emissions levels, particularly in hazy places. Chinais stepping towards cleaning smog-choked skies by canceling coal-fired plants or by closing parts of industrial units. In India, several efforts are put to make cooking cleaner through Pradhan Mantri Ujjwala Yojana Household LPG by providing gas cylinders where hazardous stoves were dominant. Compulsion of effluent treatment plants within the factory premises is also enforced. Coal based power plants are moving towards cleaner technology by installing Flue-gas desulfurization (FGD). According to recent news reports India has recorded 6% decline in emissions of SO_2 as compared to previous years because of less use of coal and more of green energy. Namami Ganaga Programme is especially aimed to effectively stop pollution, conservation and transformation of Ganga River. Riverfront plans in major cities help to improve Environment and cause reduction in floods to safeguard cities.

Conclusion

Measurements were carried out for Air pollution to get the insight of pollution levels at four different city locations during the months of July to October 2020. It was found that AQI level of pollution was consistent in initial month but later on it gradually increased. These were crucial months as the unlocking period begins after pandemic. The difference was straightaway observed in Vatva and Ankleshwar as all the industrial routine work started. The pollution levels rose compared to the previous months of July and August. Though development is our necessity it is in line that whole industrial sectors has to function but in turn need the preventive measures or pollution handling capability with each units. This could help to control pollution levels arising from air and water. Taking in to consideration the specific objectives of monitoring AQI and control it at green level will be challenging task but mandatory to improve surrounding environment and health.

In view of the present scenario each individual has to be actively responsible and participate to keep air and water clean. Small acts when multiplied by millions of people, can transform the world. If you can't clean your surrounding then do not make it dirty. This philosophy would only help to save environment and save our lives.

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MODERN PHYSICS AND MEDICAL DIAGNOSTICS

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Introduction

Physical science has assumed a critical part in the headway of clinical science. Clinical science has been altered by the revelations in Physics previously. A progression of advances in Physics suffers a heart attack and direct effect on clinical science today essentially every one of the symptomatic and helpful apparatuses of present-day medical clinics have their starting point in Physics research. Clinical Physics isa part of Applied Physics, sought after by clinical physicists, that utilizes material science standards, strategies and procedures practically speaking and exploration for the counteraction, finding and treatment of human sicknesses with a particular objective of improving human wellbeing. Clinical physical science may additionally be characterized into various sub-fields (fortes), including Radiation Oncology Physics, Medical Imaging Physics, Non-ionizing Medical Radiation Physics and Physiological Measurement. Clinical material science is the utilization of physical science standards in the act of medication. It is regularly used to portray material science applications identified with the utilization of radiation in medication.

Any sound with a recurrence over 20,000 Hz (or 20 kHz) that is, over the most elevated perceptible recurrence is characterized to be ultrasound. An ultrasound is an imaging test that utilizes sound waves to make an image (otherwise called a sonogram) of organs, tissues, and different constructions inside the body. In contrast to x-ray beams, ultrasounds don't utilize any radiation. An ultrasound can likewise show portions of the body moving, for example, a heart pulsating or blood moving through veins. Ultrasound imaging (sonogram, ultrasonography, pregnancy sonography, fetal ultrasound, obstetric ultrasound, symptomatic clinical sonography, analytic clinical ultrasound) utilizes high-recurrence sound waves to see inside the body. Since ultrasound pictures are caught continuously, they can likewise show development ofthe body's inward organs just as blood moving through the veins. Dissimilar to X-ray beam imaging, there is no ionizing radiation openness related with ultrasound imaging. In an ultrasound test, a transducer (test) isset straightforwardly on the skin or inside a body opening. A slim layer of gel is applied to the skin with the goal that the ultrasound waves are communicated from the transducer through the gel into the body. The ultrasound picture is created dependent on the impression of the waves off of the body structures. The strength (abundancy) of the sound sign and the time it takes for the wave to go through the body gives the data important to deliver a picture.

There are two fundamental classifications of ultrasounds: pregnancy ultrasound and demonstrative ultrasound.

Pregnancy Ultrasound is utilized to take a gander at an unborn child. The test can give data about an infant's development, advancement, and by and large wellbeing. A pregnancy ultrasound is done to get dataabout the soundness of an unborn child.
It very well might be utilized to:

- ✓ Ensure that you are pregnant.
- ✓ Identify the size and position of the unborn baby.
- ✓ Identify to see you are pregnant with more than one baby.
- ✓ Estimate how long you have been pregnant. This is known as gestational age.
- ✓ Check for signs of Down condition, which thickened for the back of the newborn child's neck.
- ✓ Identify for birth absconds in the psyche, spinal string, heart, or various bits of the body.
- ✓ Check the proportion of amniotic fluid. Amniotic fluid is an undeniable liquid that includes anunborn newborn child during pregnancy.
- ✓ It moreover propels lung improvement and bone turn of events.

Diagnostic Ultrasound is utilized to see and give data about other inside pieces of the body. These incorporate the heart, veins, liver, bladder, kidneys, and female regenerative organs. An ultrasound can be used in different ways, depending on the type of ultrasound and which part of the body is being checked. **Diagnostic ultrasound might be utilized to:**

- ✓Find out if blood is streaming at an ordinary rate and level.
- ✓See if there is an issue with the design of your heart.
- ✓Look for blockages in the gallbladder.
- ✓Check the thyroid organ for disease or non-malignant developments.
- ✓Check for anomalies in the mid-region and kidneys.
- ✓Help manage a biopsy system. A biopsy is a technique that eliminates a little example of tissue fortesting.

In women, diagnostic ultrasound might be utilized to:

- ✓Look at a bosom knot to check whether it very well may be malignant growth.
- ✓ Help discover the reason for pelvic torment.
- ✓ Help discover the reason for strange feminine dying.
- ✓ Help analyze barrenness or screen fruitlessness medicines.

In men, diagnostic ultrasound might be utilized to help analyze problems of the prostate organ.

An Ultrasound Generally Incorporates the Accompanying Advances

During an ultrasound, you rest on an assessment table or bed. An ultrasound professional applies an exceptional gel to your midsection and pelvic territory. The gel is water-based, so it shouldn't leave blemishes on your garments or skin. The gel helps the sound waves travel appropriately. Then, the professional places a little wand, called a transducer, onto your paunch. They move the transducer to catchhigh contrast pictures onto the ultrasound screen as represented in figure 1. The specialist may likewise take estimations of the picture on the screen. They may request that you move or hold your breath while they catch pictures.

The professional at that point verifies whether the essential pictures were caught and on the off chance that they are clear. At that point, the professional wipes off the gel and you can purge your bladder.

- ✓ You will lie on a table, uncovering the territory that is being seen.
- ✓ A medical services supplier will spread a unique gel on the skin over that space.
- ✓ The supplier will move a wand-like gadget, called a transducer, over the space.
- ✓ The gadget sends sound waves into your body. The waves are so shrill that you can't hear them.
- ✓ The waves are recorded and transformed into pictures on a screen.
- ✓ You might have the option to see the pictures as they are being made. This regularly occurs duringa pregnancy ultrasound, permitting you to take a gander at your unborn infant.
- ✓ After the test is finished, the supplier will clear the gel off your body.
- ✓ The test takes around 30 minutes to an hour to finish.

Purposes behind a Pregnancy Ultrasound

An ultrasound can be utilized for an assortment of reasons during pregnancy. Your primary care physician may likewise arrange more ultrasounds in the event that they recognized an issue in a past ultrasound or blood test. Ultrasounds may likewise be accomplished for nonmedical reasons, for example, to deliver pictures for the guardians or to decide the sex of the child. While ultrasound innovation is alright for both mother and youngster, medical services experts debilitate the utilization of ultrasounds when thereis no clinical explanation or advantage.

During the Main Trimester of Pregnancy

In the main trimester of pregnancy (weeks one to 12), ultrasounds might be done to:

- ✓ Confirm pregnancy
- ✓ Check the fetal heartbeat
- ✓ Determine the gestational age of the infant and gauge a due date
- ✓ Check for different pregnancies
- ✓ Examine the placenta, uterus, ovaries, and cervix
- ✓ Diagnose an ectopic pregnancy or unsuccessful labor
- ✓ Look for any strange development in the baby

During the Second and Third Trimesters of Pregnancy

In the subsequent trimester (12 to 24 weeks) and the third trimester (24 to 40 weeks or birth), an ultrasound might be done to:

- ✓Monitor the baby's development and position
- ✓Determine the infant's sex
- ✓Confirm different pregnancies
- ✓Look at the placenta to check for issues, for example, placenta previa (when the placentacovers the cervix) and placental unexpectedness
- ✓Check for attributes of Down condition
- ✓Check for innate irregularities or birth deserts
- ✓Examine the embryo for underlying anomalies or blood stream issues
- ✓Monitor the degrees of amniotic liquid
- ✓Determine if the embryo is getting sufficient oxygen
- ✓Diagnose issues with the ovaries or uterus, like pregnancy tumors
- ✓Measure the length of the cervix

✓Guide different tests, like amniocentesis
✓Confirm an intrauterine passing

Sorts of Pregnancy Ultrasounds

Further created ultrasound methodologies may be used when a more ordered picture is required. These may give the expert the information essential to make a finding in case they perceived issues duringyour standard ultrasound.

Transvaginal Ultrasound

A transvaginal ultrasound may be done to convey a clearer picture. This ultrasound will undoubtedly be used during the starting periods of pregnancy, while getting an unquestionable picture maybe more irksome. For this test, a little ultrasound test is inserted into the vagina. The test inclines toward the back of your vagina while the photos are gotten.

3-D Ultrasound

As opposed to a standard 2-D ultrasound, a 3-D ultrasound allows your PCP to see the width, height, and significance of the hatchling and your organs. This ultrasound can be especially helpful in diagnosing any conjectured issues during your pregnancy. A 3-D ultrasound follows a comparative method as a standard ultrasound, yet it uses an uncommon test and programming to make the 3-D picture. It moreover requires one of a kind planning for the expert, so it may not be as comprehensively open.

4-D Ultrasound

A 4-D ultrasound may similarly be known as an incredible 3-D ultrasound. As opposed to various ultrasounds, a 4-D ultrasound makes a moving video of the hatchling. It makes a prevalent image of the charming countenances and improvements. It also gets highlights and shadows better. This ultrasound is performed correspondingly to various ultrasounds, anyway with novel equipment.

Fetal Echocardiography

A fetal echocardiography is performed if your primary care physician presumes your infant may have inherent heart abandons. This test might be done also to a customary pregnancy ultrasound, yet it may take more time to finish. It catches a top to bottom picture of the baby's heart one that shows the heart's size, shape, and construction. This ultrasound likewise gives your primary care physician a gander at how your child's heart is working, which can be useful in diagnosing heart issues.

