EVERYMAN'S SCIENCE

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COVER PHOTOGRAPHS

Past General Presidents of ISCA

1. Dr. Atma Ram	**(1968)**
2. Dr. A. C. Joshi	**(1969)**
2. Prof. A. C. Banerjee (died pre-maturely)	**(1969)**
3. Prof. L. C. Verman	**(1970)**
4. Prof. B. P. Pal	**(1971)**
5. Prof. W. D. West	**(1972)**
6. Dr. S. Bhagavantam	**(1973)**

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EDITORIAL

GREAT DISCOVERIES IN SCIENCE – EUREKA MOMENTS AND SERENDIPITY

In UMIST (now University of Manchester), UK, there is a famous life size statue of Archimedes in his bath tub, sculpted in stone by Thompson Dagnall. In almost all other paintings, sketches or sculptures he is shown with beard and scholarly look, but interestingly, here he is shown cleanshaven in a bath tub as if about to jump out of it without clothes, and an expression suggesting that he is supposed to be shouting "EUREKA" (Greek-I have found it).

Statue of Archimedes in UMIST—EUREKA (Wiki)

Archimedes, (287 – 212 BC) was a Greek mathematician, physicist, engineer, inventor, and astronomer. He is known as greatest mathematician of his time. Archimedes'principle of floating bodies is his most known contribution in fluid mechanics, which has found several important applications. It states that a body when immersed in a fluid is buoyed up by a force equal to the weight of the fluid it displaces. Amongst several applications of the principle, I find the Ship Lift at Henrichenburg in Germany, and Falkrik rotating wheel in Scotland, for transferring a ship from one canal to the other when there is appreciable level difference between the two, quite interesting. In the Ship Lift at Henrichenburg, the trough load (containing water or water and ship) was supported by the buoyancy of some cylindrical floats each immersed in deep water-filled wells. Since the lift from the floats was the same as the load of the water filled trough, only a small electric motor sufficient to overcome friction and viscous resistance was needed to set the trough in motion in either direction. Falkrik rotating wheel consists of two opposing arms which take the shape of a Celtic-inspired, double - headed axe at their ends. Two diametrically opposed water-filled caissons (also known as gondolas), are fitted between the two heads of both arms. The wheel is kept balanced as the two gondolas always weigh the same, as the boat when it enters gondola displaces water equal to its weight and needs little power to rotate it. This rotation carries the gondola with or without ship upwards or downwards.

I have been to Manchester several times after the statue was installed in 1990, but am intrigued by the stories relating the event of Archimedes' sitting in the tub. It is said that the king wanted him to find out if in making of a crown goldsmith had used pure gold or was there any cheating. The water displaced by his sitting in tub is said to have given him the idea of the method to measure the volume of bodies of non regular shapes, and thus he could find the density of the crown and compare it with that of gold. Another version is that he got an idea that he could use a balance with pure gold and crown on two sides, dip them in water, and compare the buoyancy. According to another story, Archimedes is supposed to have made the discovery of the behaviour of floating bodies while stepping into his bath, causing him to exclaim "Eureka!"

Archimedes was a genius, regarded as polymath (expert in many areas) and is most known scientist from antiquity for his scientific contributions. We all know that ships were built even before the laws of floating bodies were enunciated, and I have no doubt that the knowledge of buoyancy in some form must have existed at that time. It must be the genius of Archimedes to have given precise laws for the physical phenomenon associated with the behaviour of the floating bodies. The famous stories of "Eureka" attributed to Archimedes are perhaps exaggerated to make the discovery more interesting. However, the genius of the scientist, his devotion to his work, his familiarity with the knowledge that existed at the given time and his passion to discover the phenomenon, remain the basic factors responsible for the eventual eureka moments.

Importance of the existing researches conducted by the earlier scientists and the existing knowledge is reflected in the famous quote of Sir Isaac Newton in a letter written to Robert Hooke in February 1676 :

"If I have seen further it is by standing on the shoulders of giants"

Sir Isaac Newton (1643 – 1727) is perhaps most known and considered as one of the greatest scientists of all times, who made several fundamental contributions in physics, mathematics, astronomy, natural philosophy and theology. His monograph *Philosophiæ Naturalis Principia Mathematica*, published in 1687, is considered to be one of the most important scientific books ever written. In this book, he laid the foundations of most of the classical mechanics, described universal gravitation and the three laws of motion, which dominated the scientific view of the physical universe for over three centuries. Newton showed that the motions of objects on Earth and of celestial bodies are governed by the same set of natural laws, by demonstrating the consistency between Kepler's laws of planetary motion and his theory of gravitation.

Despite being such a great and highly influential scientist, Newton's humility and quest for knowledge is reflected in his famous lines :

"I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

A popular story attributed to Sir Isaac Newton says that an apple once fell on the head of Newton, and that is what led him to discover the laws of gravitation. Over the years, several pictorial representations including some famous cartoons have come up to illustrate this event. There seem to be other versions as well, which say that falling of an apple from a particular tree would make him ponder over the issues of gravity. Perhaps this was also a myth, or exaggeration like "Eureka" story of Archimedes, however, various trees are claimed to exist even today, which are the apple tree (or its descendants) described in these stories.

The stories of Archimedes in the tub and falling of apple on Newton's head seem to exemplify that there are moments of Eureka, which bring sudden ideas to the prepared minds seriously engaged in pursuits of knowledge and keen to understand and discover the physical phenomenon.

Abundant examples can also be found in literature with stories of some important and useful discoveries or inventions like penicillin and microwave-oven, that were made accidently or by chance. These are attributed to quite unexpected observations made by the investigators in the experiments, which they were rigorously pursuing, though for some other very different purpose and the phenomenon they discovered was totally unrelated to their main quest. That is what makes the observations accidental, and the serendipity at times has lead to such discoveries or inventions, which had lasting impact on our living.

Sir Alexander Fleming, Scottish biologist and pharmacologist (1881 – 1955), discovered Penicillin in 1928, when by chance he found that culture he was wanting to grow was contaminated by a fungus, which stopped the bacteria from growing. This observation led to one of the most important discoveries in medicine - an antibiotic.

Percy LeBaron Spencer (1894 – 1970) an American Engineer was responsible for efficient manufacture of magnetrons, which were used to generate the microwave radio signals. In 1945 while standing near an operating magnetron, he noticed melting of a chocolate bar that was in his pocket. He then placed some popcorn in front of the magnetron and found that it began to popup quickly. This observation led to design of microwave oven two years later.

The examples highlight the accidental or chance element in a discovery – some times exaggerated - but these serendipitous events speak highly of the preparedness of the mind of the investigator and his genius in recognizing the importance of the chance observation and eventually following this up with further researches which help in such observation becoming discovery or invention of great importance.

N. K. Gupta
Indian Institute of Technology, Delhi

A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it.

— Max Planck

PRESIDENTIAL ADDRESS

GEOLOGY IN THE SERVICE OF INDIA

PROF. W. D. WEST, C.I.E., SC.D., F.N.A., F.G.S

I am deeply grateful to the Council of the Indian Science Congress Association for having elected me their General President for this year. I have been associated with the Science Congress since 1933, when I became one of your General Secretaries, and for five years I had the privilege of working along with the late Prof. S. P. Agharkar and with Prof. J. N. Mukherjee. It was during this period that the Association celebrated its Silver Jubilee by inviting the British Association to send a delegation to attend the meeting held in Calcutta. I mention this, because next year the Association will be celebrating its Diamond Jubilee, and I have no doubt it will be celebrated in a fitting manner.

This year we had been expecting to meet under the auspices of Aligarh Muslim University. But the national emergency forced us to postpone the meeting and as it was not possible for this University to host the session except during the winter vacation, we had to give up the idea of holding the meeting at Aligarh. We are however grateful to them for all the trouble they had already taken. We then received an invitation from the University of Calcutta and we are most grateful to you Mr. Vice-Chancellor, for inviting us to hold the session in Calcutta at such short notice.

The importance of the Geological Sciences in national planning and development is recognized in all the advanced countries, but in India this recognition has come rather slowly. Since the middle of the last century the organisation mainly responsible for investigating the mineral resources of the country was the Geological Survey of India. In its early days the most important mineral was coal, and the first work of the Survey was to demarcate the various coal-bearing areas, thus paving the way for the development of the coal-mining industry, which is still the most important mineral industry of the country, accounting for 58% of the total value of the minerals produced. Subsequently, the work of the Survey became diversified, and other minerals such as iron-ore, manganese-ore, mica, gold and salt received special attention. But the Survey, although the third oldest in the world (the British and Canadian Surveys were started earlier) remained a small Department until the temporary loss of the mineral wealth of Burma and Malaya during the second world war emphasized the need for a more thorough search for minerals in India, and the value of the work of geologists at last became appreciated. It was then that the expansion of the Department began and with the coming of independence the expansion was accelerated both in the number of its personnel and in the variety of its work. When I first joined the Survey there were less than 30 gazetted officers, who were responsible for geological work in India, Burma and what is now Pakistan and there were only a handful of technical personnel and clerks. At that time the annual budget of the Department

* General President, Fifty-Eight Indian Science Congress held during January, 1972 at Calcutta.

was about Rs. 3 lakhs. Today the number of gazetted officers is nearing 1500, and the annual budget amounts to about Rs. 8 crores, a truly remarkable transformation, the greater part of which has taken place since 1947; and I must pay tribute to my successors who have brought this about and to the Government of India who have had the wisdom to sanction it. But this is not the whole story. For whereas previously the Geological Survey was responsible for practically all the geological investigations undertaken in the country, during the past 30 years a number of independent sister organizations have come into being, such as the Indian Bureau of Mines, the Oil and Natural Gas Commission, the National Coal Development Corporation, and the State Geological Departments, all of which are employing earth scientists.

With such a great expansion in the Departments of the earth sciences, it may well be asked; what has the country gained from it? In a single sentence I can point to the fact that the national income from the mining sector at current prices has increased by 170% in ten years, from Rs. 1308 million in 1960 to Rs. 3617 million in 1969.

But in spite of the small number of geologists working in the Survey during its first century, their work was outstanding, and it influenced the course of Geological Science in more than one direction. In particular I may refer to the recognition of the Upper Carboniferous ice age in India and in the continents of the southern hemisphere, which gave rise to the conception of the ancient southern continent of Gondwanaland, leading later to the theory of continental drift; to the discovery of the three main types of earthquake waves following a study of the great Assam earthquake of 1897, which has thrown light on the internal structure of the earth and provided a powerful tool for the geologists exploring for oil; to the theory of mountain compensation leading to the doctrine of isostasy and to the theories of the evolution of the mammals arising from studies on the rich fossil mammalian fauna of the Siwalik hills. On the economic side it gave much attention to coal, mica, manganese ore, petroleum, bauxite, iron ore and refractory materials. And let us not forget that all this was done before the ubiquitous jeep had been thought of, and when reliance had to be placed on the bullock cart, the camel and the elephant.

Minerals do not occur in a haphazard manner. Their distribution is closely related to the geological history of the country. Thus such a mineral as coal, formed in the main from the past accumulation of plant remains is found in India mostly along the lines of old river valleys such as the Damodar valley. Oil is generally found in the younger formations where the rocks have been folded in such a way as to trap the oil underground and so the chief oil occurrences of India are in the young folded rocks of the foothills of Assam and the Punjab, and at the head of the Gulf of Cambay. On the other hand, many metallic minerals and others such as mica, have been formed when the molten material of the earth's interior has been intruded into the outer crust where it has slowly cooled and crystallized. Such minerals, therefore are mainly found where the superficial crust of the earth has been eroded away exposing deeper portions, as in peninsular India, but are found hardly at all in the young Himalayan mountains where erosion has not proceeded far enough to expose them.

In understanding India's mineral position it is convenient to group the minerals into three categories according as to whether they are three

1. is excess of her requirements,
2. adequate for her present and foreseeable requirements and
3. inadequate for her requirements.

In the following table the more important minerals are grouped according to those categories.

I. Minerals which are in excess of India's requirements

Coal	Kyanite
Felspar	Magnesite
Ilmenite	Manganese ore
Iron ore	Mica
	Steatite

II. Minerals which are adequate for India's requirements

Aluminum ore	Gypsum
Barytes	Salt
Chromite	Salt peter
Gold	

III. Minerals which are inadequate for India's requirements :

Asbestos	Lead ore	Silver ore
Copper ore	Nickel ore	Sulphur
Diamond	Petroleum	Tin ore
Graphite	Phosphate	Zinc ore

No country in the world can claim self-sufficiency in its minerals resources. But the picture shown in the tables given above may be regarded as fairy satisfactory. It may be explained that in the case of some minerals for example bauxite (aluminum ore), though the reserves of the mineral are adequate; the present production of the metal is at present insufficient for the country's requirements.

The total value of the minerals produced in India during 1968 was over Rs. 3,700 million and about 44% of these minerals were exported, iron ore accounting for about one-half of the total. On the other hand, the value of minerals imported into India in 1968 totaled Rs. 1213 million. Thus the value of minerals imported is nearly one-third of the value of minerals produced in the country, providing an indication of the country's deficiency in its mineral production. Of all the States in India, Bihar is the richest in mineral wealth, accounting for one-third of the country's total mineral production. It is followed by West Bengal and Madhya Pradesh.

About 95% of the net value of the country's mining activity concerns only six minerals namely coal, petroleum, iron ore, manganese ore, limestone and mica.[1] I would like to speak to you briefly about some of these minerals.

COAL

The output of coal in 1950-51 was about 34 million tons. Today it is about 71 million tons, used almost entirely within the country. Perhaps the most spectacular results have been obtained in the Singrauli coalfield (in the Mirzapur and Sidhi districts) through the discovery by the Geological Survey of a 134 metre thick seam, probably the second thickest seam in the world, estimated to contain 190 million tonnes of coal valued at over Rs. 5,000 million. This discovery will provide the opportunity to industrialize this rather backward area through the establishment of thermal power plants. Other thermal power plants are being or have recently been set up in the Pench and KanhanValley coalfield, at Pathakhera as a result of detailed exploration by the Indian Bureau of Mines; in the Korba coalfield; and in the Talcher coalfield, where it will be used partly for a coal-based fertilizer plant.

The largest consumers of coal are the railways but on account of progressive dieselisation and electrification the consumption has decreased from 18.80 million tonnes in 1963-34 to 16.20 million tones during 1969-70. The use of coking coal by the Railways has fortunately been considered reduced. Very little coal is now being exported, since it is mainly coking and superior quality coals that are required abroad, and the country cannot afford to export such coals, the reserves of which are limited. Nevertheless an increased production of non-coking and other inferior quality coals will be necessary if the coal-based industries are to

grow as planned. The position will be improved if this inferior coal is beneficiated by washing and already 11 coal washeries have been established.

IRON ORE

The necessity to construct railways in the middle of the last century led to the search for iron ore and it is interesting to recall that the first iron works were established in Kumaon in 1867, using local iron ore with wood as fuel though the Geological Survey had considered Raniganje to be a more promising place. In this connection let us not forget the pioneering work of P. N. Bose, who reported on the iron ore deposits of Bailadila and Rajhara in Madhya Pradesh, and who after his retirement from the Geological Survey in 1903, discovered the rich iron ores in Mayurbhanj on which the prosperity of the house of Tata is founded, the first blast furnace coming into operation at Jamshedpur in 1911.

During the Second and Third Plan periods investigations carried out by the Indian Bureau of Mines and the Geological Survey, following on the work of P.N. Bose, revealed large reserves of high grade iron ore in the Rajhara and Bailadila areas. The ores of the former are supplied to the Bhilai steel plant, while the ores of Bailadila are exported to Japan, and will later be used in the proposed steel plant at Visakhapatnam. Today the iron ore industry in India is the third most important foreign exchange earner and with the enormous resources of high grade iron ore that could become one of the major world producers of iron and steel.

MANGANESE ORE

Though the occurrence of manganese ore in India was first recorded in the Nagpur district in 1829, it was first mined in the Visakhapatnam district in 1891 after it had been noticed that railway contractors were making up blocks of manganese ore for railway ballast and found them to be rather heavy!

The history of the manganese ore industry in India is an example of the industry which, because it exports the greater part of its production is effected, adversely or otherwise, by a variety of external factors. By 1867 India had become the world's largest producer of manganese ore and continued to be so up to 1912. Thereafter, each of the two world wars adversely affected her position, though there was a remarkable recovery after the second world war when in 1953 a record 1,900,000 tons of ore were produced, largely due to stock-piling in the U.S.A. Two-thirds of the Indian production comes from the belt of country extending from the Chhindwara district in the west, through the Nagpur and Bhandara districts, to the Balaghat district in the east. It is unfortunate that these deposits are so far from the main ports, that this adversely affects the final price at which the ore has to compete in the world markets. But even more important than this is the recent rapid growth of manganese ore mining in South Africa, Brasil, Gabon and Australia, which has displaced India from its leading position. It is indeed tragic to find that a large mine like Shivrajpur in the Panch Mahals district of Gujarat State, which only a few years ago was producing around 1 lakh tons of manganese ore a year, is now virtually derelict. Thus the position of manganese ore is not very bright. I am informed by the Geological Survey that the present requirement for internal consumption and export is of the order of 2.7 million tonnes, while the total requirement by 1980-81 is expected to be about 4 million tonnes to meet the needs of the steel industry and export. At this rate the known reserves are adequate for a period of only twenty-five years.

The remedy (as in the case of other minerals which at present are largely exported such as mica) appears to be to use more of them in the production of finished or semifinished products such as ferro-manganese for the iron and steel industry, and

battery and chemical grade ore; and the Indian producers appear to be moving in this direction. There are now seven ferro-manganese plants in operation.[2]

OIL

Oil today provides much of the energy used in industrialised countries. In some countries, as a result of the widespread replacement of steam by diesel traction on the railways, one ton of diesel oil, which is equivalent in its value to about 1.5 tonnes of coal, can save up to 7 tons of coal. As pointed out by W. B. Metre, even in the U.S.A., which has plentiful resources of coal, petroleum products and natural gas provide about 73% of the country's energy requirements.[3]

As in the case of many minerals, the Geological Survey pioneered the search for oil in India when on its advice the first six wells in Assam were completed in 1897. Not much oil was found, but it was at least a beginning. After 1914, geological investigations for oil in this area were carried out by the Assam Oil Company, and recognition should be given to the fine work done by the Company's senior geologists.

For long the hill tracts of Assam provided the sole source of oil in India (including Pakistan) centered around Digboi, a field which is still in production. But the oil produced could satisfy only a very small part of the country's requirements. Then came the introduction of geophysical methods of exploration, which enabled alluvium covered tracts where no hard rocks are visible to be investigated, and in the alluvial Brahmaputra valley two hidden oil fields were discovered at Nahorkatiya and Moran. The success of the new methods led to oil exploration in other alluvium covered tracts in West Bengal and Gujarat. And though the results obtained in West Bengal were disappointing, in Gujarat they were eminently successful.

Reconnaissance geophysical surveys carried out by the Geological Survey in Gujarat in 1948–49 indicated the presence of structures suitable for the accumulation of oil. In the meantime the Oil and Natural Gas Commission was set up in 1955 and the first well was drilled by them in the Cambay area in 1958, yielding both oil and gas. Another larger oil field was discovered in Ankleswar, on the south side of the Narmada valley in 1969. Thus the oil industry in Gujarat was bom as a consequence of geophysical surveys conducted by the Geological Survey, and developed by the Oil and Natural Gas Commission. The achievements of this organization have been recorded by W. B. Metre when he reminded us that when it began the various exploration activities it had about 50 geologists, 80 geophysicists and a few drillers. Now (i.e. up to 1967) the number of geologists, geophysicists, chemists, drillers, production engineers and other specialists number up to a total of 2,000 with 50 drilling rigs. During these twelve years more than 500 wells have been drilled all over the country, and over 80% of the exploration and development wells drilled have been successful in finding oil or gas. The remarkable achievements of the Commission in a period of less than 12 years, include the discoveries of several oil and gas fields in Gujarat and two oil fields in Assam.[4]

In other sedimentary basins where exploration has been undertaken, for example in the extensive Gangetic basin, the results so far have been disappointing and it seems that there is a complete absence of marine Tertiary sediments in this region. Exploratory work in other possible oil producing areas such as western Rajasthan, in the Cauvery basin and off the west coast have not yet advanced sufficiently far to warrant any conclusion being drawn.

Before the separation of Burma in 1937 and of Pakistan, ten years later, the production of oil in the three countries catered for about half the requirements. But with the loss of the oil fields of Burma and Pakistan, the Digboi oil field in India could provide only about 8% of India's requirements

of crude oil. With the discovery of oil in the Brahamaputra valley and in Gujarat, however, the position greatly improved and the production of crude petroleum in 1969 was about 15 times what it was in 1960, while the production of natural gas increased by five times in the same period, a remarkable achievement. Unfortunately the consumption of petroleum and its products is also rapidly increasing, by about 10% annually and if India is to attain self-sufficiency in oil several more oilfields must be discovered for at present the country is spending over Rs. 950 million in importing over 10,000 tons of crude oil per year, accounting for nearly 50% of the total cost of imports.

I have devoted some time to oil, because of the vital part it plays in the Indian economy, and because, if for any reason the supplies of crude oil from abroad should be cut off, the country would be placed in considerable difficulty.

GROUNDWATER

Water is perhaps the most important mineral asset that we have. And since water is one of the prime necessities of life, for human and animal consumption, for crop production and for industry, and keeping in mind the rapid increase in the size of the population, it is obvious that the study of our groundwater resources is of the greatest importance.

A few years ago Dr. K. L. Rao the Union Minister for Irrigation and Power, estimated that an annual rainfall of 45 inches average over the whole country represents something of the order of 3,000 million acre feet of water. Of this amount about one-third is lost immediately due to evaporation about one-fifth seeps into the soil, while a little less than one-half flow in the river systems. Of this one-half, about one-third can be harnessed for irrigation through the use of reservoirs and canals.

Regarding the one-fifth that seeps down in the soil, according to Dr. Rao about one-half gets absorbed in the top layers, contributing to the soil moisture which is essential for the growth of vegetation. The other half percolates down into the porous strata below. Dr. Rao also estimated that the total underground storage of water in India is about 30,000 million acre feet down to a depth of 1,000 feet that is ten times the annual rainfall in the country. It will be realized that the utilization of even a fraction of such a large reservoir of water will help greatly in developing irrigation, especially in areas where flow irrigation by rivers is not possible. But at present only about one per cent of this underground water is being tapped.

In times of drought the rivers and canals may dry up, or in times of rainfall flooding or water-logging may occur. But those hazards do not apply to groundwater, which is like a bank on which one can always encash, which never closes its doors, and the sources of which are being continuously replenished.

As far as industry is concerned groundwaters are as important as surface waters. For example it is stated that nearly 60,000 gallons of water are required to produce one ton of steel, and 85,000 gallons to produce the same weight of paper. The role of groundwater was in fact fully appreciated by the Planning commission, which sought to have an assessment made of the groundwater potentialities of the country. It was with this objective in view that a large groundwater exploration project was launched in 1954 under the Indo-U.S Technical Cooperation Agreement. Under this 15 areas were selected for exploratory study and the results achieved included the discovery of a large reservoir of fresh water in the deserts of the Jaisalmer plateau and considerable reserves of groundwater in the thick alluvial deposits of the Narmada valley.

Useful groundwater studies can well be undertaken by the Geology Departments of our universities. In my own University of Saugar, some teachers and research scholars of the Applied

Geology Department are helping the State Government and thereby the farming community, in all districts of the State, locating the sites of new wells after preparing the groundwater table maps. We no longer live in an ivory tower.

In a recent address. Shri. G..C. Chaterji has emphasized the need for a optimal development of the country's groundwater resources, which must be based on a scientific evaluation of the various factors involved, on a complete appreciation of the interrelation of surface water and ground waters, and on the necessity of coordinating work that is being done in the various disciplines concerned.[5]

AIRBORNE SURVEYS FOR BASE METALS

As will be seen from the table given at the beginning of this address, India appears to be deficient in the important ores of copper, lead and zinc and large amounts of foreign exchange have to be spent in importing these metals.

To speed up the exploration for these minerals, U.S.A.I.D agreed to finance a scheme of airborne geophysical surveys, to be followed by intensive ground exploration. This type of rapid air reconnaissance, using magnetic and electromagnetic and radiometric sensors, offers an effective means of scanning large tracts of potential ore-bearing country and of delimiting target areas before embarking a mineral exploration programme. The data so obtained are interpreted in the light of the known geological setting and premising areas are then subjected to detailed geological, geochemical, geophysical examination on the ground, and finally any promising locations are drilled. The method, of course, has its limitations since the airborne surveys only measure contrasts in the physical properties of the rocks and do not directly locate ore bodies.

A Department of Airborne Mineral Surveys and Exploration (formerly a wing of the Geological Survey) had been set up in 1965, and the project named as "Operation Hardrock", was drawn up and put into effect from July 1967, commencing with airborne geophysical flights over three select areas; the northern part of Rajasthan, the eastern margin of the Cuddaps basin and parts of the eastern Bihar and West Bengal, including the Singhbum copper belt.

The results of this work led to the selection of 20 targets for drilling and significant ore finds of copper in Bihar and Rajasthan and of lead zinc-silver mineralisation in the Bhilwara district of Rajasthan have been reported. In addition, potential groundwater zones have been located in Bihar and Andhra Pradesh.

An agreement has now been reached with the Bureau do Recherts Geologiques et Minieres, Paris to carry out airborne geophysical survey in parts of Rajasthan, Gujarat, Madhya Pradesh, Maharashtra and Mysore covering a total area of 80,000 square kilometers, and the results will be looked forward to with interest.[6]

In this address, I have tried to bring out the important part played by the Earth Sciences in promoting the development and prosperity of the country. That Government also recognizes this is clear from the enormous expansion that they have sanctioned in the departments concerned in developing the country's mineral and water resources. In 1948, the total value of minerals produced in India was Rs. 640 million. In 1968 years later it was Rs. 3555 million, an increase of nearly six times. The value of minerals exported in 1948 was Rs. 146 million. In 1968 it was Rs. 1622 million, an increase of eleven times, earning valuable foreign exchange . But the country's mineral wealth is a heritage that should be used wisely. Unlike other natural products, such as forests and agricultural resources, minerals are an asset which once used cannot be replenished. They are like a deposit in a bank, and with every cheque drawn the reserves diminish. But they differ from such deposits in that if they are left in the ground unused no interest is earned. It will therefore be

appreciated that our earth scientists and mining engineers have a very responsible role to play.