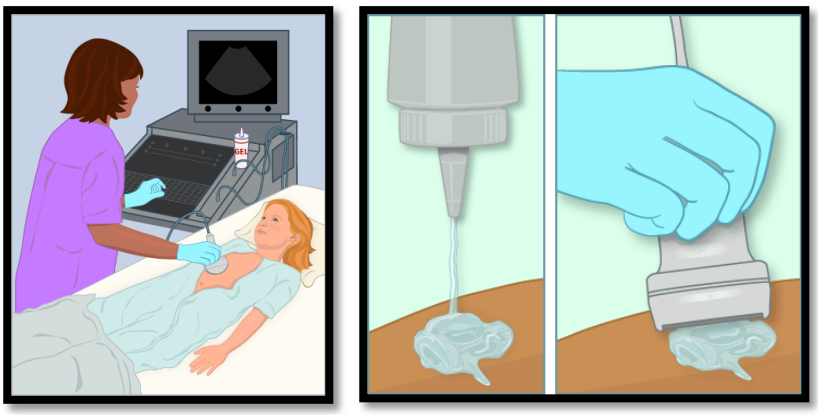

Fig. 1. Ultrasonic imaging system with Probe

the Fundamental Standard of Ultrasound

Ultrasound or sonography depends on a similar essential standard utilized by bats. An ultrasound machine gauges the echoes bobbing back to the transducer from the body of the patient to frame a picture.

Bats 'hear' echoes and measure them to decide the distance away the item is that caused the reverberation. They utilize what's called 'echolocation' to fly around evening time without finding anything. In the transducer test are piezoelectric precious stones that change shape when an electrical flow is applied to them. The vibrations or shape changes make sound waves that move outward. At the point when they are aimed at the human body, they go directly through the skin and into the interior life systems. As the waves experience tissues with various attributes and densities, they produce echoes that reflect back to the preciousstones. This happens in excess of 1,000 times each second.

The returning echoes are changed over to electrical signs, and the PC utilizes them as points of brilliance on the picture, relating to the anatomic position and strength of the reflecting echoes. A transducer contains a huge exhibit of gems which permit it to make a progression of picture lines that together structure a total picture outline called a sonogram. Every one of the gems are over and again initiated commonly so that a total picture outline is conformed to 20 times each second. This implies that 'continuous movement is shown in the ultrasound picture. As pictures are caught continuously, they can show how the blood is traveling through the vessels and how an inner organ is moving. This is the reason they are valuable during pregnancy as they can be utilized to notice the construction and development of the embryo. They are particularly helpful with regards to seeing the interface between spaces that are strong and those that are loaded up with liquid. The field of view relies upon the state of the test, and the recurrence of the dischargedsound waves decides the profundity to which they enter.

Physical Properties of Ultrasound

Sound is an influx of energy that, in contrast to X-ray beams, should be communicated through a medium. Sound waves can be portrayed by their recurrence, frequency, and speed. The recurrence is the quantity of cycles or waves that are finished each second, and the frequency is the distance expected to finish one wave cycle. A backwards relationship exists between the recurrence and the frequency of a soundwave: the higher the recurrence, the more limited the frequency. This relationship influences the decision of recurrence utilized in every understanding going through ultrasonography. Higher-recurrence ultrasound waves make higher-goal pictures, yet their more limited frequency makes them unfit to infiltrate further tissues. Lower-recurrence waves have better entering power, but since of their more drawn-out frequencies,their goal is lower. Gauging the requirement for higher goal versus seriously infiltrating power is consistently a thought while choosing a transducer recurrence. The speed of an ultrasound wave is free of the recurrence. Notwithstanding, it changes relying upon the medium through which the wave is voyaging.

Picture Production

Two essential standards should be perceived with respect to how ultrasound is produced and a picture is shaped. The first is the piezoelectric impact, which clarifies how ultrasound is created from earthenware precious stones in the transducer. An electric flow goes through a link to the transducer and is applied to the gems, making them misshape and vibrate. This vibration creates the ultrasound shaft. The recurrence of the ultrasound waves delivered is foreordained by the gems in the transducer. The second key standard is the beat reverberation rule, which clarifies how the picture is generated. Ultrasound waves are delivered in beats, not persistently, on the grounds that similar precious stones are utilized to produce and get sound waves, and they can't do both simultaneously. In the time between the beats, the ultrasound pillar enters the patient and is skipped or reflected back to the transducer. These reflected sound waves, or echoes,cause the gems in the transducer to disfigure again and produce an electrical sign that is then changed over into a picture showed on the screen. The parts of an ultrasonic imaging system consist of CPU, Transducer,Display, Cursor, Printer as mentioned in figure 2.

Central Processing Unit (CPU)

The CPU is the mind of the ultrasound machine. The CPU is fundamentally a PC that contains the microchip, memory, speakers and force supplies for the chip and transducer test. The CPU sends electrical flows to the transducer test to discharge sound waves, and furthermore gets the electrical heartbeats from the tests that were made from the returning echoes. The CPU does the entirety of the estimations associatedwith handling the information. When the crude information is handled, the CPU shapes the picture on the screen. The CPU can likewise store the prepared information as well as picture on circle.

Transducer Pulse Controls

The transducer beat controls permit the administrator, called the ultra-sonographer, to set and change the recurrence and length of the ultrasound beats, just as the output method of the machine. The orders from the administrator are converted into changing electric flows that are applied to the piezoelectric precious stones in the transducer test.

Display

The showcase is a PC screen that shows the handled information from the CPU. Presentations can be high contrast or shading, contingent on the model of the ultrasound machine.

Console/Cursor

Ultrasound machines have a cursor, like a trackball, implicit. These gadgets permit the administrator to add notes to and take estimations from the information.

Disk Storage

The handled information as well as pictures can be put away on circle. The plates can be hard circles, floppy circles, minimal circles (CDs) or computerized video plates (DVDs). Regularly, a patient's ultrasound filters are put away on a floppy circle and filed with the patient's clinical records.

Printers

Numerous ultrasound machines have warm printers that can be utilized to catch a printed copy ofthe picture from the presentation.

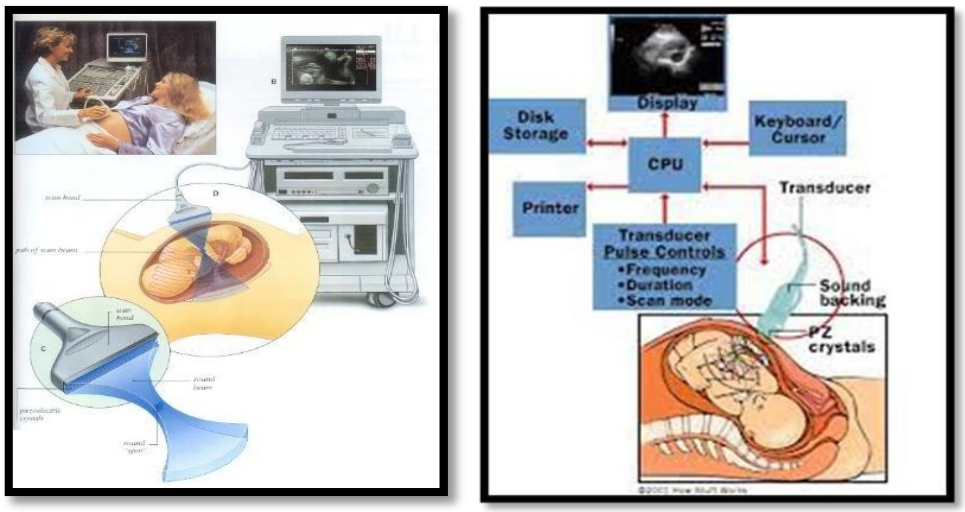

Fig.2. Parts of an Ultrasonic image system

Connection with Tissue

Ultrasound delivered by the transducer connects with various tissues in an assortment of ways thatmay help or impede picture development. Weakening and refraction are the two significant kinds of tissue collaboration.

Attenuation

It is the slow debilitating of the ultrasound shaft as it goes through tissue. Lessening can be brought about by reflection, dispersing, or retention of the sound waves and is made up for by utilization of explicitcontrols, examined below.

Reflection

It happens when ultrasound waves are skipped back to the transducer for picture age. The part of the ultrasound pillar that is reflected is controlled by the distinction in acoustic impedance between nearbystructures. Acoustic impedance is the result of a tissue's thickness and the speed of the sound waves going through it; in this manner, the denser the tissue, the more noteworthy the acoustic impedance. The huge contrasts in thickness and sound speed between air, bone, and delicate tissue make a correspondingly enormous distinction in acoustic impedance, making practically the entirety of the sound waves be reflected at delicate tissue-bone and delicate tissue-air interfaces. Then again, in light of the fact that there is little contrast in acoustic impedance between delicate tissue structures, generally few echoes are reflected to thetransducer from these spaces.

Dissipating

It alludes to the redirection of ultrasound waves as they associate with little, unpleasant, or lopsided structures. This tissue collaboration happens in the parenchyma of organs, where there is little contrast in acoustic impedance, and is liable for delivering the surface of the organ seen on the screen. Dispersing increments with higher-recurrence transducers, in this way giving better detail or goal.

Ingestion

It happens when the energy of the ultrasound bar is changed over to warm. This happens at the sub-atomic level as the bar goes through the tissues.

Refraction

It happens when the ultrasound bar hits a construction at a sideways point. The adjustment of tissue thickness creates an adjustment of speed, and this adjustment of speed makes the shaft twist, or refract. Thiskind of tissue collaboration can likewise cause relics that should be perceived by the sonographer.

Care of Equipment Alignment

It is suggested that ultrasound treatment gadgets be adjusted by appropriately prepared staff at anyrate once every month to guarantee that the ultrasonic force is demonstrated with a precision of ±25%.

Upkeep

Mechanical stuns and overheating of either the implement or lodging should be kept away from. Abrasives or synthetic substances should not be utilized on the utensil face. On the off chance that such activity happens, or is suspected, the ultrasonic force alignment ought to be checked.

Administrator Safety Precautions

- ✓ The instrument face should not be moved by the administrator when the gadget is producing ultrasound.
- ✓ The administrator should not inundate any piece of his/her body in the water shower in the way of the direct sent shaft, while an ultrasound treatment gadget is working in that water shower.
- ✓ Ultrasound treatment gadgets ought to possibly be turned on when the substance of the implementis in satisfactory acoustic contact with the patient, and the administrator is holding the utensil by its handle.
- ✓ Adherence to this rule additionally lessens the chance of warm harm to the implement.
- ✓ To help keep away from any reflected or dispersed ultrasound from entering the administrator's hand during submerged medicines, a dry delicate sew glove might be worn inside an elastic gloveto give air-hole assurance.

Patient Safety Precautions

- ✓ The administrator ought to be available all the time during a ultrasound openness, so the force can be decreased or the treatment can be ended if the patient gives minimal indication of misery.
- ✓ Records ought to be kept of every understanding, taking note of the openness levels, times, and couplet utilized. Keeping up all around reported, reproducible openness conditions, should help limit superfluous openness.
- ✓ The ultrasound is completely reflected at an air-tissue interface, coupling media should consistently be utilized between the tool surface and the patient. Helpless coupling could prompt all or a large portion of the ultrasound energy being dispersed in the instrument. Ensuing warming of the instrument could either harm it or potentially consume the patient.
- ✓ Moreover, where a huge part of the ultrasound shaft is required to spread to the site of exit from the body, it very well might be fitting to stay away from unwanted reflections by guaranteeing thatthe locale being dealt with is coupled to, and lays on, a safeguard.
- ✓ The transducer ought to be continued moving gradually, calculated at 90° to the treatment territory,throughout treatment to limit the danger of causing problem areas.
- ✓ Another motivation to keep away from the utilization of a fixed transducer concerns the risk that the pinnacle force will stay over similar tissue for the full treatment and delayed standing waves could create.

MODERN PHYSICS AND MEDICAL DIAGNOSTICS

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Key words: MRI, Medical diagnostic tools, Physics and medical diagnostics, Medical diagnosis.

MRI

Brief Introduction to The Topic

Exact diagnosis of any disease is very important for the treatment of the patient. This work is beautifully done by diagnostic tools developed on the basis of scientific principles. Many instruments from simple thermometer to stethoscope in early times to the latest PET scan all are based on physics principles. Since the advent of thermometer till now a series of diagnostic tools have been developed and are being used. Timeline of invention of some diagnostic tools is like this in the beginning endoscopy in 1805 Stethoscope in 1816,thermometer in 1867,the first electrocardiogram (ECG) was done in 1887,EEG in 1929, ultrasound was invented in 1956. Lasers were started to be used in medical field in 1964PET scan in 1974.Thus the field of medical diagnosis has gone a long way . At present we have the most sophisticated instruments mostly based on physics. MRI started in 1977 is one such diagnostic tool which is most effective. Raymond Vahan Damadian an American physician and medical practitioner is inventor of the first MR (Magnetic Resonance) Scanning Machine.

Different Types of Medical Diagnostic Tools -MRI

MRI means Magnetic Resonance Imaging. It is a very useful diagnostic tool of modern times as compared to other diagnostic tools available viz., X rays, Ultra sound, Lasers and Nuclear Medicines. It is based on the principle of Nuclear Magnetic Resonance.

Nuclear magnetic resonance consists of three words. Meaning of it is Magnetism of nuclear particle is set in resonance and then emitted radiations give rise to a branch of spectroscopy commonly known as NMR. Magnetism of the materials is due to motion of charged particles like electrons and nucleons init in orbital motion and spin motion.

The molecules which have unpaired electron have a net magnetic moment. Likewise the nuclei which have unpaired proton or neutron have a net magnetism. We will concentrate on nuclear magnetism only because NMR is nuclear phenomenon. If in a nucleus number of protons and number of neutrons areeven then due to pairing net magnetism is zero. If numbers of neutrons or number of protons or both are odd then the nucleus has a net magnetism. If anyone proton or neutron number is odd then spin is half integral. If both proton and neutron numbers are odd then net spin is integral. This net spin of the nucleus produces magnetism. Thus each nucleus behaves as a magnet. In normal condition these atomic magnets are randomly arranged in the material. When an external magnetic field is applied on the material these atomic magnets align in the direction of external magnetic field say B_0. The atomic or nuclear magnets may align parallel or anti parallel to the external magnetic field B_0. The magnetic vector in this condition processes around the external magnetic field with Larmor frequency.

The Larmor frequency depends on gyromagnetic ratio and strength of the external magnetic field. The energy of parallel alignment is lower and that of anti-parallel is higher. Transition betweenthese states may give rise to emission of a radiation. When an oscillating electromagnetic field is applied to the material precessional frequency of the atomic magnet changes and at a certain frequency resonance absorption occurs when field is less the atomic magnet returns to its original frequency and emits a radiation. This is NMR spectroscopy used to determine the structure of materials.

This NMR spectroscopy of body tissues is done using a specific device and the emitted radiations are analyzed to get the image of the body tissue then this is called Magnetic Resonance Imaging in shor MRI.

Principle of Physics

Certain nuclei like 1H, 13C, 15N which have unpaired nucleon resulting in net spin magnetic moment. This can be calculated as under. First calculation is done for orbital motion then by analogy we write for spin motion. Quantum mechanically spin angular momentum is a part of total angular momentum.

Considering the orbital motion of electron $i = e/T$

$$=ev/2\pi r$$

Orbital magnetic moment due to this current $\boldsymbol{\mu_l} = i\,A$

$$= (ev/2\pi r)\,\pi r^2$$

$$= evr/2$$

$$= em_e vr/2m_e$$

$$= -(e/2m_e)\mathbf{L}$$

$$\mu_l /L = e/2m_e = \gamma_l \qquad (1)$$

This ratio of magnetic moment to angular momentum $\boldsymbol{\mu_l}/\mathbf{L}$ is known as gyro magnetic ratio γ_l for orbital motion of electron. Magnetic moment may also be written as $\boldsymbol{\mu_l} = -(e/_2m_e)\sqrt{(l+1)}\,h/2\pi$

$$= -(eh/4\pi m_e)\sqrt{(l+1)}$$

$$= -\boldsymbol{\mu_b}\sqrt{(l+1)}$$

The quantity $eh/4\pi m_e$ denotes a unit , multiple of which gives magnetic moment. This quantity is known as Bohr Magneton written as $\boldsymbol{\mu_b}$. Its value for electron is $0.927X10^{-23}$ A m^2. Now by analogy same relation is written for spin magnetic moment as

$$\boldsymbol{\mu_s} = -(e/2m_e)\mathbf{S}$$

$$= -(eh/4\pi m_e)\sqrt{s(s+1)}$$

$$= -\boldsymbol{\mu_b}\sqrt{s(s+1)}$$

$$= -\boldsymbol{\mu_b}\sqrt{s(s+1)}$$

$$= -\gamma_s.\mathbf{S} \qquad \text{in terms of gyromagnetic ratio } \gamma$$

$$= -\gamma_s.(h/2\pi)\sqrt{s(s+1)}$$

Here γ_s is gyromagnetic ratio. In the presence of external magnetic field B_0 , z component of magneticmoment

$$\mu_{sz} = -g\,\gamma_s.(h/2\pi)\,m \qquad (2)$$

g is Lande's factor value of which is 2 for spin motion and 1 for orbital motion. Magnetic quantum number can take values = +1/2 to -1/2.The above calculation when done for nucleon gives nuclear magnetic moment arising due to spin of nucleons. Then γ_s will be gyromagnetic ratio for nucleon and instead of Bohr magneton we will consider nuclear magneton μ_n. Considering z component of nuclear magnetic moment given in equation (2) for nuclear spin motion let and external magnetic field B_0 is now applied on it, then due to this external magnetic field torque on nuclear magnet $\boldsymbol{\tau = \mu_s \times B_0}$ Due to this torque magnetic moment changes, its rate of change is

$$\frac{d\mu}{dt} = -(\gamma)\,(\mu_s \times B_0)$$

The effect of it is the spin precesses about the external magnetic field B_0. The precessional frequency called Larmor frequency is given by $\omega = \gamma B_0$ (3)

The Larmor frequency depends on gyromagnetic ratio of the nucleus and strength of external magnetic field.

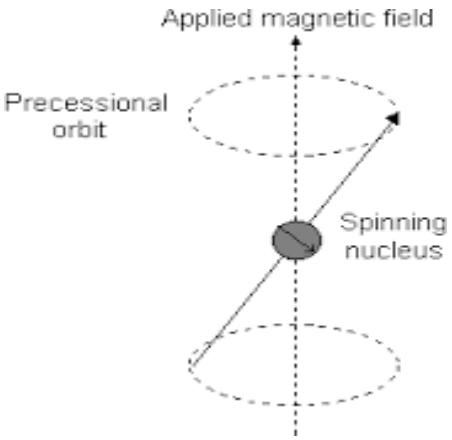

Figure 1 showing precession of nuclear spin

The energy of these levels will be $E = - \mu_{sz}.B_0$

$$E = - g \gamma_S.(h/2\pi) m . B_0$$

Difference between the two energy levels will be $\Delta E = h\nu = - g \gamma_S B_0 (h/2\pi)$ (4)

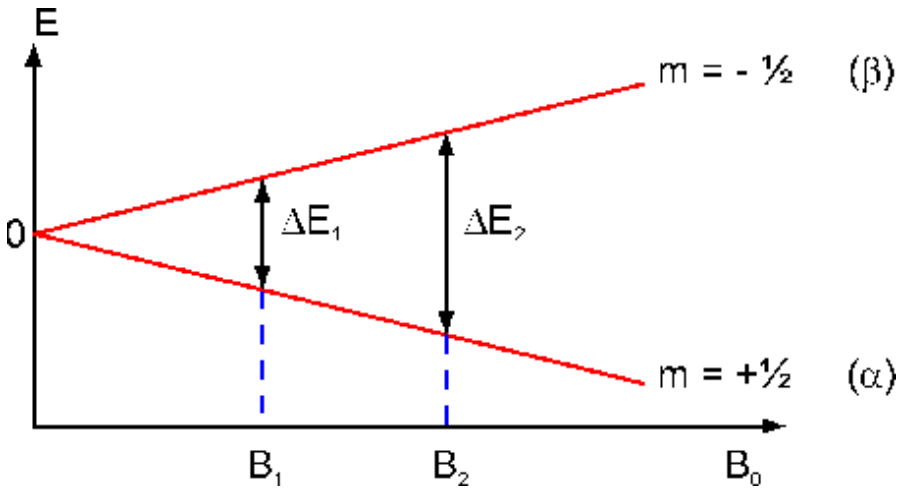

Figure 2 showing splitting of energy levels due to external magnetic field B_0

When a radiation of appropriate frequency given by equation (4) is incident on it resonant absorption and subsequent emission occurs. Either frequency of radiation or strength of the magnetic field may be

changed. In early days the frequency of radiation was changed slowly to know the resonance. It is known as continuous wave spectroscopy. Now a days pulsed fourier transform technique is used in which a pulseis sent. A pulse consists of so many frequencies thus exciting all nuclei simultaneously.

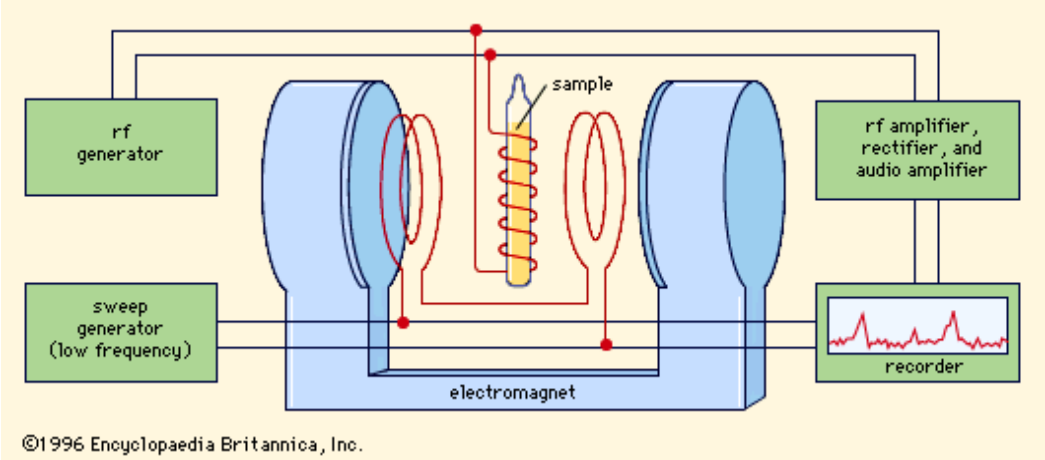

Fig. 3 showing the arrangement for Magnetic Resonance Spectroscopy

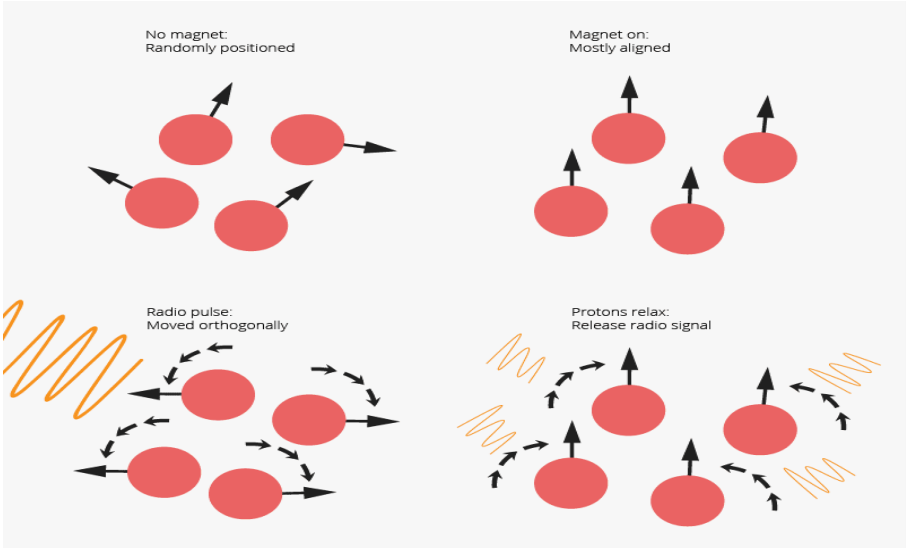

Fig 4 Showing alignment on application of external magnetic field, resonance absorption onapplication of radio frequency pulse and the emission of the radiation.