The facts presented in the tables given at the beginning of this address show that the various geological and related agencies have a three-fold task to perform.

1. to locate additional payable deposits of those minerals which are in serious deficit ;
2. to estimate the reserves of those minerals the adequacy of which is uncertain ; and
3. to prospect in detail the deposits of those minerals which, though apparently adequate, will be required in increasing quantities (particularly high grade) for the country's expanding industries in particular for the iron and steel, non-ferrous metals, heavy chemicals fertilizer, refractory, ceramic and glass industries.

Increase in the number of scientists employed in the exploration and utilisation of the country's mineral and water resources is likely to continue and will require to be fed by a constant stream of young geologists, geophysicsts and geochemists. The institutions training these young men have to shoulder the great responsibility to see that the right type of training is given in both the pure and applied sides. Geology, though based on Physical Sciences is itself an inexact Science, requiring a display of judgement and a sense of integrity which have to be instilled in the young geologists. A former Director of the Geological Survey wrote more than once that, "There is no Science with which it is so easy to acquire a mere slight acquaintance, and to play the imposter". It is here that the teacher have a vital role to play, if the country's mineral wealth is to be utilised to the best advantage.

Perhaps I may conclude this address on a personal note. I have watched the progress in India for nearly 50 years. During this period I have seen remarkable changes taking place in the development of Science and technology, and also in education. The great national laboratories have come into existence a memorial to the late Shanti Swarup Bhatnagar. The scientific services and allied organisations have expanded enormously. In the area of the service to which I belonged the expansion has been thirty-fold. In the field of education, when I arrived in India in 1923 the number of universities was 12; it is now about 90. Significant has been the setting up of the five Indian Institutes of Technology. Planned on modern lines they have so far escaped the stagnation that seems to have set in in our universities which have got bogged down in ill-conceived precedents and bad traditions, and from which we now find it difficult to extricate ourselves.

Dr. Kothari tells us that the total yearly expenditure on education in 1900 was about Rs. 4 crores; today it is Rs. 600 crores. In 1900 the number of students receiving higher education was no more than 16,000 today it is nearly two million. Much of this development has taken place since 1947, that *annus mirabilis.* As far a higher education is concerned we own a deep debt to the University Grants Commission, which under the enlightened leadership of successive dedicated chairmen, has changed the face of higher education in a remarkably short time. This Science Congress has played an increasingly prominent role in the development of Science. At the first meeting that I attended, the Calcutta meeting of 1928,40 papers were down for reading. Forty years later the number had grown to 1724. But more significant has been the change in emphasis from reading papers to holding discussions on problems of vital importance to the country. Thus in the programme of this meeting more than 40 discussions are being held, many of them interdisciplinary in content.

I mention these facts because there seems to be in the country today a feeling of dissatisfaction and an attitude of self-criticism, which hinders progress;

instead of which there should be a feeling of pride in what has been achieved. Our scientists and technologists will see to it that the progress continues at an ever-increasing rate, for the benefit of the common man and for the security of the nation. As Dr. Kothari has so well put "The modern world is Science and technology based, and this more than anything else has made education, as never before, a most important element in the life and progress of a nation. Economic development, welfare and security are all closely dependent on the extent and quality of education. Knowledge and survival now literally go together." [7]

I should like to conclude with another quotation, from an address delivered to the British Association by Herbert Morrison, at that time the President of the Council.

"We have to build a partnership, cooperation and associated effort between Science, industry and government; and they must come together as free partners, and as free debaters and arguers in the spirit of cooperation and in the determination to make the partnership for the advancement not of Science alone, not of industry alone, not of government alone, but the advancement of the wellbeing of the nation, and in the end for the wellbeing of mankind." Towards this end the earth scientists of India are striving to play a significant and effective role.

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LUDWIG PRANDTL'S BOUNDARY LAYER THEORY AND THE FLUID MECHANICS

B. B. Singh

The inability to solve the Navier-Stokes equations for most practical flow problems was particularly frustrating to those investigators interested in calculating the frictional shear force on a source immersed in a flow. Prandtl's boundary layer concept solved this problem. In his concept, Prandtl theorized that an effect or friction was to cause the fluid immediately adjacent to the surface to stick to the surface so as to assume a no-slip condition on the surface. The frictional effects are experienced only in a boundary layer, a thin region near the surface. This concept is now used to solve the boundary layer equations in fluid mechanics.

INTRODUCTION

Towards the end of nineteenth century, researchers in fluid mechanics were divided into two broad groups; viz, those engaged in the study of hydrodynamics, which dealt with inviscid fluid flow, and those studying hydraulics. Hydrodynamics, though mathematically elegant, was not able to predict the drag experienced by bodies moving in fluids. This is known as D'Alembert's paradox. On the other hand, hydraulics offered solutions to practical problems but was based mainly on empirical data.

This situation changed radically when Ludwig Prandtl proposed his famous boundary layer theory in 1904. This theory states that due to the no-slip condition, the velocity on the surface of a stationary body is zero, but the velocity given by inviscid flow theory would be reached within a thin layer called the boundary layer. Since the layer is thin, the velocity gradients are large and the shear stresses are not negligible even when viscosity is small. The thinness of the boundary layer enables simplification like rendering the governing equations parabolic and imposing external pressure on the boundary layer. The theory further showed that the separation of the flow is decided mainly by a stream-wise pressure gradient in the external flow. Though this theory was originally developed for laminar flow, it was soon extended to turbulent flow also. This theory got acceptance after some years and helped in the better design of airplanes, engine components and many other equipment involving fluid flow. The boundary layer concept developed rapidly and is now applied in almost all branches of engineering.

The theory has also led to the development of mathematics tools like method of matched asymptotic expansions. This article touches upon some aspects of the developments in boundary layer theory.

THE 1904 PAPER

During the week of August 8, 1904, a small group of mathematicians and scientists gathered in Heidelberg, Germany which was the natural venue for the Third International Mathematics Congress. One of the presenters at the Congress

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was Ludwig Prandtl, a 29-year old professor at the Technische Hochschule in Hanover. Although the presentation given by Prandtl was only ten minutes long, that was all the time needed to describe a new concept that would revolutionize the understanding and analysis of fluid mechanics. His presentation, and the subsequent paper that was published in the Proceeding of the Congress one year later, introduced the concept of boundary layer in fluid flow over a surface. The modern world of aerodynamics and fluid dynamics is still dominated by Prandtl's idea.

THE BOUNDARY LAYER CONCEPT

It was initially Archimedes (287-212 BC) who introduced some basic ideas of fluid statics, and Leonardo da Vinci (1452-1519) observed and drew sketches of complex flows over objects in streams. But a quantitative physical and mathematical understanding of the fluid flow could be given by Newton (1642-1727) in his famous book of Principia Mathematics (1687). But the mathematical formulation of the fluid flow took shape during the century following the publication of the Principia with the contribution of Daniel Bernoulli (1700-82), D'Alembert (1717-83), and Euler (1707-83). Euler was actively involved with the conceptualization of the mathematical description of a fluid flow. Euler described the flow as a continuous collection of infinitesimally small fluid elements. He described the flow in terms of spatially varying three-dimensional pressure and velocity fields. By applying the basic principles of mass conservation and Newton's second law, Euler obtained two coupled, non-linear partial differential equations which involved the flow fields of pressure and velocity. But Euler did not take into account the effect of friction ; i.e. viscosity on the motion of the fluid elements.

It was another hundred years before the Euler equations were modified to take into account the effect of the internal friction in the flow-field first by Navier in 1822 and then by Stokes in 1845. The resulting non-linear partial differential equations are now called Navier-Stokes equations which form the mathematical description of the fluid flow. No mathematician could find out a general analytical solution of these equations till-date. The problem of solving the Navier-Stokes equations became all the more acute at the beginning of 20th century with the invention of airplane by Orvilla and Wright and with a subsequent need to calculate the drag and lift on the airplanes.

Against this back-drop, there came the seminar presentation of the paper of Prandtl at Heidenberg in the year 1904. Prandtl's paper gave the first description of the boundary layer concept. According to this theory, the effect of the friction was to cause the fluid in the close vicinity of the surface to stick to the surface. He assumed a no-slip condition at the surface. As a result of this assumption, the frictional effects were confined to a thin layer called the boundary layer. Outside the boundary layer, the flow was essentially the inviscid flow as studied by researchers in previous two centuries.

MARCHING TOWARD A SOLUTION

When Prandtl was working as an engineer at Maschinenfabric Augsburg, he arranged a conical diffuser in a large air duct but failed to achieve the desired pressure recovery. The angle of the cone was too large and the flow separated from the diffuser walls. The reason for the loss of the pressure and separation of the flow occupied Prandtl's inquiring mind and after three years the concept of boundary layer provided the answers. The 1904 paper is a brief account of just eight pages and contains features of boundary layer theory, separation of boundary layer and

delay of separation by suction. The article begins with the following continuity and N-S equations for an incompressible fluid :

$$\nabla . \vec{V} = 0 \qquad \text{..... (1)}$$

$$\frac{D\vec{V}}{Dt} + \nabla P = \mu \nabla^2 \vec{V} \qquad \text{..... (2)}$$

These equations is scalar, non-dimensional form for steady two-dimensional flow can be written as :

$$\frac{\partial U^*}{\partial x^*} + \frac{\partial V^*}{\partial y^*} = 0 \qquad \text{..... (3)}$$

$$U^* \frac{\partial U^*}{\partial x^*} + V^* \frac{\partial U^*}{\partial x^*} = -\frac{\partial p^*}{\partial x^*} + \frac{1}{\text{Re}} \left(\frac{\partial^2 U^*}{\partial x^{*2}} + \frac{\partial^2 U^*}{\partial y^{*2}} \right) \qquad \text{..... (4)}$$

$$U^* \frac{\partial V^*}{\partial x^*} + V^* \frac{\partial V^*}{\partial y^*} = -\frac{\partial p^*}{\partial y^*} + \frac{1}{\text{Re}} \left(\frac{\partial^2 V^*}{\partial x^{*2}} + \frac{\partial^2 V^*}{\partial y^{*2}} \right) \qquad \text{..... (5)}$$

All the symbols used in the above equations are in their standard forms. Prandtl provided the equations (1) and (2). The equations (3), (4) and (5) have been presented for the sake of explanation.

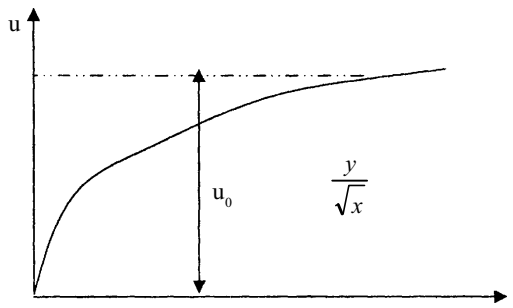

Fig. 1 : Boundary Layer Profile

The equations (1) and (2) are non-linear partial differential equations and exact solutions can be obtained only for very slow motion, where the inertia terms can be ignored or when the viscous terms are ignored (inviscid flow). It was known that the inviscid flow equations do not predict the drag experienced by bodies. To tackle this problem, Prandtl argued that the fluid adheres to the surface of the body i.e. the velocity of the fluid is zero on a stationary body or equal to the velocity of the body when the body is moving. However, the velocity around the body which can be obtained by the potential flow theory or inviscid flow theory, would be outside a thin layer. Prandtl called this thin layer a transition layer but later the term boundary layer was accepted. Since the layer is very thin, the cross-stream velocity gradient is high and produces noticeable effects even for very small viscosities. Then Prandtl further argued that since the layer is thin, the normal component of velocity (V) is small and the external pressure gradient is impressed on the boundary layer. He stated the following boundary layer equations, which can be obtained by applying the order of magnitude analysis.[4]

$$\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0 \qquad \text{..... (6)}$$

$$U \frac{\partial U}{\partial x} + V \frac{\partial U}{\partial y} + \frac{1}{\rho} \frac{dp}{dx} = \nu \frac{\partial^2 U}{\partial y^2} \qquad \text{..... (7)}$$

Prandtl mentions that $\frac{dp}{dx}$ is to be given throughout the length of body and the profile of U should be given at an initial cross-section. Then the problem can be solved numerically. What he seems to imply is that the N-S equations of elliptic nature are now converted to equations of parabolic nature. Subsequently, the paper presents the result for the problem of flow past a flat plate without giving the proof. He also states that the equations (6) and (7) can be simplified by using similarity hypothesis i.e. U can be expressed as $f\left(\frac{y}{\sqrt{x}}\right)$. Again without

giving any details, he mentions that the resistance or the skin friction drag taken together for both sides of the plate is $R = 1.\ 1b(\mu\rho / U_0^3)^{1/2}$, where b is the width of the plate, 1 is the length of the plate and U_0 is the velocity of the undisturbed flow. He obtained the velocity profile as shown in the Figure 1.

The details of the analysis were later given in a paper by Blasius published in 1908[4]. Blasius obtained the correct expression of $R = 1.328b(\mu\rho l U_0^3)^{1/2}$. After obtaining the boundary layer profile, he mentioned an important practical result, that in certain cases the flow separates from surface at a point entirely determined by external conditions as shown in Figure 2.