Working of the Instruments Involved in these tools

Magnetic Resonance Imaging uses principle of NMR spectroscopy and forms images of body tissues which are infected or having inflammation due to any disease. These parts of the body contain more water as compared to other healthy tissues of the body. In the water content hydrogen nucleus is there which is a single proton. This proton has spin magnetic moment and can be made to precess around the external constant high magnetic field say B_0. These nuclear magnets during there precessional motion absorb the resonant frequency from an RF generator and emit signals. These signals are analyzed to get an image of the body part. This method is non-invasive and safe and forms an image with good resolution as compared to other imaging techniques. In NMR spectroscopy image is formed on the basis of frequency of the emitted radiation while in MRI image is formed on the basis of intensity of theemitted radiation.

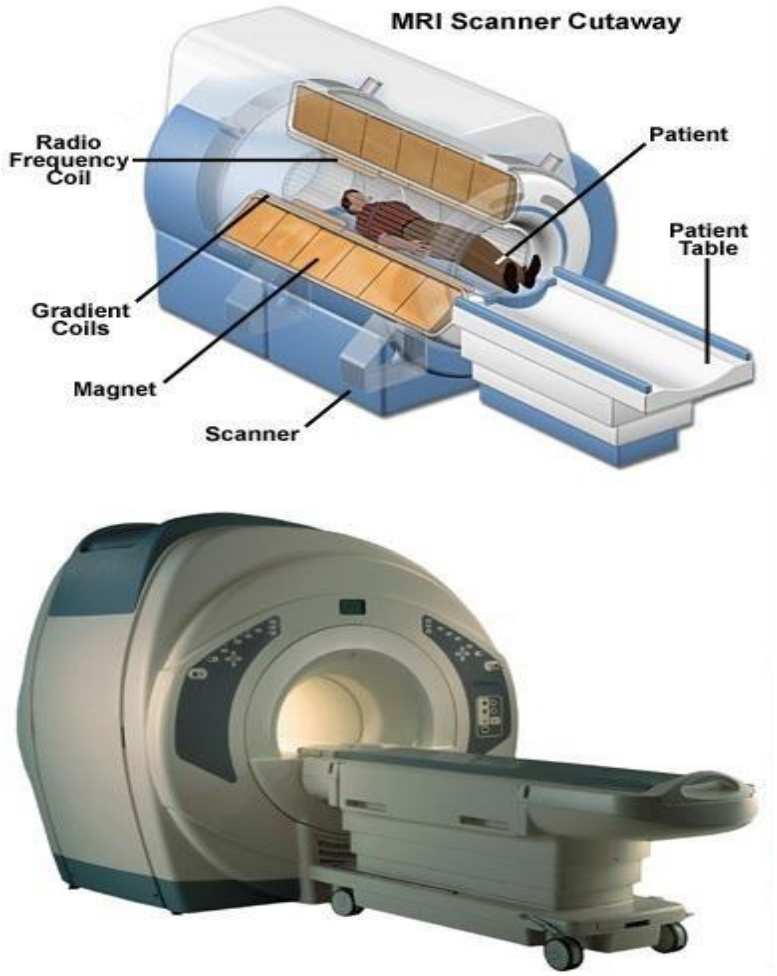

Fig 5 Showing cross sectional and front view of the MRI machine

The MRI machine has a large long hollow cylindrical structure with large magnets/ superconducting coils and gradient coils to produce a high magnetic field ranging from 5000 to 20000 Gauss. Patient is made to lie down on the stretcher. Then it moves inside the cylindrical machine. High magnetic field is switched on. This sets the protons of the affected part to precess around the high M.F. Now Radio Frequency signal is applied perpendicular to the high magnetic field. At this stage the high magnetic fieldis changed with the help of gradient magnets till resonance occurs. The protons of water align in the direction of high magnetic field and precess around it. At resonance they absorb RF signal and after sometime sends signals in the form of electromagnetic waves which are identified by the receiver coils. These electrical signals are now sent to computer for further analysis. Several signals from different parts of the body at different angles are now converted into image with the help of Fourier transform. This image in the form of black and white film reveals that some parts are light while some others are dark anddensity of darkness changes at affected part. Darker part represents solid part of tissue while light part represents infected area. Comparison or blending of several images gives information about the cancer, inflammation or infection of the tissue. To get a clear image the patient must be steady for about 30-40 minutes. Anesthesia is given to some patients for this. If the image is not clear then contrast agent Gadolinium is injected in the patients' body which helps to send signals from a certain part because Gadolinium has magnetic properties.

Types of MRI T1 and T2

Standard MRI- A huge cylindrical machine inside which whole body of the patient is placed for the examination time. Inside it some patients may fill uneasy.

Short bore MRI- It is nearly half in size as compared to standard machine. In it only the affected part of the patients' body is kept inside, rest is outside.

Open MRI- It has more space in it. Its shape is similar to bagel sliced in half. It has poor resolution as compared to Standard MRI

Depending on the rate at which RF signal is repeated and signal is received two types of images are formed T1 and T2. T1 is longitudinal relaxation time defined as time in which protons realign with the strong magnetic field. T2 is the time in which the excited protons reach equilibrium. In T1 weighted images Fat is bright and in T2 images inflammation is bright. Expert radiologist derive conclusion by comparing the different images.

A short description of the diseases in which these tools are utilized

MRI is used to detect brain tumor, blood clotting, epilepsy, stroke, facture, spinal cord problems. It can also image arteries and veins, cancer, dementia, headache. etc. All parts of the body may be examined using MRI since it is non-invasive and safe.

The basic safety measures recommended by various Governments agencies to run Labs for these tests.

Since the MRI uses strong magnetic field which is nearly 50000 times more than earth's magnetic field it is advised to the patients and their helpers not to wear jewelry, wrist watch and any metallic goods with them. These objects are attracted by the strong magnetic field and may create a problem. The patients with any metallic implant in their body can not be examined using MRI.Gadolinium contrast agent may be allergic to someone so the patient as well as radiologist must take care of it.

The patient must be prepared to stay calm for a longer time. It is not named Nuclear Magnetic Resonance Imaging but Magnetic Resonance Imaging only due to reason that it is premired in cold war. At that time people were afraid of nuclear treatment. These are the main safety measures adopted. Others include the sign boards showing safe and unsafe areas for common people.

Fig 6 Showing the MRI image of slip disc

MODERN PHYSICS AND MEDICAL DIAGNOSTICS

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Key words: Radio-pharmaceutical, PET/SPECT, Annihilation, Gamma- camera detector, F-18 FDG.

The power of humanity lies in its ability to gain mastery over the tools. The founder of Quantum theory, Erwin Schrodinger, in his book, "What is life?" rejected the presence of life-force, the mysterious spirit that animates living things. His speculation of life based on a code came out true with Watson and Crick unraveling the structure of DNA. Cracking of genetic code by Dr. Har Gobind Khorana laid bare before us, the book of life, each chapter of which makes us see ourselves in a new light. In the words of David Baltimore, "I don't think our bodies are going to have any secrets left with in this century. Anything we can manage to think about will have a reality". The branches of science amalgamated to satiate curious enquiries, to fuel research output and to devise application. Seamless merger of Physics, Chemistry, Mathematics, Computing, Engineering and Biology made advancements in Medical Science, with off-shooting of Biophysics, Medical Physics, Nuclear imaging, Radio biology, Radio pharmacy and Nuclear Medicine etc. The principles of Physics do not speak against the possibility of maneuvering things atom by atom- So said Nobel Laureate, Richard Feynman. And this is precisely what Nuclear Medicine does in our bodies.

George Charles de Hevesy, a Hungarian radio-chemist and a Noble laureate in Chemistry was recognized in 1943 for his key role in the development of radioactive tracers to study chemical processes such as metabolism of animals. Considered as Father of Nuclear Medicine, he also happens to be the co- discoverer of element Hafnium. He was the first to apply the radioactive tracer technique in biology when he investigated lead uptake in plants using Pb-212. In 1924, Weiss injected Bi-212 into one arm of the patient and measured the arrival time in the other arm. They concluded that the arrival time was prolonged in patients with heart disease. In the beginning, nature was the only supplier of radioactive nuclides used. Joliot Curie showed that alpha particles induced radioactivity in aluminum foil. The emitted radiation was identified to be from P-30. Hevesy studied the uptake and elimination of P-32 phosphate in various tissues of rats and demonstrated the kinetics of vital elements in living creatures. I-128 was soon applied for the diagnosis of thyroid disease. Radiobiology is the qualitative and quantitative study of the actions of ionizing radiations on living matter. Since radiation has the ability to cause changes in cells which may later cause them to become malignant, or bring about other detrimental functional changes in irradiated tissues and organs, the associated radiobiology is very important to be considered in all diagnostic applications of radiation. Nuclear medicine first became recognized as a potential medical specialty in 1946 when it was described by Endocrinologist Sam Seidlin in the Journal of American Medical Association. Seidlin reported on the success of radioactive iodine in treating a patient with advanced thyroid cancer.

Different elements have different target organs or tissues in our body. Strontium, just like Calcium deposits in bones. It is this transfer characteristic of an element or its compound to a particular tissue that is made use of in Nuclear Medicine. Iron deficiency leads to anemia as iron is the central metal in the heme part of respiratory pigment, Hemoglobin. Consuming foods rich in iron like spinach replenishes the deficiency. Iron-59 ($t_{1/2}$ = 46 days) is used to study iron metabolism in the spleen.

What purpose does iodized salt serve in our food? Iodine aids thyroid gland to produce thyroxin hormone, so essential for controlling carbohydrate, protein and fat metabolism in our body. Iron and iodine preferentially localize in our spleen and thyroid gland. Iodine-131, with a half -life of 8 days and a powerful beta emitter is used to treat thyroid cancer because the gland naturally accumulates iodine-131.When I-131 dose is swallowed, it is absorbed into the bloodstream in the gastrointestinal tract and concentrated in the thyroid gland, wherein the radiation from I-131 attacks nearby cancer cells with minimal effect on healthy tissues. Iodine-131, because of being a gamma emitter as well, is used for nuclear imaging of thyroid, diagnosis of abnormal liver function, renal blood flow and urinary tract obstruction. Radioactive iodine also treats an overactive thyroid in a condition called hyperthyroidism. Hyperthyroidism can be caused by Grave's disease in which either the entire thyroid gland is overactive or some nodules within the gland are locally overactive. Similarly, Iodine-125 ($t_{1/2}$ = 60 days) is used in cancer brachytherapy (prostrate and brain), and diagnostically to evaluate the filtration rate of kidneys and to diagnose deep vein thrombosis in the leg.

Nuclear Medicine application requires combining radioactive nuclei with other chemical compounds called vectors. A Radiopharmaceutical is the radioactive nuclei combined with a suitable vector. Radio- pharmacy is the art of preparing high quality, radioactive, medicinal products for use in diagnosis and therapy. The production and handling of radiopharmaceuticals requires specific expertise. Different aspects need to be taken into consideration- correct usage, storage of rapidly decaying diagnostic radionuclides, disposal of radioactive waste when using longer lived therapeutic radionuclides and quality control. The choice of radionuclide is based on 3 factors

a) The purpose for which radiopharmaceutical is to be used

b) The compatibility of radionuclide with the vector molecule

c) The availability and price of the radionuclide

Detection and mapping of this radioactive drug i.e., radiopharmaceutical, with in a patient's body to create diagnostic images and producing the images on a computer screen is the basis of Nuclear Medicine. These images are based on cellular function and physiology rather than on physical changes in tissue anatomy. The emitted radiation can be captured by various imaging techniques like Single Photon Emission Computed Tomography (SPECT) or Positron Emission Tomography (PET), depending on the radio isotope used. Through such imaging, physicians are able to examine blood flow to specific organs and assess organ function or bone growth and malignancies. Radio isotopes have short half-lives and typically decay before their emitted radio activity can cause damage to the patient's body. The amount of radiopharmaceutical administered is carefully selected to ensure the safety of each patient. Radioisotopes are an essential part of radiopharmaceuticals. Medical radioisotopes are made from materials bombarded by neutrons in a reactor or by protons in an accelerator called cyclotron. The former is called reactive radioisotopes (with short half-lives) while the latter are called the cyclotron radioisotopes (with very short half-lives). Some hospitals have their own cyclotrons, which are used to make radiopharmaceuticals with short half- lives of seconds and minutes. A radiopharmaceutical is a molecule that consists of a radioactive tracer attached to a pharmaceutical. Radionuclide Labeling is the term for the technique to track the passage of a radioactive sample by detecting the radiations emitted by it as it decays. After entering the body, the radio-labelled pharmaceutical will undergo decay and produce specific amounts of radiations that can be used to diagnose or treat human diseases and injuries. The nuclear medicine technologist monitors the characteristics and functions of tissues and organs in which the radiopharmaceuticals localize. Abnormal areas show higher or lower concentrations of radioactivity than the normal.

Physicians use these images to diagnose molecular, metabolic, physiological, anatomical and pathological conditions. Nuclear medicine technologists may also operate computed tomography (CT) and Magnetic resonance imaging (MRI) scanner that are used in conjunction with nuclear medicine procedures.

The ionizing radiations carry enough energy per quantum to move an electron from an atom or a molecule, thus introducing a reactive and potentially damaging ion into the environment of the irradiated medium. These radiations can traverse human tissue thereby enabling their use in medicine for both imaging and therapeutic procedures. The directly ionizing radiation consists of charged particles such as electrons, protons, alpha particles and heavy ions. It deposits energy in the medium through direct Coulomb interactions between the charged particles and the orbital electrons of atoms in the absorber. Indirectly ionizing radiation consists of uncharged particles which deposit energy in the absorber through a two-step process. In the first step, the neutral particle produces a charged particle in the absorber. In the second step, it deposits a part of its kinetic energy in the absorber through Coulombic interactions with the orbital electrons.

Annihilation is a reaction in physics in which a particle and an anti-particle collide and disappear releasing energy. The most common annihilation on earth occurs between electron and anti-particle positron. When a parent nucleus undergoes beta + decay (proton transforming into neutron leading to lowering of atomic number) or a high energy photon, it interacts with the electric field of either the nucleus or the orbital electron, an energetic positron may be produced. In moving through the absorber medium, the positron loses most of its kinetic energy as a result of coulombic interaction with absorber atoms. These interactions result in collision loss when the interaction is with the orbital electron of the absorber atom and in radiation loss (Bremsstrahlung) when the interaction is with the nucleus of the absorber atom. After the positron loses all its kinetic energy through collision and radiation losses, it comes to rest with in a short distance. This distance is dependent on the energy of the positron, which is a function of the parent isotope and is in the order of a millimeter. It will eventually undergo a collision with an available orbital electron in a process called positron annihilation. During annihilation, the positron and electron disappear and form a short lived positronium (Life time of about 100 ns) which eventually gets annihilated converting all mass to energy. Positronium consists of an electron and a positron, orbiting around each other. If the spins of the two particles point in the same direction, the system is called ortho positronium. It immediately gives out two oppositely directed (at an angle of 1800) annihilation quanta, each with an energy of 511 Kev, equal to the rest mass of the two original particles. These are the high energy gamma rays. See **Figure (I)**

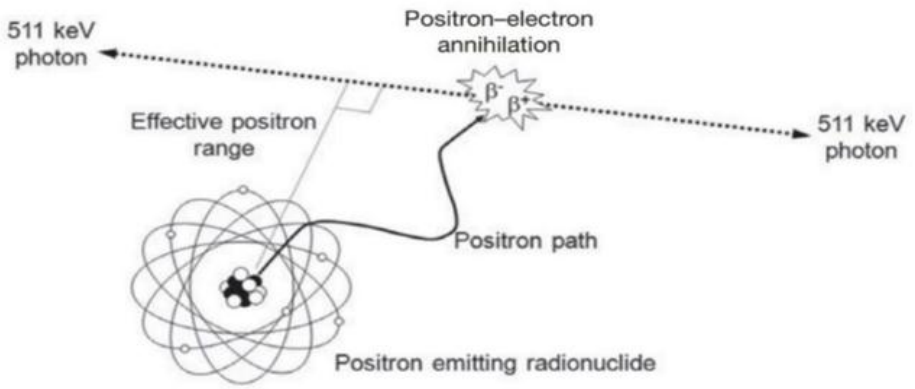


Figure (I)

The unique characteristic of simultaneous emission of two annihilated photons forms the basis of detection and localization of positron emitters using a technique called coincidence detection.

Scintillation detectors are inorganic crystals that emit scintillation light in the visible range when high energy photons are incident upon them. Examples are Bismuth Germinate (BGO) or Cerium doped Lutetium oxy orthosilicate (LSO) and photomultiplier tubes are placed opposite to the source of positron emitter. The signals are then fed into separate amplifiers and energy discriminating circuits. This process results into detection of the coincidence event, which localizes an annihilation event somewhere along the line joining the two detectors. In a typical PET scanner, there are hundreds of such points of detector banks in the form of ring surrounding the patient. Seed figure (II)a) and b)

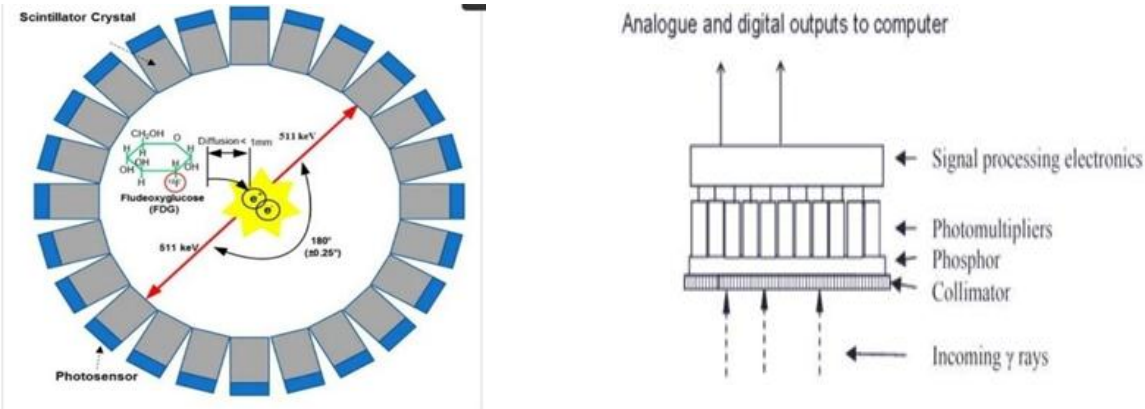


Figure (II) a) Detectors arranged in a ring b) Close look of Scintillation detectors

Detection of millions of coincidence events provides information about the concentration and special location of positron emitters within the patient. The data pertaining to the coincidence events is stored as two -dimensional matrix in which the horizontal axis represents offset from the center of the field of view (CFOV) whereas the vertical direction describes the projection angle. This set of data in terms of two -dimensional matrix is called cyanogram and helps to reconstruct the image. This process satisfies a number of conservation laws: conservation of electric charge, conservation of linear momentum, conservation of angular momentum and conservation of energy. Even the distance between the two opposing detectors affects spatial resolution. If the annihilation occurs before the positron has lost all its momentum, then the residual momentum translates into a small deviation of about +/- 25^0. This effect, called non-collinearity, contributes to blurring of image. The detectors are to be placed almost a cm apart to get adequate spatial resolution.

The tools employed to detect or quantify radioactivity depends on the nature of emission and range of radioactivity to be measured. A Geiger Muller tube is used for detection of alpha, beta and gamma radiations. A dose calibrator is used to measure gamma radiation in higher range of radioactivity as is found in generator eluate, radioactive sources or during dispensing of radio pharmaceutical to patients. A gamma counter is used to measure gamma radiation in lower range of radioactivity as in biological samples like blood. A beta counter is used to measure beta particles. Gamma cameras, SPECT and PET detect and quantify gamma ray emissions. While the SPECT detects the gamma radiation emitted by the radionuclide directly where- as PET measures it indirectly when gamma radiations are produced by the annihilation of electron and positron.

PET (Positron Emission Tomography) is a nuclear medicine imaging technique used for early detection and treatment follow up of many diseases like cancer. The major clinical applications of PET are in oncology, cardiology and neurology. PET requires positron emitting isotope labeled biomolecules, which are synthesized prior to perform imaging studies. F-18 is routinely used in radio labeling of biomolecules for PET, for its positron emitting property and favorable half-life of 109.8 min. The flagging of F-18 on glucose gives Fluorine-18 fluorodeoxyglucose (F-18 FDG) which is

commonly used for in-vivo measurement of abnormal glucose metabolism (typical symptom in cancer patients) thus, F-18 is used for tumors, cardiac and brain imaging and also to detect infection. Here, F-18 is the radionuclide and glucose is the vector molecule that carries it. Increased FDG uptake occurs with inflammation and infection as a result of activation of granulocytes and macrophages. The concentration of tracer accumulation demonstrates the metabolic activity of tissue in terms of regional glucose metabolism and accumulation. F-18 decays by positron emission 96% of the time and electron capture by 4% of the time. $^{18}F_9 \rightarrow {}^{18}O_8$ + positron + neutrino.