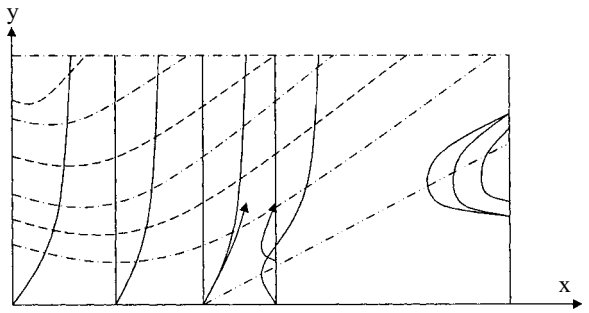

Figure 2 : Boundary Layer Separation

Further he said that on closer examination, the necessary condition for separation of flow is that there should be pressure increase along the surfaces in the direction of the flow, which is now called adverse pressure gradient.

EXTENSIONS OF PRANDTL'S WORK

The Third International Mathematics Congress was an obscure setting for such an important contribution, and Prandtl's idea went virtually unnoticed by anybody outside of Gottigen for several years. It surfaced again in 1908 when Prandtl's student Blasius, published in the respected journal Zeitschift *für* Mathematik and Physik (ZAMP), his paper "Boundary Layers in Fluids with Little Friction", which discussed 2D boundary-layer flows over a flat plate and a circular cylinder.

Blasius solved the boundary layer equations in both cases. For the flat plate, he obtained an even more accurate solution for skin-friction drag than appeared in Prandtl's original paper. Boltz (1908) reported the results on boundary layer over a sphere. Prandtl (1910) applied the boundary layer concept to heat transfer problems. Heimenz (1911) presented results for boundary layer over circular cylinders with experimental pressure distributions. Toffer (1912) presented the refined calculations of cases investigated by Blasius. Prandtl (1914) explained the reduction in drag of a sphere after a certain Reynolds number, as observed by Eiffel (1912) as due to the transition of flow in the boundary layer from laminar to turbulent. It may be added that the transition to turbulence in channels and pipes was known earlier through the experiment of Reynolds in 1883[4]. Orr and Sommerfiled had derived equations for stability in 1907 and 1908[4].

The important developments in the period 1914 to 1924 are : (i) Vonkarman developed the following momentum integral equation, obtained by integrating (7) across the boundary layer :

$$\frac{d\theta}{dx} + \frac{\theta}{U_e}(H + 2)\frac{dU_e}{dx} = \frac{C_f}{2}, \qquad \text{..... (8)}$$

where θ, U_e, H and C_f are momentum thickness, external velocity, shape parameter and skin friction coefficient respectively[4]. This equation permits calculation of skin-friction drag needed for optimizing airfoil shapes : (ii) Tollmien (1924) reported the results of boundary layer on a rotating cylinder ; (iii) Burger *et al*. (1924–25) reported the hot wire measurements in boundadry layer.

During the period 1924 to 1834, the spread of the boundary layer research was facilitated (Tani 1977) by Tollmien's (1931) article in

handbuch der experimental Physik and Prandtl's article in Aerodynamic Theory, edited by Durand (1935). In this decade, the concept developed originally for laminar flow was extended to turbulent flow and also to free shear flows like wakes and jets.

The stability of laminar flow was also investigated as the cause for origin of turbulence.

During the period 1935 to 1944, the analysis of the compressible boundary layer was pursued in response to the need for high speed flight and to flows with real gas effects. Boundary layer studies were also used in aeronautical engineering. Due to study of heat and mass transfer in moving fluids, the applications of boundary layer theory were extended to mechanical, chemical engineering, etc. by 1950's.

Over the years, significant advances have been made in the following areas.

(i) Prediction of transition under the influence of various parameters like pressure gradient, curvature, compressibility, roughness etc.

(ii) Turbulent boundary layer under the influence of pressure gradient, curvature, compressibility, etc.

(iii) Study of this shear like wakes, jets, wake-boundary layer interaction, wall jet etc. subject to effects like curvature, pressure gradient, etc.

(iv) Three-dimensional boundary layers.

(v) Unsteady boundary layers with application to rotating machinery and helicopters.

(vi) Atmospheric boundary layers.

(vii) Computation of boundary layers using
  (a) Momentum-integral equation,
  (b) Reynolds averaged Navier-Stokes (RANS) equations which can be derived by decomposing instantaneous velocity and other flow variables as the sum of the time averaged part plus the fluctuating part e.g. $U = \overline{U} + u$
  (c) Direct Nurmerical Simulation (DNS) of turbulent boundary layers
  (d) Large Eddy Simulation (LES). The approach is in between the RANS and DNS approaches and involved the resolution of large eddies and modelling the smaller ones.

(viii) Models of turbulence of boundary layers : mixing length, one-equation, two-equation, half equation, Reynolds stress models and non-linear models, etc.

(ix) Boundary layer control by blowing, suction, moving wall, etc.

(x) Singular perturbation theory and higher order boundary layer.

CONCLUDING REMARKS

A single paper (Prandtl 1904) led to the developments in several branches of engineering that in itself are tribute to the genius of Ludwig Prandtl. In the present article, a few aspects of the entire spectrum of applications of the boundary layer concept have been depicted. Though several flow situations have been tackled by various authors, there are many areas in which research is still continuing. Some of these areas are : (i) transitions in hypersonic flow, (ii) transitions in three-dimensional boundary layers like those on airplane wings, (iii) computation of three-dimensional boundary layers, and (iv) thermal boundary layers on porous surfaces with suction.

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INDIAN LEGISLATIONS FOR PROTECTING AND RESTORING ENVIRONMENT : A BIRD'S EYE VIEW

Shreerup Goswami

The Directive Principles of State Policy of the Indian Constitution provide the State's commitment to protect the environment. A series of separate legislations occurring in different time and space depicts an integrated understanding of the causes of environmental degradation and destruction and its remedial measures. The Constitutional provisions made the way to formulate regulatory environmental protection laws such as The Factories Act, 1948 ; The Water (Prevention and Control of Pollution) Act, 1974 ; The Water (Prevention and Control of Pollution) Cess Act, 1977 ; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986 ; The Public Liability Insurance Act, 1991; The National Environment Tribunal Act, 1995 ; The National Environment Appellate Authority Act, 1997 ; The Indian Forest Act, 1927 ; The Forest (Conservation) Act, 1980; The Wildlife (Protection) Act, 1972 ; and The Biological Diversity Act, 2002. These legislations have been formulated to ensure the protection of the environment with an aim of sustainable development. A brief account of the various provisions of the environmental legislations with special reference to the environmental management is discussed herewith.

INTRODUCTION

The planet earth is the abode of man, an intelligent creature of nature. It also houses plants, animals, insects, birds, and other living beings. There are also billions of objects formed by five basic elements- water, air, soil, sky and fire. Man influences and is influenced by all these living and non-living creations of nature. The totality of all such objects is usually referred to as his environment. As a rule of nature, man has been living with these members of his environment from times immemorial leading a peaceful life. Each member supported the existence of the other on the planet— one complemented the other, with no contradictions.

But of late, as civilisation progressed and science advanced, man started creating his own 'artificial' environment: machines, satellite, chemicals, weapons and tried to fit them into the natural environment. This made way for several serious problems for which solutions are not that simple. These consequences are serious. Population explosion, global warming, environmental pollution, energy crisis are but a few to mention. It is now clear that technological progress, and the way it progressed, had a disastrously negative impact on our environment[1-3].

Subsequently and traditionally we became a pollution loving nation and gradually forgot minimum civic sense. We need wholesome oxygen. However, we pollute air by bursting crackers on the occasions of marriages, on Dussehra, Diwali, especially on the processions of idol immersions, wining of an election, and in many other festivals. We worship river. Nevertheless, we pollute our

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rivers by disposing domestic and industrial effluents, even dead bodies and immersing thousands of idols every year. Since Vedic period, we worship trees, but we take out wood from trees for fuel and carpentry and other uses, so that in many parts of India tree now have become scarce. We worship many animals as they are associated with many God and Goddess, but our wildlife is on the verge of extinction. We are primarily a vegetarian nation, but sacrifice goat, sheep and other animals and birds near deities. We are lovers of cleanliness and thus broom out all our household and other waste in the public streets. Any place in space and time is good enough for us to urinate. Even in this twenty first century more than one third population of the country believes in open latrines. Municipalities and other local bodies are oblivious of their duties and our drainage system is so bad that municipal waste including domestic waste, trade effluents are allowed to flow in open drains and to flood streets with them. We equally enjoy noise pollution. Our marriage and even burial processions/ cremation must be accompanied by bands, twists, and *Bhangras.* Gods and Godmen's voice must be heard by one and all, day and night and our *Akhand paths, Harinam Sankirtan, Azan* must use loudspeakers and amplifiers[4].

Therefore, different relevant environmental legislations should be implemented properly and strict action should be taken at all levels to change our polluting mindset and attitude to prevent and abate pollution. If the law does not eradicate human sufferings, inequalities and operate without social goals and environmental goals, it becomes a meaningless. Human rights are inextricably linked with environmental rights. Thus, every Indian should know the broad outlines of different legislations meant for the purpose. The Constitution of India overtly makes environmental conservation a duty. Article 48-A, Constitution of India explicitly states that Government has the responsibility to protect and restore the natural environment. Constitution of India, Article 51-G clearly opines that every citizen has the fundamental duty to protect and improve the natural environment including forests, lakes, rivers and wildlife.

Mrs. Indira Gandhi, the then Prime Minister of India, was the only visiting head of State to attend the Conference on 'Human Environment' at Stockholm, from 5th June to 12th June, 1972. Government of India actively participated in the conference and Mrs. Gandhi presented a thought provoking paper on poverty and environment and strongly voiced concerns. Several measures were taken in India for Environmental Protection before the conference but there was no general legislation on a holistic manner to protect the environment. The existing laws dealt directly or indirectly with several environmental issues like forest conservation, wild life conservation etc., but no general comprehensive law existed to deal with pollution prevention, control and abatement. India has witnessed > 50 fold increase in Industrial sector by 1970s and the increasing tendency of industrialization and urbanization led to discharge of high volumes of effluents and municipal sewage to water bodies causing environmental pollution and health hazards. Indian surface water in rivers (all 14 major rivers), ponds and lakes is unfit for human consumption. WHO data show that 21% of all communicable diseases in India are water related. Over exploitation, enhanced pumping, intrusion of saline water in coastal areas, discharge of toxic effluents on land and in water bodies have led to decline in water table and contamination of groundwater resources. The Indian ground water Board has identified 231 blocks, where ground water depletion has reached critical level. It was following this conference; different environmental acts such as The Water Act, The Air Act, The Water Cess Act and The Environmental (Protection Act) etc. were formulated. It was following this

Conference that a Department of Environment was established by the Government of India in 1980, to act as the nodal agency for planning, promotion and coordination of various environmental programs in the country. Since its inception, the Department has emphasized the promotion of environmental education at different levels, making it a people's movement.

Important provisions of legislations having environmental concern are discussed hereunder[2-9].

THE FACTORIES ACT, 1948 ***(Amendment, 1987)***

The Factories Act, 1948 is a post-independence statute that shows explicit concern for the environment. The Act contains a comprehensive list of 29 categories of industries involving hazardous processes (First Schedule to the Act). Section 2 (c, b) of the Act defines "hazardous process" as any process or activity in relation to an industry specified in the first schedule, where unless special care is taken, raw materials used therein or the intermediate or finished products, byproducts, wastes or effluents thereof.

The Factories Act, 1948: A bird's eye view

Chapter IV-A :	Provisions relating to hazardous processes
Section – 41A :	Constitution of site appraisal committees
Section – 41B :	Compulsory disclosure of information by the occupier
Section – 41C :	Responsibility of an occupier for workers' medical checkup
Section – 41D :	Inquiry committee for the occurrence of an accident
Section – 41E :	Emergency standards
Section – 41F :	Permissible limits of exposure of chemical / toxic substances
Section – 41G :	Worker participation in safety management
Section – 41H :	Workers' right to warn about imminent danger

CONSTITUTIONAL PROVISIONS

Article 21 opines 'No person shall be deprived of his life or personal liberty except according to procedure established by law'. The Supreme Court interpreted this Article to include right of having a living environment congenial to human existence, while disposing the Vellore Tannery case in 1996. So pollution due to different industrial activities can be interpreted by the Supreme Court as violation of Article 21. Under Article 39A (42nd amendment) (equal justice and free legal aid), PIL was introduced. Article 47 states that 'the state is to ensure as its primary duty of (i) raising standard of living of its people; and (ii) to increase the level of nutrition of the people and to bring improvement in public health. In the 42nd amendment of the Constitution, two articles (Articles 48A, 51A-g) having direct bearing on the environment were incorporated in 1976. The Article 48A states that 'the state shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country.' The Article 51A (g) states that 'it is the duty of citizen to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for all living creatures'. In addition, Article 372 and PIL (Public Interest Litigations) are legal instruments to initiate proactive actions towards the environment.

PROVISIONS IN IPC AND CrPC

The Indian Penal Code has provisions to punish a variety of acts under Public Nuisance (Section 268-290 of Chapter 14). Some relevant Sections viz. 269, 277, 285 are negligent act to spread infection of disease dangerous to life; fouling of water of public springs and reservoirs; and negligent conduct with respect to fire or combustible matters, respectively. Similarly, Section 133 of Chapter 10 of the Code of Criminal Procedures enumerates a list of public nuisances. Public nuisance action against polluters is also mentioned in the respective chapters of IPC and CrPC.