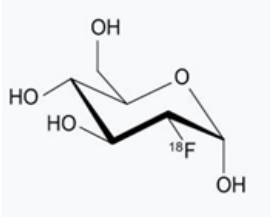
Both modes of decay yield stable O-18. F-18 emits a positron (a positively charged beta particle) that collides with an electron by an annihilation reaction and produces two photons with 511 Kev (Gamma radiations) 180^o apart. The gamma camera system detects the pairs of gamma rays emitted through annihilation reaction and 3-dimensional images of the radiotracer concentrations within the body are reconstructed by a computer using appropriate software and analysis. Because a pair of gamma quanta is detected in PET compared with only one gamma quantum in SPECT, the special resolution of PET images is higher than that of SPECT images. The cost of PET is higher than that of SPECT because of the cost of the cyclotron and the automatic radiolabeling process. Recently PET probe was approved by the FDA to aid in the accurate diagnosis of Alzheimer's disease which previously could be diagnosed with accuracy only after patient's death. In the absence of this PET imaging test, Alzheimer's disease is difficult to distinguish from vascular dementia or other forms of dementia affecting old people.

SPECT imaging instruments provide 3-d (tomographic) images of the distribution of the radioactive tracer molecules that have been introduced into the patient's body. SPECT imagers have gamma camera detectors to detect gamma ray emissions from radiopharmaceuticals in the patient's body. The cameras are mounted on a rotating gantry that allows the detectors to be moved in a tight circle around a patient who is lying motionless on a palette. A SPECT tracer is currently used for accurate diagnosis of Parkinson's disease. Small region in the brain that is to be imaged requires a dedicated brain SPECT imager with special gamma cameras to provide high resolution, but this adds to the cost of the procedure. National Institute of Biomedical Imaging and Bioengineering (NIBIB) is supporting research to create an inexpensive adaptor for the conventional SPECT Imagers that would provide high resolution images.

Nuclear Medicine uses radioactive isotopes in a variety of ways. Most commonly an ionizing Radioactive tracer, usually injected into the blood stream, to produce images that show function of internal organs. Technetium-99m (m stands for meta stable), when taken orally, inhaled or injected circulates through the body and is taken up only by certain tissues. Its distribution can be tracked according to the radiation it gives. This isotope decays to Tc-99 and a gamma emission of low intensity Technetium -99m ($t_{1/2}$ =6 hrs.) is used to image the skeleton and cardiac muscle in particular. The isotope flows in the blood stream. If there is less blood flow in the heart, there will be less isotope concentrated in the heart muscle. Similar information can be obtained for blood flow in the brain. Tc-99m can also be used for thyroid, lungs (perfusion and ventilation) liver, spleen, kidney (structure and filtration rate), gall bladder, bone marrow, salivary and lachrymal glands.

Radiology is designed to see anatomy, nuclear medicine is designed to see physiology i.e., chemical interaction at atomic and molecular level. But Nuclear medicine determines the disease on the basis of metabolic changes rather than changes in organ structure. Nuclear Medicine includes both imaging and treatment, because a radiopharmaceutical can be used for either. The main difference between nuclear imaging and other imaging systems like CT -Scan and X ray is that, in nuclear imaging, the source of emitted radiation is within the body. Nuclear imaging shows the position and concentration

of the radioisotope. If very little of the radioisotope has been taken up by the tissue, a 'cold spot' will show on the screen indicating that blood is not getting through. A hotspot indicates excess radioactivity uptake in the tissue or the organ due to a diseased state, such as an infection or cancer. Both bone and soft tissue can be imaged successfully. For example diagnosis of Prostate-cancer involves injecting a radiopharmaceutical in to the patient for imaging. PET scan is then done. Even the treatment involves the administration of Xofigo (Radium 223) by a Radiation Oncologist. Xofigo was FDA, approved in 2013 for men on hormone therapy with rising PSA and bone metastases. Administering Radiopharmaceutical may involve any one of the following therapies:



Brachytherapy is an internal radiation therapy in which a tube called catheter or a larger device called an applicator is used to insert the radioactive implant, in the form of a tube, wire, capsule, seeds or pellets. Once the catheter or the applicator is in position, the doctor will place the radiation source inside it. The implant may remain in the body for a shorter time, such as few minutes and repeat the treatment periodically for as long as several weeks. Once the course of treatment is complete, the catheter or applicator is removed. An implant may remain in the body permanently, but it will stop emitting radiation after sometime.

Systemic radiation therapy is another kind of internal radiation therapy in which the patient is required to swallow a radioactive substance, which travels through- out the body to find and kill the cancer cells. A radiopharmaceutical can also be injected intravenous.

Teletherapy, commonly called External beam Radiation Therapy is the one in which the energy beams come from a machine outside of the body. The penetrating beam reaches the cancer cells and damages the genetic material of these cells. Unable to repair the DNA, the cells will not be able to reproduce and die. Carefully planned Radiation Therapy minimizes damage to neighboring healthy tissues

Boron Neutron Capture Therapy (BNCT)

When Chadwick discovered neutron in 1932, he would never have thought that his chargeless heavy subatomic particle would become an important milestone in the treatment of as serious a disease as cancer. BNCT is based on the nuclear reaction that occurs when B-10, a stable isotope is irradiated with low energy thermal neutrons to yield alpha particles and Li-7 nuclei. BNCT selectively aims to treat tumor cells sparring the normal cells using boron compounds like boronophenylalanine and borocaptate sodium.. The high linear energy transfer (LET) of alpha particles to the new plastic cells ravage them but the normal cells abutting the cancer cells are saved from high LET irradiation. See Figure (III). There are three generations of boron compounds for selective targeting of the tumour cell and providing reasonably low toxicity in the living system.

S. No.	Type of compound	Examples	Remarks
1	1st generation boron compds.	Boric acid	Non -discriminatory compounds with meagre tumor retention, giving low tumor/brain ratios.
2	2nd generation boron compds.	Boronophenylalanine, Borocaptate sodium	Lesser toxicity, longer persistence, higher tumor/brain ratios
3	3rd generation boron compds.	BPA fructose complex	Work more specifically towards targeted tumor cells.

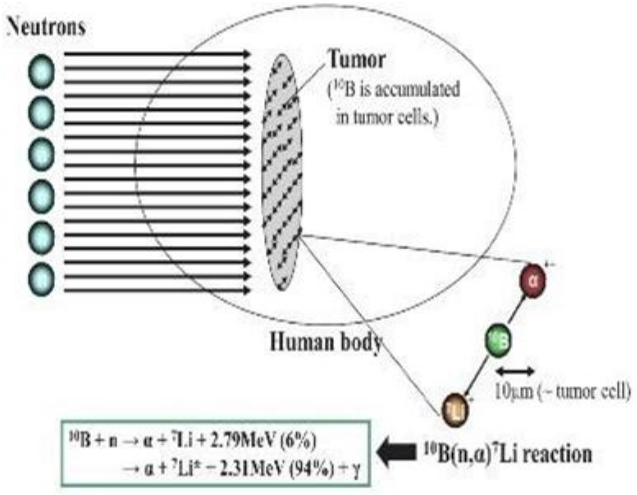


Fig-3

The unique feature of BNCT is its ability to deposit an immense dose gradient between the tumor cells and the normal cells. The tumor/brain and tumor/blood concentration ratios are >3 to 4:1. Other properties of boron compounds like low systemic toxicity, rapid clearance of blood and normal tissues and persistence in tumor also favor BNCT for the treatment of cancer. The most promising infusion route for boron compounds is by using tumor target moiety and nano scale delivery of drugs by nano particle.

Louis Pasteur was right when he said, "The role of infinitely small is infinitely large".

Safety measures recommended by Government Agencies to run labs

Regulating safety is a national responsibility. Risk of hazardous radiations transcends national barriers.International cooperation can promote and enhance radiation safety by exchanging experience in controlof leakage, response to emergency situations and mitigating harmful effects. Radiation can induce mutagenicity, genotoxicity and specific organ toxicity. Use of Nuclear medicine in India is regulated by Atomic Energy Regulatory Authority- Mumbai (AERA). The Civil Liability for Nuclear Damage Act was passed on 21st Sept. 2010. The radiation detriment that results from radiation exposure may beclassified as being stochastic or deterministic in nature.

Stochastic effects are those for which the likelihood of occurring is dose related but the severity of the resultant condition is not related to dose received, for example hereditary damage, cancer induction etc. These effects are basically the potential side effects from diagnostic uses of radionuclides.

Deterministic effects manifest themselves with a severity which is dose related, for example. cataract induction,bone marrow ablation, radiation syndromes and damage to embryo or fetus. Both the type of effects present a long time concern. The International Commission on Radiological Protection (ICRP) puts individuals in three categories according to their exposure.

Sr.	Type of exposure	Incurred by
1	Medical Exposure	a) Patients during diagnosis or treatment b) Attendants taking care and supporting the patient. c) Volunteers involved in Biomedical Research
2	Occupational Exposure	a) Workers during their course of duty
3	Public Exposure	a) General public like those residing in the vicinity of laboratories / medical facilities

The ICRP has also listed three fundamental principles of radiological protection:

Sr.	Principle	Basis
1	Principle of Justification	Any decision that alters the radiation exposure situation should do more good than harm.
2	Principle of Optimization of protection	The likelihood of incurring exposures, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable (ALARA)
3	Principle of Limitation of Dose	The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits recommended by the ICRP.

The three traditional principles for ionizing radiation safety are : Time , Distance and shieldingThe Inverse Square Law with respect to radiation safety says that the Radiation intensity is inversely proportional to the square of the distance between the source and sample. That means,if you double your distance from a source of ionizing radiation. You will reduce your exposure by four times. Some prescribed measures for Radiation Safety are listed below:

- Suitable personal protective clothing like lead aprons of appropriate thickness and rating , Lead gloves, safety lead glasses, overshoes as well as caps and masks, Thyroid shield should be provided to all employees of the lab/medical facility.
- Safe storage of radiopharmaceuticals must be practiced. The radioactive wastes must be disposed of after segregation. Each type of waste should be kept in a separate container properly labeled to give the information about radionuclide, physical form, activity and external dose rate.
- The room for interim storage of radioactive waste should be properly marked and locked. The waste should be properly packed to avoid leakage. Inflammable waste should be placed separately. Biological waste should be refrigerated or put in a freezer
- The floors and the workbenches should be quoted with impermeable material which is washable and resistant to chemical change with all joints sealed. The walls should also be cleaned regularly. A sign requesting patients to always “sit down”, “flush the toilet” and “wash the hands” should be displayed to lower the risk of contamination of the floor.
- Rooms in which radioactive aerosols and gases may be produced or handled should have appropriate ventilation system including a fume hood, laminar air flow cabinet or glove box.
- A separate bathroom for the exclusive use by injected patients is recommended.
- The bathroom and the sink should be finished in materials that are easily decontaminated.
- Drain pipes from the nuclear medicine facility should go as directly as possible to the main building sewer. Some countries recommend the drain pipes from isolation wards to end up in a delay tank.
- Safe working procedures are to be followed at all levels.
- The final disposal of the radioactive waste produced in a nuclear medicine facility includes several options like storage for decay and disposal as cleared waste into the sewage system (aqueous waste) through incineration or transfer to a landfill site (Solid waste) or transfer of sources to a special waste disposal facility outside the hospital.
- The work area should be kept tidy and free for articles not required for work.
- No food or drink, cosmetic or smoking materials, crockery or cutlery should be brought into an area where unsealed radioactive substances are used. Handkerchiefs should never be used in such areas.

- Direct handling of vials, syringes or other sources which produce a significant radiation is not recommended. Forceps or tongs to reduce the radiation exposure by increasing the distance between the source and the hands.
- All work should be performed behind a properly designed lead glass shield or some protectivebarrier.
- Any spill of radioactive material should be immediately covered with absorbent material to prevent the spread. Decontamination of the area must begin at the earliest.
- According to Basic Safety Standards (BSS), no person under the age of 16 years is to be subjected to occupational exposure and no person under the age of 18 years is to be allowed to work in a controlled area unless supervised and then only for the purpose of training. Removal of pregnant women from work in laboratories where large quantities of radionuclides are prepared and administered should be considered.

Internationally acclaimed physicist, Michio Kaku, in his book titled "Physics of the future", has delved deep on the future of Medicine. In his words, "A nanoparticle can deliver cancer fighting drugs to a specific target, which might revolutionize the treatment of cancer. The nanoparticle can be compared to a smart bomb, designed to hit a specific target with a chemical payload, vastly reducing collateral damage in the process. While a dumb bomb hits everything, smart bombs are selective and ravage only the cancer cells". With BNCT progressing fast, this thought might turn into reality soon.

Wonder what was at the back of **Gerald Sussman when he opined "I don't think, the time is quite right,but it's close. I'm afraid, unfortunately that I'm in the last generation to die.**

MODERN PHYSICS AND MEDICAL DIAGNOSTICS

Mihir Pal
Kabi Nazrul Mahavidyalaya, Sonamura, West Tripura

Introduction

In modern clinical practice, physics is playing a vital role by supporting the diagnostic techniques. With the help of theoretical basis of the physics, newer diagnostic devices are being invented day by day and Physics has now become an essential element of medical practice. In fact in the last century, it is due to the modern physics discoveries that many remarkable medical technologies along with diagnostic tools and even treatment methods have been explored. Out of these X-rays, radiation treatment method, laser surgery, high resolution ultrasound scans, computerized tomography scans, color Doppler, magnetic resonance imaging etc. are very crucial. Here is an attempt to explore the principles of Physics used for designing such tools and to highlight on some investigating diseases by these diagnostic tools. As basic safety is very essential for operating such tools, safety measures for running laboratory set up related to such tools has been highlighted, as recommended by various Governments Agencies.

Within a small domain, it is quite tough to explore all these medical diagnostic tools governed by the rules of Physics and so an effort has been done here to provide a basis for understanding the use of lasers in medicine only. Laser is a growing technological discipline in medicine that willat last add to the wide and fast development of both symptomatic and treatment techniques. Laser is an expanding technological discipline in medicine that will ultimately contribute to a broad and rapid expansion of both diagnostic and treatment procedures. The use of lasers in medicine has some very definite advantages in the surgical and medical treatment of a variety of disorders. The laser can be a wonderful tool when used by an experienced, well-trained physician. For the successful application of laser technology to a patient, the physician must be aware of the interaction of laser light with biological tissue. The nature of the interaction of all laser light with biological tissue is the most important issue for the success of this medical diagnostic tool and can be described properly in terms of reflection, transmission, scattering, or absorption phenomena. The simplified physics behind laser technology, properties of some individual lasers along with some laser beam delivery systems, some overview of clinical applications of this technology along laser safety are the major issues to be discussed here. This is worth mentioning that the actual credit of this technology goes to famous Physicist Einstein. The physical principle on which lasers are based was developed from his theories in the early 1900s, though the first laser device was not produced until the 1960s.

In 1961, it was a matter of concern about the hazards to those who were making and using lasers. It was felt that the eyes may be harmed by openness to the laser. Thus, a proposition was submitted to the National Institute of Health for the investigation of the perils of the ruby laser that had been created in 1961 by Maiman. In this way, in 1961, the Department of Dermatology of the College of Medicine of the University of Cincinnati set up the principal clinical laser research center. The Medical Laser Laboratory formed into a staff of 18, which included physicists, electrical designers, scholars, specialists of numerous strengths, and experts. This multidisciplinary staff is normal for the present laser research centers and laser clinical establishments.

Simplified theory of Physics behind Laser

In any atom, electrons are found to possess certain discrete energy levels or orbits. These electrons are not allowed to have energies between levels or to take up positions between orbits, so when the energy level of an atom is changed, the electrons should go up or down to the following orbital level. At the point when a molecule or atom assimilates energy, electrons move into higher orbits, yet fall back to their own less lively resting orbits very quickly. At the point when an electron tumbles to a lower energy level, there gets away from a minuscule explosion of surplus energy - a photon, the essential unit of light. The energy of the photon is essentially the distinction in energy between the two levels included. Energy fixes the frequency, which irresponsible for different colors of light. At the point when numerous atoms in a medium undergo such spontaneous orbital decay, the process is known as spontaneous emission and we get incoherent light.

A substance has the potential to behave as a lasing medium if it can have more atoms or molecules in a high energy state than in its ground energy state. This is known as population inversion. Lasers are named after the medium that produces light, i.e. carbon dioxide, argon, etc. Different media emit characteristic colours of light which, in turn, are used for various medical applications. In most lasers, a medium of gas, liquid, or crystal is energized (pumped) by a suitable source (light, electric discharge, radio frequency). The required pumping energy can raise electrons to higher energy levels, more quickly than their return to original level by spontaneous decay. As a result, there exist more atoms in higher energy states than in the lower energy states and a further process becomes probable in addition to the spontaneous emission. A photon from an initial spontaneous decay can stimulate each excited atom in its way and emit an identical photon to generate a coherent output. This is known as stimulated emission. The waves of light produced in this way are reflected back and forth many times by mirrors placed at each end of the laser chamber and thereby increasing the amplitude of wave with each reflection. In medical laser systems, one of these mirrors is made partially transmissive which allows the laser beam to leak out at this end. This is the beam of laser light. The produced laser beam is then allowed to pass through some delivery system to the surgical field.

Special properties of laser light

Laser light differs from ordinary light in much the same way that music differs from noise. Three particular properties are responsible for this difference: coherence, collimation, and monochromaticity.

Coherence

Ordinary light is 'incoherent', and such light waves radiating (shining) in all directions are out of phase with one another. Since in ordinary light multiple wavelengths are produced, the waves can't be in phase. Laser light is 'coherent'. Its light is also monochromatic and hence when the waves are phased together they become synchronize.

Collimation

Laser light is practically parallel, and in the case of a laser beam there is a minimum loss of power along the beam, and that it can be focused to intensify its effect or couple it into a slender single fiber. A laser beam can be a billion times brighter than sunlight.

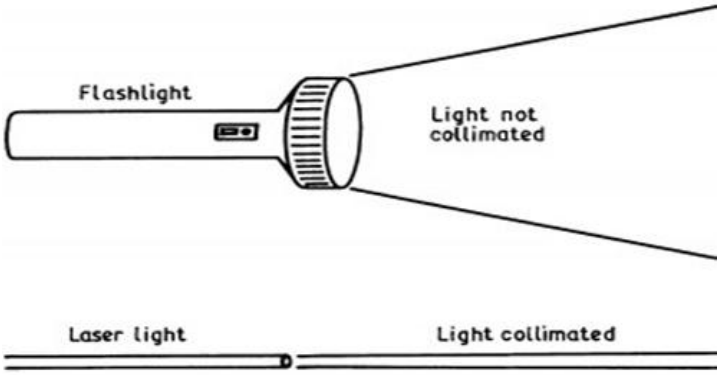


Fig. 1: Collimation nature of Laser beam

Mono chromaticity

Mono chromaticity indicates that light is all of the same wavelengths. Ordinary light sources generate light following the hot body process. Like the glowing filament in a lamp, the light usually consists of a mixture of all possible colors in a broad range. This results in white light. All the light of the laser obtained from a different source is concentrated in a few discrete wavelengths showing the mono chromaticity in nature. Lasers produce pure colors of light. Different materials emit characteristic colors.

Laser-tissue interaction

The effects created by surgical lasers - namely cutting, vaporizing and coagulation - are all caused by the heating of the tissue. Table 1 describes the effects on soft tissue as the temperature increases, from a laser or any other source of heat. The wavelength (color) of the laser determines how efficiently this heat transfer occurs over a certain volume of tissue. The nature of the interaction of any laser light with biological tissue can be well explained in terms of reflection, transmission, scattering, or absorption.

Temperature °C	Visual change	Biological change
100	Smoke plume	Vaporization, carbonization
90–100	Puckering	Drying
65–90	White/Grey	Protein denaturization
60–65	Blanching	Coagulation
37–60	None	Warming, welding

Table 1: Absorptive heating

For heating up of tissues, laser light falls on it must be absorbed. If the incident laser light is reflected or transmitted through tissue then no such remarkable heating effect will have occurred. If the light is scattered, it will be absorbed over a larger volume so that its effects will be more diffuse. Fig. 2 compares the relative effects of carbon dioxide, argon (or KTP), and Nd: YAG lasers.

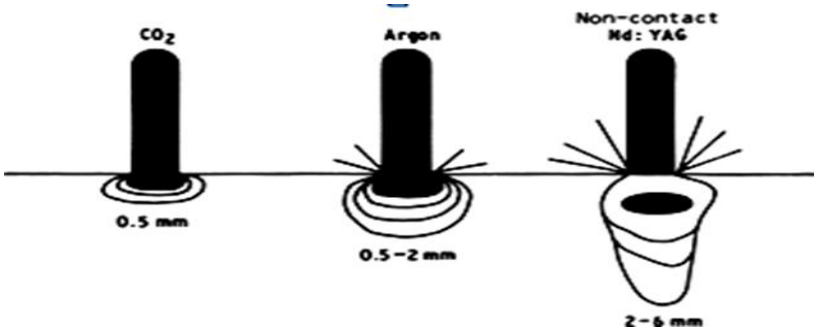


Fig.2: Tissue reaction and depth of thermal damage of CO_2 , argon and neon- contact Nd: YAG lasers

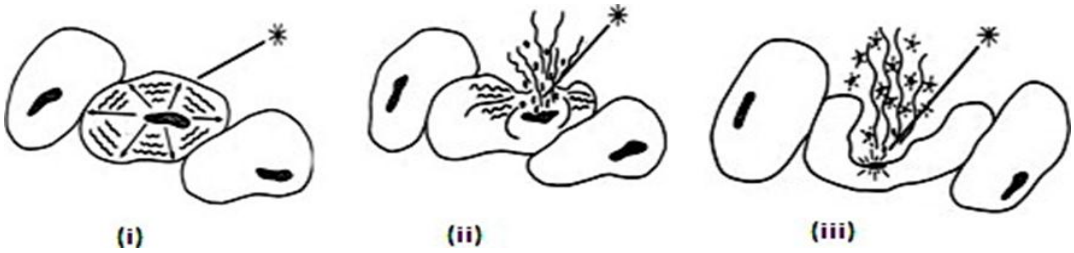


Fig. 3 (i) A cell has absorbed laser light and is heated to boiling point. The cell is destroyed.

(ii) The cell explodes, throwing off steam and cellular debris. (iii) The steam and debris rise from the site of impact and are carbonized in the laser beam.