THE WATER (PREVENTION AND CONTROL OF POLLUTION) ACT, 1974, ***(Amendment, 1978 and 1988)***

A committee was set up in 1962 to draw a draft enactment to prevent water pollution. The report was circulated to the state governments and considered by the Central Council of Local Self-Government (CCLF). A draft bill was prepared and considered in the joint session of CCLF and 5th conference of the state ministers on Town and Country planning held in 1965. Finally The Water (Prevention and Control of Pollution) Bill was passed by both the Houses of Parliament under Article 252 (1) of the Constitution and received the assent of the President on 23rd March, 1974. The Water Act, 1974 represents one of India's first attempts to deal comprehensively with an environmental issue. The Act was amended in 1988 to conform closely to the provisions of the Environment (Protection) Act, 1986. This Act is meant for the prevention, control and abatement of water pollution and maintaining or restoring the wholesomeness of water. It applies to streams, inland water, subterranean water and sea or tidal water. Its primary objective was to establish pollution control boards and assigning them the necessary powers and functions. Central Pollution Control Board (CPCB) was established in September, 1974. Standards for the discharge of the effluent or the quality of receiving waters are not specified in the Act itself. Instead, the Act enables the CPCB and the State Boards to prescribe these standards. The Water Act regulates water pollution through a system of 'command and control'. This Act provides for a permit system or consent procedure to abate, prevent and control pollution. A person must obtain consent from the State Board before taking steps to establish any industry, operation or process, any treatment or disposal system or any extension or addition to such a system.

The Water Act, 1974: A bird's eye view

Section — 2	: Definitions
Section —3 & 4	: Setting up of CPCB and SPCB
Section — 16	: Functions of the CPCB
Section —17	: Functions of the SPCB
Section —19	: Power to restrict the application of the Water Act to certain areas
Section — 23	: Power of entry and search
Section — 24	: Prohibition on use of streams or wells for disposal of polluting matter
Section — 25	: Application for consent
Section — 26	: Refusal of Consent
Section — 28	: Review by an appellant authority
Section — 30	: Notice
Section — 31	: Furnishing information
Section — 32	: Emergency measures in case of pollution of a stream or Well
Section — 33	: Injunction from court
Section — 33A	: Power to give directions for closure
Sec — 41 to 50	: Penal Provisions

THE WATER (PREVENTION AND CONTROL OF POLLUTION) CESS ACT, 1977 ***(Amendment, 2003)***

This Act is enacted for collection of cess on water consumed by persons carrying on certain (Schedule I) industries and by local authorities, with a view to augment resources of the Central and State Pollution Control Board(s). This Act aims to augment the resources of the Central Board and the State boards for the prevention and control of water pollution. The industries specified in the schedule are to affix meters and submit reports of consumption in prescribed forms to the Central Board. There is a provision for 25 per cent rebate for industries, which install a plant for the treatment of trade effluents.

THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981 ***(Amendment, 1987)***

The Air Act was enacted in 1981 under Article 253 of the Constitution of India, which gives power to the Central Government to make laws to implement decisions made at the United Nations Conference on the Human Environment held at Stockholm in 1972. To counter the problems associated with air pollution, ambient air quality standards were established under the Air Act, 1981. The Air Act (1981) provides means for the control and abatement of air pollution. The Act seeks to combat air pollution by prohibiting the use of polluting fuels, explosives and appliances that causes air pollution. Under the Act establishing or operating of any industrial plant/ mining in the pollution control area requires consent from the State boards. The boards are also expected to examine the air in the air pollution control areas, inspect air pollution-control equipments and manufacturing processes. The Air Act provides for State boards even in states which do not have pollution control boards established under the Water Act. The Air Act provides power to State boards for the protection of environment.

The Air Act, 1981: A bird's eye view

Section — 16	: Functions of the CPCB
Section —17	: Functions of the SPCB
Section —19	: Declaration of restricted areas
Section — 23	: Information to SPCB
Section — 24	: Power of Entry
Section — 25	: Power to obtain information
Section — 31A	: Power to order closure, prohibition or regulation of any industry
Section — 37 to 46	: Penal Provisions

The ambient air quality must therefore, be measured before establishing the plant. The existing background ambient air quality levels for SO_2, NOx, TSPM are to be provided in the Environmental Impact Assessment (EIA) report. The report must comprise one full season other than the monsoon and information to be collected as per the CPCB guidelines. If the results of the mathematical modeling of air quality prediction indicate a significant change in the ambient air quality, it would be necessary to provide adequate air pollution control equipment as well as a system for measuring air quality and emissions. CPCB/ SPCB prescribes standards for stack height of various plants for better dispersal of pollutants.

THE ENVIRONMENTAL (PROTECTION) ACT, 1986 (EPA)

In the wake of the Bhopal Gas Tragedy, the Government of India enacted the Environment (Protection) Act of 1986. The Act (EPA) is designed to provide a framework for Central Government coordination of the various Central and State authorities established under the Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981. This Act envisages filling up gaps in the legislative protection to the environment.

Laws existing prior to this Act generally focused on specific types of pollution, namely water and air pollution, not on the general management principles for restoration and protection of environment. Disposal of hazardous wastes and chemicals, biomedical and municipal solid wastes etc. were not covered. There were inadequate linkages in handling matters related to industrial and environmental safety. Thus, incorporating most of environmental issues, it was conceived as an Umbrella Act.

The Environmental (Protection) Act, 1986 : A bird's eye view

Section 3(1) : Powers to and functions of the Central Government

To set new national standards for the quality of the environment (ambient standards), as well as standards for controlling emissions and effluent discharges ;

To regulate industrial locations ;

To prescribe procedures for managing hazardous wastes ;

To establish safeguards for preventing accidents; and to collect and disseminate information regarding environmental pollution

Section 5 : Power to issue directions

Section 6 : Rules to regulate environmental pollution

Ministry of Environment and Forest (MoEF) is responsible for making rules to implement the EPA and has adopted industry specific standards for effluent discharge and emissions for 24 designated industries.

Section 7 : This section states that those persons, who are carrying on industry, operations etc., are not allowed to emit or discharge environmental pollutants in excess of the standards.

Section 9 : Furnishing of information in certain cases

- In cases where discharge of an environmental pollutant occurs in excess of the prescribed standards, or there is an apprehension of this occurring due to an accident or some other unforeseen event, then the person who is in charge at that particular time is responsible for preventing environmental pollution due to the said discharge.
- It is the responsibility of the person to intimate the occurrence of the discharge to the CPCB/ SPCB, and provide all possible assistance to the regulatory agencies to counter the ill effects of the discharge.
- All expenses incurred by the regulatory agency in undertaking remedial measures may be recovered from the polluter.
- Central Government has the power under Sections 3 and 5 of the EPA to levy and recover the cost of the remedial measures.
- The polluter pays principle was also held to be applicable and Sections 3 and 5 of the EPA were held to empower the Central Government to give directions and take measures.

Section 10 : Power of search and entry

- The EPA empowers authorized officers to enter, at all reasonable times, any place, or premises for determining the infringement of standards and procedures set under the Act, and for testing any equipment, industrial plant, record, register or document or any other material object for determining offences under theEPA.
- A willful delay or an obstruction of such an inspection is an offence and the person in-charge is liable for prosecution

Section 11 : Power to take samples of air, water, soil or any other substance from the factory premises. Collected samples are to be sent without delay to the environmental laboratories. CPCB/ SPCB and the officers empowered by the respective Board under Section 21 and 23 of the Water Act, 1974 or under Section 24 of the Air Act, 1981 are empowered to enter and search the premises and take samples.

Section 12 and 13 : The samples collected are to be sent to notified environmental laboratories for analysis.

Government analysts with specific qualifications are appointed under Section 13. The functions of environmental laboratories and the qualifications of Government analysts are discussed.

Section 14 : A document, which is a report signed by a Government Analyst, can be used as *evidence* for any proceedings under the EPA.

Section 15 : Penal provision

Section 18 : Protection of action done in good faith

Section 19 : Cognizance of offences (citizen's suit)

Section 22 : Bar of jurisdiction : No civil court has the jurisdiction to entertain any suit, or proceedings in respect of anything done, action taken, or order or direction issued by the Central Government or any other Authority or officer in pursuance of any power conferred by or in relation to its or his /her function under the Act

Section 23 : Powers to delegate : The Central Government can delegate its functions.

Critique of the Environment (Protection) Act, 1986

Section 3 of EP Act, 1986 provides for collection and dissemination of information regarding environmental pollution. However, the Government has not yet adopted regulatory provisions to implement this power. In the absence of such regulations a community may not be aware that a potentially hazardous operation is situated in their midst. Also, in such a situation the local authorities may not know what possible preparedness may be needed for emergencies.

No minimum sentence is prescribed in the Section 15, which deals with penal provisions. Section 15 should provide some minimum punishment, so that the violators may have apprehension of such minimum punishment even in case of his smallest mistake.

Section 19 (Citizen's suit provision) of the Act seemingly gives the public significant powers to enforce the Act. However, only Government officials are given the power under the Act to collect samples needed as evidence of violation of the Act. In addition, during the sixty days notice period required for the Government to decide whether to proceed against the alleged isolator, the offending industry has time to clean up and prepare itself for collection of samples.

Section 24 of the Environment (Protection) Act 1986 is one of its controversial provisions. Generally more recent legislation, which conflicts with the previous legislation, supersedes the previous legislation. Standards established under the EP Act are also dealt with under the Water Act and Air Act. In case of a violation, both under the EP Act and Water Act or Air Act, the penal provisions of the Water Act or the Air Act would apply. The high penalties thus provided in the EP Act are therefore illusionary for those violations, where the Water Act and Air Act also apply. Suppose the Water Act allows discharge of a higher concentration of a particular pollutant than the concentration permissible under the EP Act and if a factory discharges wastewater containing the pollutant at a level higher than allowed under the EP Act but within the permissible limits of the Water Act, then whether the Water Act penalty provision applies becomes debatable.

The Act is also criticized on the ground that it is absolutely silent with respect to civil liability and compensation to the victim.

After all, The EP Act is far better than earlier Acts projecting wider perspectives for preservation, protection, conservation and restoration of environment and is good enough for curbing environmental pollution and disaster management. However, the above discussed demerits of the Act require immediate attention and remedial measures to be adopted by the Parliament.

THE ENVIRONMENT (PROTECTION) RULES, 1986

Some relevant provisions of the Rules are :

Rule - 3	Standards for emission or discharge of environmental pollutants
Rule - 4	Issuance of specific directions to an industry
Rule - 5	Prohibition and restriction on the location of industries in different areas
Rule - 6	Procedure for taking samples
Rule - 8	Procedure for submission of the sample for analysis
Rule - 9	Functions of environmental laboratories
Rule - 11	Manner of giving notice
Rule - 13	Prohibition and restriction on the handling of hazardous substances
Rule - 14	Submission of Environmental Statement (Environmental audit report)

The Central Government has notified many rules and notifications under the Environment Protection Act, 1986. Few of them are as follows :

Hazardous Wastes (Management and Handling) Rules, 1989: Provides safeguards in handling hazardous wastes.

Manufacture, Storage and Import of Hazardous Chemical Rules, 1989: Provides safeguards in handling hazardous chemicals.

Coastal Zone Regulation, 1991: Regulates activities in the coastal zone between the low tide line and 500 meters from the high tide line.

Rules for the Manufacture, Use, Import, Export, Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cell, 1989.

Rules on Emergency Planning, Preparedness and Response for Chemical Accidents, 1996: Provides safeguard against chemical accidents.

Ash Content Notification (1997)

Notification of Compulsory Public Hearing, 1997: Makes compulsory, the public hearing for certain category of projects before EIA clearance.

Notification for Environmental Impact Assessment (EIA), 1994 and as amended in (1997), and 2006 : Makes it compulsory for certain category of projects to take prior EIA clearance from the Central Government.

Disposal of Fly ash Notification (1999): Provides safeguards for disposal of fly ash.

The Noise Pollution (Regulation and Control) Rules, 2000: It is enacted to abate noise pollution.

THE ENVIRONMENTAL IMPACT ASSESSMENT (OF DEVELOPMENT PROJECTS) NOTIFICATION, 1994 *(Amendment, 1997 and 2006)*

Until January 1994, obtaining environmental clearance from MoEF was only an administrative requirement intended for mega projects undertaken by the Government or public sector undertakings. The EIA notification of September, 2006, makes EIA statutory for 40 items (A and B category) under 8 projects/activities (Schedule of the notification). There will be a Central Expert Appraisal Committee for all projects included under MoEF (A- category) and state level EIA Authority for B category projects

The salient provisions of the notification are as follows :

- All projects listed under Schedule are required to obtain environmental clearance (EC) from the MoEF/State Government.

- Projects that fall under 'A' category need clearance from the MoEF.
- All development projects whether under Schedule or not, if they are to be located in certain notified ecologically sensitive or fragile areas will have to obtain clearance from MoEF.
- Industrial projects are further required to obtain a LOI (Letter of Intent) from the Ministry of Industry, and a NOC (no objection certificate) from the SPCB and the State Forest Department, if the location involves forestland.
- Once the NOC is obtained, the LOI is converted to an industrial license by the State authorities. However, if the project falls under Schedule of the EIA notification (A-category), it must obtain an environmental clearance from the MoEF.