Overview of Clinical Applications

At this point, the medical applications of the laser are so numerous that it is not possible to discuss them all in such a small domain. The advantages of laser surgery vary with each type of procedure, each type of laser, and sometimes from case to case. Conventional techniques for applying laser will always give better performance than a misapplied laser. Clinically, the advantage of using a laser in diverse medical diagnoses collectively include dry surgical field, Reduced blood loss, Reduced edema, Limited fibrosis and stenosis, Fiber optic delivery, non- interference with monitoring equipment, Potential reduction in the spread of metastasis, Precision, Fewer instruments in the field, Reduced postoperative pain (selectively), Sterilization of the impact site and Contact or no-touch technique as an option.

Pulmonary medicine

Carbon dioxide or Nd: YAG lasers may be used for the treatment of tumors of the trachea and bronchi. The carbon dioxide laser is precise and immediately vaporizes the obstruction when applied on the obstruction like a tumor. For delivery of such laser beam towards the obstruction, a rigid carbon dioxide laser bronchoscope and coupler cube are very useful. The long focal length of the laser lens also allows the beam to remain in focus over a long distance. This may be a potential hazard and one must be fully careful not to penetrate the trachea and underlying great vessels while dealing with this beam.

Neurosurgery

In the field of neurosurgery the basic useful instrument is the carbon dioxide laser, for the same reasons as for micro laryngoscopy. The carbon dioxide laser is an ideal instrument for microscopic use, long reach into small holes, and precision. The useful adjunctive type of laser for this field is Nd: YAG. It has helped shrivel very vascular tumors and has begun to be used in treating certain

aneurysms and arteriovenous malformation (AVMs).

Dermatology and plastic surgery

The carbon dioxide and argon lasers are used extensively in dermatology. To reduce blood loss in breast surgery carbon dioxide laser is very useful.

A scar is produced while skin incisions are made with carbon dioxide laser and this is cosmetically similar to that of a cold knife. Though carbon dioxide lasers are very useful in this field, it is more difficult to control them for not to penetrate the flap and maximum precaution is to be adopted.

Gastroenterology

In the case of gastrointestinal disease both argon and Nd: YAG lasers are very useful and are being used endoscopically. Lasers may also be used successfully in the endoscopic treatment of bleeding from peptic ulcers.

Urology and Gynecology

Argon or KTP lasers may be used endoscopically and are useful for superficial bladder tumors treatment. A pulsed dye laser producing green light at 504nm is now being used to fragment kidney stones. In gynecologic applications, the carbon dioxide laser can vaporize and sterilize condylomata and external lesions. Partial nephrectomy may be performed with the carbon dioxide laser or contact Nd: YAG laser to significantly reduce blood loss and retain maximum function in the remaining portion of the kidney.

General surgery

The application of laser in this area has sometimes been referred to as the sleeping giant of laser use. Most of the work to date has been with carbon dioxide lasers, and the Nd: YAGis just coming into play. The use of contact Nd: YAG laser is significantly expanding laser use into general surgery as a handheld modality that can cut, vaporize, and coagulate tissue.

Ophthalmology

Ophthalmologists were the pioneers of lasers in surgery. Lasers have been used for precise photocoagulation of the retina since the mid-1960s. The argon laser is the primary photocoagulator. Krypton lasers, with their yellow and red wavelengths, are also used by retinal specialists to achieve greater control in the macular area. Now a day's Lasik surgery is very popular for eliminating the burden of using spectacles or external lenses in the eyes.

Vascular surgery

Laser work in this area centers primarily around laser recanalization to open closed vessels or tissue welding. Tissue welding of small vessels is occurring experimentally in laboratories and has been used clinically in various cases.

Oral surgery and dentistry

Application of Laser beam is very useful for treatment related to soft tissue like gums and hard tissues like enamel and dentin. Carbon dioxide laser is very useful for treating patients with dilantin hyperplasia of the gums. This type of laser is also useful for preparing amalgam(filling).Application of this type of beam can reduce bleeding , sterilizes the operative place and generate less postoperative pain than conventional techniques.

Basic safety measures

Appropriate safety precautions and policies are very essential for overcoming and restricting the

hazards generated due to the use of surgical laser systems. As a guideline for laser safety measures, this has been recommended to wear laser safety glasses, utilize proper storage, follow standards and regulations, work with trained personals and use warning signs while dealing with the laser beam. To delineate fully the potential biological and ocular hazards associated with the full spectrum of laser wavelengths is a very crucial issue. Quality control programs along with safety measuring parameters should run throughout all Indian laboratories dealing with Laser beam application. All such laboratories should be graded as per their performance in this regard.
National guidelines: Actually the Radiological Safety Committees should also monitor the laser safety policy properly and also restrict its unauthorized access.

Conclusion: This can be concluded that a Laser is simply a surgical tool used in the practice of medicine. Recent technological advancement with lasers and fiber-optics makes it possible to deliver high-intensity laser light to almost any site in the body, at surgery, or through endoscopes and needles. Applications of this combined technology include pulmonary, urological, gastrointestinal, ENT, and dermatological tumors. All laser procedures are safe for both patient and personnel provided one acquires proper training, observes necessary precautions, and maintains equipment in proper operating order. Wide Application of this technology in medical diagnosis systems by increasing the safety parameter is a challenging task towards the blessing of this technology in the medical field.

Appendix

Guidelines for Essay Writing and Developing Skills for Science Communication

Do you know that the word 'essay' is derived from a Latin word 'exagium', which roughly translates to presenting one's case? Essay is often considered synonymous with a story or a paper or an article. Essays can be formal as well as informal. There are broadly four types of essays.

Descriptive Essays: Here the writer will describe a place, an object, an event or may be even a memory. But it is not just plainly describing things. The writer must paint a picture through his words.

Narrative Essays: This is when the writer is narrating an incident or story through the essay.

.***Expository Essays:*** In such an essay a writer presents a balanced study of a topic. To write such an essay, the writer must have real and extensive knowledge about the subject.

Persuasive Essays: Here the purpose of the essay is to get the reader to your side of the argument.

Format of an Essay

As such there is no rigid format of an essay. It is a creative process and should not be confined within rigid boundaries. However, there is a basic structure that is generally followed while writing essays. So let us take a look at the general structure of an essay

Introduction: This is the first paragraph of your essay. This is where the writer introduces his topic for the very first time. You can start with a quote or a proverb. Sometimes you can even start with a definition. Another interesting strategy to engage with your reader is to start with a question.

Body: This is the main crux of your essays. This need not be confined to one paragraph. It can extend to two or more paragraphs according to the content. Usually, we have a lot of information to provide in the body. Write the information in a systematic flow so that the reader can comprehend. So, for example, you were narrating an incident. The best manner to do this would be to go in a chronological order.

Conclusion: This is the last paragraph of the essay. Sometimes a conclusion will just mirror the introductory paragraph but make sure the words and syntax are different Make sure you complete your essays with the conclusion, leave no hanging threads.

In writing an essay on scientific topic, you have to ferret out interesting science themes/dimensions of the subject. Observation, exploration and investigation- things around you and activities you witness on a daily basis. For example if you are mentioning population you may also mention population density (an idea similar to surface charge density) or when mentioning power you may have a graph showing how it has grown over the decades. As a keen scientist you need to share your observations, exploration and investigation. If you are mentioning pollution of air then mention AQI; you may also mention vehicle density. Further you may have a graph showing how the number of vehicles has grown over the decades. Data presented in such an essay particularly in visual format through graphs, diagrams, flowcharts, pictures etc. can add a lot to the comprehension of your article. It is a good idea to do a survey of literature to gather facts. You should never involve in cut and paste business; it is plagiarism and is unethical. Acknowledge the sources in the end by giving a comprehensive bibliography. It is a joy to be part of this process of writing, where one acquires a skill which can become a strong part of the profile of the author and may be launch him as a science journalist.

As a sample we are including the details of NCEWP-2022 of this year containing necessary guidelines for our future participants.

IAPT National Competition on Essay Writing in Physics (NCEWP -2022)

Writing makes one perfect, essay writing more so……

NCEWP is one of the three national competitions being held by IAPT every year. The competition is open to participants in two categories: viz., students and teachers (including Science Communicators).

Category A - *Students* of Higher Secondary /Jr. College, UG and PG levels;

Category B - *Teachers* of Higher Secondary/Jr. College, UG and PG institutions, also Science Communicators working in recognized institutions.

Essay topic for both the categories is:

"PHYSICS BEHIND THE CLIMATE CHANGE"

Climate change is a significant time variation in weather patterns occurring over long periods ranging from decades to millions of years. Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions.

The idea is to explore the Physics behind the Climate change and ferret out interesting science themes. As a keen scientist you need to share your observations, exploration and investigation.

Your essay may be written considering the following points:

(i) Scope of study: your city/town- relevant map with latitude and longitude; area and population.

(ii) You may obtain the data for rainfall, temperature variation (minimum and maximum) during winter and summer seasons for the last ten years from your local Meteorological office. You may have graphical representation of these parameters. This will give an idea of the climate change in your region.

(iii) You may report:

(a) Natural causes of Climate change

(b) Man-made causes of Climate change

(c) The Physics of Climate change

(d) Effect of Climate change on Economy

(e) Effect of Climate change on Social Factors

(f) Some remedial solution

(iv) Conclusion

General Instructions:

The essay will be limited to 08 pages including figures / tables etc. type-written in the Times New Roman 11-point fonts, with 1.15 spacing. A format is given below:

IAPT National Competition on Essay Writing in Physics: 2022 (NCEWP – 2022)

Topic: -"PHYSICS BEHIND THE CLIMATE CHANGE"

Tick Category: A B

Author's Details (with Affiliation & Signature):- Total No. of Words:-

Key Words (Maximum Five)

Important Changes in the IAPT Essay Competition NCEWP-2022

All the RC's will conduct the regional level essay competition digitally. Students at all the levels i.e. Higher Secondary/UG/PG can submit their essays through e-mails to President/Secretary/EC member of the respective regional council. Only two entries per institution may be submitted in a category.

(1) Students will send their entries duly forwarded through respective school/college/institute to the appropriate Regional Council (RC) with all contact details clearly. The RC's will have the initial scrutiny at their level. They will select 2 best essays from each level. Thus each RC will submit 6 best entries to the national competition. RCs may award certificate etc., for their participants. Even the RCs may issue a certification of Participation to those whose Essays are sent to the National Competition.

(2) For the regional competition, students may write their Essays in Hindi or their regional languages. If such entries are forwarded for the National Competition, then the concerned RCs will translate the Essay in English (with the help of Google translator etc.) Only English Version will be submitted for National Level Competition.

(3) Similarly, Teachers & Science Communicators will send their entries through e-mails duly forwarded directly to the Coordinator/Member. Retired teachers can self-attest their entry. All entries (in English only) will be scrutinized. All entries will be subjected to the online plagiarism test. All entries will be assessed by three evaluators.

The last date for essay submission is 15th August, 2022.

Final entries for the national competition must be submitted in PDF format by e-mail to any one of the following:

1. Prof. S. K. Joshi, Coordinator, NCEWP, Mail id:- joshisantoshk@yahoo.com
2. Dr. Himanshu Pandey, Member, NCEWP, Mail id:- himanshukrpandey@gmail.com
3. Dr. Shivanand Masti, Member, NCEWP, Mail id:- shivanandmasti@yahoo.co.in

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