ENVIRONMENTAL CLEARANCE

Environmental Clearance (EC) will have four stages:

- Screening for A, B_1 and B_2 categories of projects.
- Scoping for A and B_1 category of projects.
- Public Consultation (for A and B_1 categories-except building, township etc, defense infrastructure, expansion of roads and highways, modernization of irrigation projects and all B_2 category projects).
- Appraisal (detailed scrutiny by Central Expert Appraisal Committee (CEAC) or State level Expert Appraisal Committee.

The EIA report that is submitted after the site clearance contains the following :

- Description of site and site map
- Land requirements, No objection certificate from State Forest Department if forest land is involved
- Rehabilitation plan for displaced people
- Consent from SPCB (regarding effluents and emissions)
- Report on impacts on the environment during construction
- Collection of ambient air quality and meteorological data
- Report on hydrology and water quality
- Report on occupational safety and health
- Details of transport and handling of raw materials

THE NATIONAL ENVIRONMENT APPELLATE AUTHORITY ACT, 1997 (NEAAA)

This Act was established to hear appeals with respect to an environmental clearance given under the Environment (Protection) Act, 1986. The NEAA is located in Delhi and has Judge of the Supreme Court or a Chief Justice of any High Court as its Chairperson. A person aggrieved by an order granting environmental clearance in a given area for establishing an industry may, within 30 days from the date of such an order, appeal to the NEAA. The timeframe can be extended to 90 days if there are good grounds for delay. The appellant can be a person who owns or controls the project, an association of persons, Central or State Government or any local authority. No civil court or other authority has jurisdiction to entertain any appeal in respect of any matter with which the NEAA is empowered. All proceedings before the NEAA are deemed to be judicial proceedings. Failure to comply with any order made by the NEAA is punishable with imprisonment for a term of up to seven years or with a fine which may

extend to one lakh or both. The corporate liability is pinned on the person in-charge of and responsible to the company. Ignorance and due diligence are considered adequate defense against corporate liability.

The National Environment Appellate Authority Act, 1997: A bird's eye view

Section 3 : Establishment of Authority
Section 4 : Composition of Authority
Section 11 : Appeals to Authority
Section 12 : Procedures and powers of Authority
Section 15 : Bar of jurisdiction
Section 16 : Proceedings before the Authority to be judicial proceedings
Section 19 : Penal for failure to comply with orders of Authority
Section 20 : Offences by companies
Section 22 : Power to make rules

ENVIRONMENTAL AUDITING

Environmental auditing is a management tool, which simply inspects the environmental management activities performed by the industries or organizations and aware them with new cleaner technologies. It is the examination of accounts of revenues and costs of environmental and natural resources, their estimation, depreciations and values recorded in the books of accounts. In India, recognizing the importance of Environmental Audit (EA), procedure for EA was first notified under the Environmental Protection Act, 1986 by the Ministry of Environment and Forest by issuing of a gazette notification (No. GSR 329 (E)) on 13th March 1992. This makes the submission of the environmental audit reports mandatory. The industries are now required to submit their audit reports to the concerned State Pollution Control Boards on or before 15th day of May every year beginning 1993. A large number of polluting industries were identified to submit their EA reports. The EA report has been renamed as Environmental Statement (ES) in 1993. The detail format prepared by the State Pollution Control Board is known as Form V.

ISO-14000 is a methodology for environmental management. It provides necessary requirements and recommendations for any organization to develop and implement a cost effective system of management by introducing environmental auditing. ISO-14000 series covers environmental audit, audit procedure, audit criteria, audit management, site assessment, labeling, performance evaluations and life cycle assessment.

THE PUBLIC LIABILITY INSURANCE ACT 1991 (PLIA) ***(Amendment, 1992)***

The PLIA deals with accidents involving hazardous substances and insurance coverage for the same, where death or injury results from an accident. This Act makes the owner liable to give relief as is specified in the Schedule of the Act. Every owner is required to take out one or more insurance policies to cover such situations. The owner of hazardous substances can be prosecuted in a designated court not lower than that of a metropolitan magistrate or a first class judicial magistrate. The expenses of such prosecution are recoverable from the owner as arrears of land revenue. The punishment for violation of the Act is imprisonment for a year, extendable to six years for continued violation or a fine of Rs. One lakh. The Central Government has the power to issue directions under the Act to regulate the handling of any hazardous substance and to stop or regulate the supply of electricity, water or any other service to the owner. The PLIA was amended in 1992. Under Section 7, the Central Government has been authorized to establish the Environmental Relief Fund, which can be utilized for making relief payments by the Collector.

NATIONAL ENVIRONMENT TRIBUNAL ACT, 1995 (NETA)

The NETA prescribes the procedure and substantive law relating to compensation for the death of, or injury to, a person and damage to property and environment, by any industry wherein a hazardous substance is used or is a by product. Where death or injury has resulted from an accident due to the hazardous substance, the owner of the source is liable to pay compensation, irrespective of the wrongful act, neglect or default. Where the source of damage is multiple, the liability is split and apportioned on an equitable basis. A National Environment Tribunal is established by the Central Government under NETA. The tribunal has jurisdiction over matters specified in the Public Liability Insurance Act. The tribunal receives claims of compensation by the person who has sustained the injury or by his or her legal representative. The application for claim is to be submitted within five years of the occurrence of the accident, otherwise it is liable to be dismissed. The tribunal is not bound by the Code of Civil Procedure, but is guided by the principles of natural justice. For the purpose of NETA, the tribunal is vested with the powers of a Civil Court and can make its own rules of procedure, summon or enforce attendance of any person, examine witnesses on oath, require discovery or production of documents, and receive evidence on affidavits. The tribunal can sit in appeal over its own decisions, and its awards are executable as civil court decrees. Appeals against the award or other orders lie only to the Supreme Court.

THE INDIAN FOREST ACT, 1927 ***(Amendment, 1930, 1933, 1937, 1947 and 2004)***

Forest policy and management was introduced in India by the British Government by setting up a Forest Department and enacting relevant legislation in the 19th Century. In 1878, British Government in India enacted the Indian Forest Act (IFA), 1878 relating to forests in British India. Subsequently it was felt that the provisions of this Act were not adequate. In order to consolidate the law relating to forests, the transit of forest produce and the duty leviable on timber and other forest-produce, the Indian Forest Bill was introduced in the Legislature and received its assent on 21st September, 1927. It came on the Statute Book as The Indian Forest Act, 1927.

THE FOREST (CONSERVATION) ACT, 1980 ***(Amendment, 1988)***

The Forest (Conservation) Act (FCA) was adopted in 1980 to protect and conserve forests. The FCA restricts the powers of the State in respect of de-reservation of forests and the use of forestlands for non-forest purposes. An advisory committee has been created to oversee the implementation of the statute as per provision of FCA. According to Section 2 of the FCA "notwithstanding anything contained in any other law for the time being in force in a State, no State Government, or other authority shall, except with the prior approval of the Central Government, make any order directing— dereservation of a reserved forest; use of any forest land for any non-forest purpose; assignment of any forest land to any private person or entity not controlled by the Government; and reforestation of any forest land of naturally grown trees.

This Act empowers the Central Government to constitute a seven-member committee to advise the Central Government on proposal made by a State Government for conversion of a forestland for a new project. The rules contain a detailed format for the State Government to follow, while asking for approval from the Central Government. The proposal requires reports on project details; location and land involved (legal status, details of flora and fauna, density, vulnerability to erosion, existence of a national park, wildlife sanctuary etc.); details

of displacement of people due to the project; details of possible impact on the forest land; cost-benefit analysis; and opinion of the head of the State Forest Department.

The Forest (Conservation) Act, 1980: A bird's eye view

Section 2 : Restriction on the dereservation of forests or use of forest land for non forest purpose

Section 3 : Constitution of Advisory Committee

Section 4 : Power to make rules

Section 5 : Repeal and saving

THE WILDLIFE (PROTECTION) ACT, 1972 (WPA) ***(Amendment, 1976, 1982, 1986,1991, 1993 and 2002)***

The Wildlife (Protection) Act, 1972, provides for protection to listed species of flora and fauna and establishes a network of ecologically important protected areas. The WPA empowers the Central and State Governments to declare any area to be a Wildlife Sanctuary, National Park or a closed area. There is a blanket ban on carrying out any industrial process or activity inside any of these protected areas. In case forestland within the protected areas network is to be diverted for any non-wildlife use, a no objection has to be obtained from the Indian Board of Wildlife and the State Legislature, before the final consideration by Ministry of Environment and Forest (MoEF). In other words, this Act seeks to constitute a Wild Life Advisory Board for each state; to regulate hunting of wild animals and birds; to lay down the procedure for declaring areas as Sanctuaries, National Parks etc.; to regulate possession, acquisition or transfer of or trade in wild animals and animal articles; and to provide penalties for contravention of the Act.

THE BIOLOGICAL DIVERSITY ACT, 2002

The United Nations Convention on Biological Diversity was signed at Rio de Janerio on the 5th day of June, 1992 and came into force on the 29th December, 1993. This Convention reaffirms the sovereign rights of the States over their biological resources. Being a signatory to the Convention, India has passed the Biological Diversity Act, 2002 to promote conservation of biological diversity. It is evident that India is rich in biological diversity and associated traditional and contemporary knowledge system. The Biodiversity Act, 2002 of India is meant for conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto. Scientific investigation of biodiversity is an essential prerequisite for its conservation, management and sustainable Utilization[10].

THE COASTAL REGULATION ZONE (CRZ), 1991 ***(recent amendment, 2011)***

According to CRZ regulation, the coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters, which are influenced by tidal action (in the landward side) upto 500 metres from the High Tide Line (HTL) and the land between the Low Tide Line (LTL) and the HTL is termed as Coastal Regulation Zone. There are some restrictions on the setting up and expansion of industries, operations or processes, etc. in the said Coastal Regulation Zone (CRZ) such as (i) setting up of new industries and expansion of existing industries, except those directly related to water front or directly needing foreshore facilities (ii) any construction activity between the Low Tide Line and High Tide Line except facilities for carrying treated effluents and waste water discharges into the sea, facilities for carrying sea water for , cooling purposes, oil, gas and similar pipelines and facilities essential for activities permitted under this Notification (iii) dressing or altering of sand dunes, hills, natural features including landscape changes for beautification, recreational and other such purpose, except as permissible under this Notification (iv) Mining of sands, rocks and other

substrata materials, except those rare minerals not available outside the" CRZ areas and exploration and extraction of Oil and Natural Gas etc.[3, 5, 7]. Unfortunately, the Coastal Regulation Zone Notification, 1991 has been amended almost 26 times (including the last amendment in 2011) to get rid of its legal impediments for development projects.

ENFORCEMENT OF THE ENVIRONMENTAL NORMS

The Ministry of environment and Forests (MoEF), constituted in 1985, is the nodal agency at the central level for planning, promoting and coordinating environmental programmes. The MoEF formulates legislation to mitigate and control environmental pollution. A number of enforcement agencies assist MoEF in executing its assigned responsibilities.

Regional Office, MoEF

The major functions of the regional offices include-(a) follow up the implementation of conditions and safeguards laid down for projects, when environmental clearance is given, (b) follow up pollution control measures taken by various industries, (c) collect and furnish information relating to EIA of projects, pollution control measures, methodology and status, legal and enforcement measures, environmental protection of special conservation areas like wetlands, mangroves and biosphere reserves.

CPCB and SPCB

The CPCB was established in September 1974 for the purpose of implementation of the Water Act. Later, in 1981 when the Air Act came into force the powers of the CPCB and SPCBs were expanded to include enforcement of the Air Act. Executive responsibilities for the prevention and control of industrial pollution are undertaken at the Central level by CPCB, which is a statutory body attached to the MoEF. The functions of the CPCB include promotion of cleanliness of the streams and wells, advising the Central Government on matters concerning abatement of water pollution, and laying down standards for water and air quality, and ensuring compliance with the EP Act. The SPCBs were constituted to implement the Water Act in the states. The functions of the SPCBs include planning and execution programmes for prevention and control of water and air pollution, advising the State Government on matters concerning abatement of water pollution, laying down standards for water and air quality, ensuring compliance with various laws, ensuring legal action against the polluters and evolving techno-economic methods for treatment, disposal and utilization of effluents.

Municipalities and Panchayats

Municipalities and Panchayats play an increasing role in the environmental management at the District level. Under the XIth Schedule of the 73rd amendment, panchayats would also be responsible for soil conservation, water management and non-conventional energy sources. Under the Xllth Schedule, Municipalities would also be responsible for water supply for industrial use, solid waste management and protection of the environment. No rule has, however, been made to put this amendment into practice.

India has an extensive framework of environmental laws. The conviction rate is extremely poor because of enforcement problems and some lacunae in the laws. Some reasons for poor implementation of environmental laws are : (a) Relevance of standards laid down ; (b) Inadequate processes for environmental decision-making and dispute resolution; (c) Insufficient infrastructure in MoEF, CPCB and SPCBs for implementation; (d) Government insensitivity; (e) Poor Legal infrastructure ; (f) Cost of compliance.

Despite the enactment of several environmental regulations, the desired result has not been achieved due to poor implementation. For effective implementation, coordination among all such agencies of government and private sector is imperative. Enforcement agencies and environmental authorities should work together at all levels to mitigate the gaps. For successful coordination, linkages at the field level among various government bodies are of the essence. Courts enforcing the law by calling upon the implementers to do their duties, by disciplining industries, through imposition of penalties, by awarding compensation and by-and-large allowing judicial activism to flourish through Public Interest Litigation (PIL) have all been welcomed[11].

GAPS IN IMPLEMENTATION, ENFORCEMENT AND COORDINATION AMONG THE ENVIRONMENTAL AGENCIES

MoEF is more involved in providing clearances instead of performing macro-tasks of environmental protection. The state and central MoEFs authorities have been scuffling constantly for giving environmental clearances to projects. While the Centre want to retain control over such an authority, the State often feels trifling in the case of large development projects coming up in its territory - its role is limited to granting just a No Objection Certificate[11]. This centre-state antipathy, have failed to enforce the environmental regulations in many recent instances (Environmental Clearance for POSCO and Vedanta projects in Orissa). In a quasifederal democracy set-up in India, where the states are consulted after the centre decides a course of action, these issues will continue to be a hurdle for effective environmental enforcement unless states are democratically involved[11].

It is also pertinent to mention here that unfortunately, environmental legislations have been systematically diluted to pine away by removing legal impediments for development projects. For instance, the CRZ Notification, issued in 1991 and publicized as a progressive law, it is now a 'toothless tiger' due to innumerable amendments mostly of the nature of exemptions for development activities[11]. This is diametrically opposite to its stated objective of protection by regulating development activities. Similarly, the new Environment Impact Assessment Notification legislated in 2006 -signal the lack of political commitment in safeguarding environment with effective regulation[11].

Thus, a comprehensive review of environmental legislations is necessary. Coupled with such a review, efforts to harmonise policy directives of states and state-level laws with existing environmental legislation should be undertaken. Such a review would be meaningless if the agencies, implementers and regulators are not strengthened with provision of adequate technical support, financial autonomy, clear decision-making powers built into accountability mechanisms[11].

The absence of technical capacity is compounded by the lack of technical man power within the Pollution Control Boards. Due to lack of funding support and lack of revenue generation, the CPCB and the state boards are heavily reliant on the funds directly provided by the MoEF. The SPCBs especially receive only marginal funding from the Central Government and mostly through specific projects to be executed at a state level. According to the CPCB, the SPCBs are dependent on the reimbursement of cess/tax collected under the Water (Prevention and Control of pollution) Act and other consent and authorisation fees imposed on industries. The Departments of Environment at the State level also face a similar problem, being unable to enforce laws due to adequate financial support[11]. For instance, a country with about 7500 kms of coastline, the Coastal' Regulation Zone (CRZ) Notification 1991 set out a range of activities

for its own implementation such as preparation of maps, coastal zone management plans and zone demarcations. Such a significant statute was not supported with funding, thereby all the above activities necessary for its effective implementation did not quite stimulate the state governments[11]. Field-level monitoring of various pollutants by Board(s) needs to reinforced, if newer pollutants and forms of pollution need to be monitored and mitigated. Some of the modern and more hazardous pollutants are still not under the radar, nor are there any standard prescribed for them[11]. These technological and financial gaps should be worked out by the monitoring and implementing agencies. Otherwise, aforesaid discussions on improvements in enforcement would go in vain. Thus to mitigate these gaps, multi-disciplinary training to control the various forms of pollution should be made available to the environmental scientists of the CPCB and SPCBs. Moreover, the growing number of industries, the increasing types of industries and the growing number of functions of the Pollution Control Board (s) dictate an urgent need for capacity building within the SPCBs and the CPCB[11].

CONCLUSION

The social and environmental issues associated with any developmental and industrial project are both highly significant and complex to manage. There are environmental, social and health impacts of such project. The challenges with environment assessment of projects are two fold— firstly, to ensure that the environmental, social and health costs are afforded by considering the economic viability and acceptability of the project; and secondly to ensure that adequate mitigation or protection measures are incorporated into project design. This requires effective enforcement of environmental legislations by regulatory institutions, proper co-ordination among the various law implementing agencies and sound environmental management practices by private and public sectors. Hence, a sagacious strategy should be implemented in industries of India to promote job-led economic growth through the adoption of employment generating, economically viable and eco-friendly technologies.

No Act howsoever flawlessly and thoroughly drafted can remain free from ambiguities, drawbacks, shortcomings and lacunae. These laws do not always clearly state the social obligations. The interpretations of some provisions of these laws are often not in conformity with intent and purpose of the law. In spite of everything, these acts provide for speedy, effective and planned strategy for preventing and mitigating environmental pollution. These laws also promote development and resource utilization for specific economic benefit along with careful analysis of the potential short and long deleterious effect on the environment.

The current environmental laws put numerous obligations on Industry, which are required to be complied with, while establishing and operating an industrial unit. Environmental laws play crucial preventive as well as remedial roles and are prime catalysts for promoting environmentally responsible behaviour. Ignorance of laws is not excusable. Thus, policy makers, officers of CPCB, SPCBs, Ministry of Environment and Forest, NGOs, other Government officials should be aware of different provisions of existing environmental legislations and they also should implement relevant laws for sustainable management of the project.

As traditionally we are a pollution loving nation and have no civic sense, we have to change our attitude, other wise no such law can make our country clean and green.

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STATISTICS IN SERVICE OF SOCIETY

B. K. Kale

Like most other sciences Statistics was developed in response to specific problems faced by the society. There are three streams theory of observations as developed by Gauss, Legendre and Laplace, theory of probability as developed by Pascal, Erma and Euler, and analysis of Socio-Economic data collected for governance. The work of Florence Nightingale which led to the establishments of Cantonment areas in India, the work of Mahalnobis on survey of the Jute crop and work of Fisher which enabled the experimenter to make several comparisons simultaneously among varieties or treatments are used in support of this paper. Some modern areas such as Finance and Insurance, Clinical Trials Computational Statistics are also touched.

The subject of Statistics is relatively young, particularly as an academic discipline in Science faculty. The first formal University level Course in Statistics was established at University College, London in the first decade of 20th Century under the leadership of K. Pearson. A formal course leading to M.Sc. in Statistics in India was established at Calcutta University in the early 1940's only. The first Department of Statistics in USA was established in 1933 at Iowa State University. However, this does not mean that Statistical methods were not being used or developed earlier. Specific problems in social and natural sciences were being studied employing statistical methods much before the formal apparatus of the subject was developed.

Like most other Sciences, Statistics developed in response to specific problems faced by society. There are three distinct streams of Statistics which later merged into one mighty tributary to the great river of Science.

The oldest stream is related to Economics, Sociology and Demography. Thus, in early 17th century, the subject was called Political Arithmetic in England and dealt with analysis of Socio-Economic data, including mortality tables, first studied by Graunt. Later in 18th Century, the parity between the sex ratio was studied by Laplace-De-Moivre among others, who discovered that in Europe this proportion of male births fluctuated around 22/43 and not $^1/_2$. The well known De-Moivre-Laplace limit theorem providing normal approximation to binomial was originally derived in this context. It is interesting to note that in India as early as in 2nd Century AD, Kautilya in his famous treatise 'Arthashashtra' provides detailed instructions as to how the king should collect information on crop yield, income, wealth of his subjects to be used for purpose of taxation. The statistical investigator who collected such information for the king was called as 'Gopa' and was instructed to treat this information as strictly confidential. The current Hindi administrative word 'Gopaniya' used for confidential documents is thus traceable to Kautilya. The practice of collecting socio-economic data for state was common in China as well as in Greek and Roman empires. Today, Governments of almost all the countries have their Census Bureaus and Departments of

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Statistics which collect extensive data on all aspects to be used in decision making for planned development of the country.

The second stream originates from the theory of observations developed in connection with observations made for understanding planetary motions in Astronomy. This problem of measuring either directly or indirectly 'magnitudes of interest' with chance error led Gauss-Legendre-Laplace in 18th century to the method of Least Squares which is extensively used even today in fields such as Economics, Psychology, Physics, Astronomy, Geology among others. Here, even though observations are made by carefully designing experiments, the chance errors show considerable variations in the data. On the other hand, in the first stream the variability was apparent immediately.

Thus, in both streams, because of variation an element of uncertainty was inevitably present. Further, as the objective in either stream was the inference from the observed to unobserved, the problem was soon recognized as that of inductive inference which in itself is uncertain. This was already noted in connection with Descartes-Bacon philosophy of rational empiricism or the scientific method of learning from experiments or experience. Many logicians and philosophers have taken the view that inductive inference is not valid because of the inherent uncertainty. Bayes-Laplace, in 18th century, used the theory of probability to quantify the uncertainty in inductive inference which is the third stream. Originally, the classical theory of probability developed in connection with various games of chance in 17th century by great mathematicians such as Pascal and Fermat and Euler. However, its connection with demography, mortality tables was already noted by De-Moivre and Laplace. The famous French mathematician Euler in the 18th century helped the French Government to establish the popular French Lottery by working out the odds for winning various prizes and adjust the entry fee so that the Government could make considerable amount of profit.

Thus the origin of Statistics is firmly rooted in attempts to solve relevant socio-economic problems as well as an attempt to quantify uncertainty. We will consider a few case histories to support this hypothesis.

Because of the dangers of AIDS, and the comeback with vengeance of diseases like TB, Typhoid and Malaria, Statistical Epidemiology in particular and Medical Public Health Statistics (MPHS) in general are emerging as important branches of Statistics which could play a significant role in near future. The origin of MPHS can be traced to the pioneering work of Florence Nightingale (FN), the great nurse of the Crimean War. Florence Nightingale had great fascination for quantified information and during the Crimean War, kept very meticulous record of causes of death of soldiers during the war. With very elementary statistical analysis, she convincingly showed that more soldiers died in barracks due to problems of health and sanitation than on the battlefield. The British government was so impressed with this work that they asked Florence Nightingale to survey military hospitals and establishments in Great Britain, which she did with a remarkable report which led to various improvements in Army Hospitals as well as barracks with considerable improved sanitation. This report led to the Statistics Department of the British Army in 1861, perhaps the first full fledged government Department of Statistics in the world. Florence Nightingale was later entrusted a similar job about British Army stationed in India, which experienced a very high death rate in barracks compared to those m the battlefield. Although she did not visit India, on the basis of detailed reports sent from India, Florence Nightingale prepared an exhaustive report and concluded that the high death rates in barracks were due to lack of knowledge about tropical diseases, hygiene and proper

sanitation. Possibly, this conclusion was responsible for establishing the now famous London School of Tropical Hygiene. Florence Nightingale was also requested to prepare a report for Royal Indian Sanitary Commission. This report was prepared by her and a brief resume was published by Florence Nightingale in 1863 in a booklet entitled "How People may live and not die in India". Her suggestions included drastic improvement in sanitation throughout British India which would have infringed on personal habits of local population. However, the war of 1857 was well remembered by the British Government, and Queen Victoria while taking over Indian Empire from East India Company in 1858 had promised not to interfere with local religious and social customs. It was therefore decided to establish separate military establishments called as Cantonment Areas in which recommendations of Florence Nightingale regarding proper hygiene and sanitation would be fully implemented. The establishment of such areas not only unproved the health standards in the British Army in India, but also influenced local authorities of the nearby cities to adopt similar measures. In a follow-up study conducted by Florence Nightingale in 1873 for the National Association for Promotion of Social Science entitled "How some people have lived and not died in India", she demonstrated that the death rate in the British Army came down from 69 per thousand to 18 per thousand in the ten-year period.

The effect of Florence Nightingale's work helped establish MPHS as one of the important areas of Statistics not only in Britain or India, but also later in Europe, America, Asia and the whole world. It is important to observe that Florence Nightingale's database was not obtained on the basis of well-designed sample survey as the modern practice would demand. Next we review how P.C. Mahalnobis (PCM) laid down the foundation of Theory of Sample Surveys and Fisher who founded the theory of Design of Experiments.

During 1920-40, one of the main items of export from India was jute, which was one of the most important commercial crops of Bengal. It was thus necessary to have an accurate estimate of the total jute that is produced in the current year or likely to be produced next year. The Government of India and Bengal entrusted this job to PCM and gave him a grant of Rs. 5 lakh to execute the project. PCM then studied the problem in depth and developed the now well-known ideas of stratification, systematic sampling, and cluster sampling, interpenetrating samples along with allocations of sample units to maximize information and accuracy at a given cost. The training on the job given to many young statisticians in India provided the second line of specialists in sample surveys. They in turn helped through United Nations to carry out large scale sample surveys in many developing nations. Such sample surveys and organizations such as National Sample Survey in India provided a database which was so essential for well-planned development in the different sectors of the society. An interesting anecdote about this jute survey is reported by Joan Fisher-Box in her biography of Fisher. It seems that a senior British ICS officer, who was also a member of Viceroy's Council, had reservations about usefulness of sample surveys and the project of Jute survey was in danger of being scrapped. However, Fisher, who was visiting ISI in 1938 had a special meeting with the Viceroy in which Fisher convinced him about the soundness of statistical methods in survey sampling and the project was saved. Fisher himself contributed to Statistics in various ways and is regarded as one of the founding fathers of the discipline. Fisher in 1919 had joined Rothamsted experimental station where trials were being conducted on different varieties of wheat. It is in this connection Fisher developed the basic ideas of Analysis of Variance (ANOVA) along with different designs such as CRD, RBD, Latin Squares and Factorials. This was a path breaking work in the true sense since before Fisher, comparisons

between different varieties were made pair wise, i.e. two at a time. Thus with 5 varieties one has to make ${}^5C_2 = 10$ comparisons. Further, due to sampling variations from trial to trial, one often got into a logical problem of resolving contradictions — where the experiments indicate that variety A is better than B, B is better than C but C is better than A. It was the genius of Fisher who showed how by an act of deliberate randomization one could validly test simultaneously several varieties. Fisher also wrote two path breaking books entitled "Statistical Methods for Research Workers" and "Design of Experiments". Both books have gone into several editions, and helped agricultural scientists all around the world to develop high-yielding disease-resistant varieties which have contributed to a substantial increase in global food production. As early as in 1936, Harvard University in its tercentennial ceremony honoured Fisher by awarding an Honorary D.Litt. along with sixty other selected individuals who had contributed significantly to art, literature, philosophy, science and world civilization at large. The local newspapers labeled Fisher as 'the man who taught experimenters how to experiment'.

Coming to more recent times, the theory of Statistical Quality Control established by Shewhart in USA helped Industry tremendously. The emphasis now has shifted to Taguchi Methods, Statistical Process Control and Total Quality Management (TQM). In the era of globalization and liberalization and emphasis on ISO standards, Statistics is bound to play a crucial role in Industry. Another area where Statistics has made significant contributions is in Medicine, where regression model incorporating covariates developed by Cox has proved extremely useful in developing new effective drugs for treatment of several diseases in general, and kidney and heart diseases in particular. On the other hand, areas like Reliability and Survival Analysis have been found to be useful in both Medicine as well as Industry. Some other new areas, among others, are Clinical Trials, Financial Statistics including Actuarial Mathematics, Computational Statistics is another important area which deserves a special mention.

Several more examples can be cited where Statistics has contributed significantly by providing better insight and better solutions to various problems. For several such case histories, one can refer to "Statistics and Public Policy" and "Statistics : A Guide to Unknown" published by American Statistical Association; along with "Statistics for Everyone" by Gore, Paranjpe and Kulkarni.

The advances made in computing facilities with virtually unlimited scope for storage, retrieval, and analyses of very large data sets have rendered many problems as solvable ; or at least made it possible to obtain feasible solutions for such problems that were considered unsolvable and for which no theoretical solutions were possible. Such advances increase the responsibility of statisticians towards the society. I hope that Statisticians, particularly younger ones will measure up and accept these challenges and will contribute significantly to this development of Statistics.

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99TH INDIAN SCIENCE CONGRESS
ISCA Best Poster Awards for 2011-2012

Section	Name
Agriculture and Forestry Sciences	1. **Saujanendra Swain** Biju Patnaik Medicinal Plant Garden, Jeypore, Orissa
	2. **Seema Rana** Department of Agriculture Biotechnology, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar – 751 003
Animal, Veterinary and Fishery Sciences	1. **Sidharth D Pagare** Department of Zoology, Dr. Babasaheb Ambedkar University, Aurangabad–431 004
	2. **Bhavna Bawra** Department of Zoology, Dr. H.S.Gour University, Sagar (M.P.)
Anthropological and Behavioural Sciences (including Archaeology and Psychology Educational sciences and Military sciences)	1. **Singtitla Vashum** Department of Anthropology, Manipur University, Imphal
	2. **Trayambak Tiwari** Cognitive Science Laboratory, Department of Psychology, Banaras Hindu University, Varanasi
Chemical Sciences	1. **Vinita Arora** Department of Chemistry, University of Delhi, Delhi–110 007
	2. **Amtul Nashim** Colloids and Materials Chemistry Department, Institute of Minerals and Materials Technology (CSIR), Bhubaneswar – 751 013, Orissa

Earth System Sciences	1.	**Nilima Das** Institute of Minerals and Materials Technology, Bhubaneswar
	2.	**Bibhuti Gogoi** Department of Geology, University of Delhi, Delhi-7
Engineering Sciences	1.	**B. Ramesh Naidu** GIITS, Visakhapatnam
	2.	**T. Vigneswari** M.A.M. College of Engineering, Tiruchirapalli, TN
Environmental Sciences	1.	**Durga Madhab Mahapatra** Centre for Sustainable Technologies, Indian Institute of Science, Bangalore–560 012
	2.	**M. K. Awasthi** Regional Office, Madhya Pradesh, Pollution Centre Board, Vijay Nagar, Jabalpur, M.P.
Information and Communication Science & Technology (including Computer Sciences)	1.	**Neeraj Kumar** Department of Electronics & Communication Engineering, Amity School of Engineering & Technology, Amity University, Sec–125, Noida, Uttar Pradesh
	2.	**Srimoyee Bhattacherjee** Department of Computer Science and Engineering, West Bengal University of Technology, B.F.–42, Salt Lake, Sector–1, Kolkata – 700 064
Materials Science	1.	**Parul Khurana** Department of Chemistry, Banasthali Univeristy, Banasthali
	2.	**Sandeep Fale** VNIT, Nagpur

Mathematical Sciences (including Statistics)	1.	**Abhirup Mallik** Department of Mathematics, Indian Institute of Technology, Kharagpur
	2.	**Sachin Shaw** School of Applied Sciences (Mathematics), Kalinga Institute of Industrial Technology, Bhubaneswar
Medical Sciences (including Physiology)	1.	**Dr. Vijay Batra** GB Pant Hospital, FNCT, Delhi & Ph.D Scholar, CSM Medical University
	2.	**Satabdi Ghosh** Department of Physiology, University of Calcutta, Kolkata
New Biology (including Biochemistry, Biophysics & Molecular Biology and Biotechnology)	1.	**Sandip K. Dash** Institute of Genomics and Integrative Biology (CSIR), Mall Road, Delhi–110 007
	2.	**B. R. Sahoo** Central Institute of Freshwater Aquaculture (CIFA), Fish Health Management Division, Kausalyaganga, Bhubaneswar, Orissa–751 002
Physical Sciences	1.	**Ashok Kumar** Theoretical Physics Division, Physical Research Laboratory, Navrangpura, Ahmedabad–380 009
	2.	**Sovan Ghosh** Department of Physics, Tezpur University, Tezpur–784 028
Plant Sciences	1.	**Ritu Panjwani** AVS Presidency International College, Raipur (CG)
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SHORT COMMUNICATION

FUGU FISH : AN OVERVIEW

Jyoti D. Vora* and Shweta M. Gokhale*

Fugu is the Japanese word for pufferfish and the dish prepared from it. Fugu can be lethally poisonous due to its tetrodotoxin; therefore, it must be carefully prepared to remove toxic parts and to avoid contaminating the meat. Japanese have eaten fugu for centuries probably for more than 2,300 years. Fugu has become one of the most celebrated and notorious dishes in Japanese cuisine. In the present article, an attempt has been made to address the adverse effects of the toxin present in the fish.

INTRODUCTION

Fugu is the Japanese word for pufferfish and the dish prepared from it, normally species of genus *Takifugu, Lagocephalus,* or *Sphoeroides,* or porcupine fish of the genus *Diodon.* Fugu can be lethally poisonous due to its tetrodotoxin; therefore, it must be carefully prepared to remove toxic parts and to avoid contaminating the meat. The resturant preparation of fugu is strictly controlled by the law in Japan and several other countries, and only chefs who have qualified through rigorous training are allowed to deal with the fish. However, the domestic preparation occasionally leads to accidental death. Fugu is served as sashimi and chirinabe.

Some consider the liver the tastiest part but it is also the most poisonous, and serving the fugu liver in restaurants was banned in Japan in 1984. Fugu has become one of the most celebrated and notorious dishes in Japanese cuisine.

Takifugu rubripes (also known as Japanese Puffer fish) is found in marine habitat, mainly in the Northwestern Pacific Ocean, the Sea of Japan, and the East China Sea. The Japanese puffer fish adults live in the shallow inlet waters and the brackish water (mix of fresh water and sea water). The adults can be found in the shallow coral surrounding the coastal areas when laying their eggs. The puffer fish also has a closed circulatory system, utilizing gills for gas exchange through the water. The Japanese puffer fish is also one of many fish that can be infected with the parasite *Heterobothrium okamotoi.* The flatworm attaches its eggs to the puffer fish's body and its gills. When the larvae form, they burrow and eat away at the puffer fish, essentially killing the fish.

THE TOXIN : TETRODOTOXIN

Fugu contains lethal amounts of the poison tetrodotoxin in the organs, especially the liver, the ovaries, and the skin. The poison, a sodium channel blocker, paralyzes the muscles while the victim stays fully conscious. The victim is unable to breathe, and eventually dies from asphyxiation. There is no known antidote. The standard treatment is to support the respiratory and circulatory systems until the poison dissipates.

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Tetrodotoxin is a very potent neurotoxin that shuts down electrical signaling in nerves by binding to the pores of sodium channel proteins in nerve cell membranes. Tetrodotoxin is not affected by cooking. It does not cross the blood—brain barrier, leaving the victim fully conscious while paralyzing the muscles. In animal studies with mice, 8 μg tetrodotoxin per kg body weight killed 50% of the mice. The pufferfish itself is not susceptible to the poison because of a mutation in the protein sequence of its cells' sodium channel.

Tetrodotoxin has very adverse side effects for humans and other animals. In humans, tetrodotoxin poisoning begins with numbness of the lips and tongue, occurring within three hours of ingestion. Numbness of the rest of the face, hands and feet follow, with headache, nausea and vomiting after that. Paralysis, increased respiratory stress, decreased speech, and cardiac arrhythmia soon occur. Death occurs within 20 minutes to 8 hours of ingestion. The symptoms from ingesting a lethal dose of tetrodotoxin may include dizziness, exhaustion, headache, nausea, or difficulty breathing. The victim remains conscious but cannot speak or move. Breathing stops and asphyxiation follows.

There is no known antidote, and treatment consists of emptying the stomach, feeding the victim activated charcoal to bind the toxin, and putting the victim on life support until the poison has worn off. Japanese toxicologists in several medical research centers are now working on developing an antidote for tetrodotoxin.

MICRO-ORGANISMS PRODUCING THE TETRODOTOXIN

The Japanese puffer fish is thought to contain one of the bacteria that produce tetrodotoxin as a biproduct, such as *Pseudomonas spp.* or *Vibrio spp.* Recent evidence has shown that tetrodotoxin is produced by certain bacteria-such as *Pseudoalteromonas tetraodonis*, certain species of *Pseudomonas* and *Vibrio*, as well as others—and that these are the source of the toxin in pufferfish.

Identification of tetrodotoxin (TTX) and its derivatives produced from a *Vibrio* strain in the intestine of the puffer fish *Fugu vermicularis radiatus* was performed by thin-layer chromatography, electrophoresis, high-performance liquid chromatography, and gas chromatography-mass spectrometry, together with a mouse bioassay for toxicity. It was demonstrated that the isolated bacterium produced TTX, 4-epi-TTX, and anhTTX during cultivation, suggesting that *Vibrio* strains are responsible for the toxification of the puffer fish.

The role of tetrodotoxin in the bacteria themselves is not yet clear. The fact that tetrodotoxin regulates the transfer of sodium ions through biological membranes may have some relevance to the function of the toxin in marine bacterial cells. Observations on marine bacteria associated with the toxin-containing animals, suggest that tetrodotoxins found in animal organs are the products of marine bacteria. If the animals accumulate the bacterial products for their own purpose, this would suggest a symbiotic relationship. Although the role of the toxin in animals is still not entirely clear, the fact that scared animals exude the toxin into surrounding seawater suggests that the toxin has a protective function. Further research should be aimed at elucidating the mechanisms of toxin production and function.

AQUACULTURE AND ADVANCED RESEARCH

Advances in research and aquaculture have allowed some farmers to mass-produce safe fugu. Scientists at Nagasaki University have reportedly succeeded in creating a non-toxic variety of torafugu by restricting the fish's diet. After raising over

4,800 non-toxic fish, they are fairly certain that the fish's diet and digestive process actually produce the toxins. The non-toxic version is said to taste the same. Researchers surmised that fugu's tetrodotoxin came from eating other animals that held tetrodotoxin-ladenbacteria and developed immunity over time. Many farmers now produce 'poison-free' fugu by keeping the fugu away from the bacteria. Usuki, a town in Oita Prefecture, has become known for selling non-poisonous fugu.

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KNOW THY INSTITUTIONS

THE INDIAN INSTITUTE OF PETROLEUM, DEHRADUN

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Topics :

- Materials Sciences
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- Physical and Applied Chemistry
- Biomaterials & Health Care
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32nd Annual Session of the Academy of Environmental Biology, 20–22 September, 2012, Lucknow, U.P., India

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- Predictive and preventive toxicology.
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- Environmental protection strategies and quality assurance.
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- Industrial and domestic waste : risk assessment and management.
- Occupational exposure, health hazards and protective approaches.
- Biological interactions of nanomaterials and fate in the ecosystem.
- Rain water harvesting and ground water contamination.
- Alternative models in environmental safety studies and treatment technologies.
- Regulatory guidelines, policies and ethical standards.

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II International Conference on Antimicrobial Research-ICAR 2012, 21–23 November 2012, Lisbon (Portugal)

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- Techniques and Methods.

- Interfering microbe-microbe communication.
- Strengthening of innate immune system.
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- Agriculture Science Section
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Conference & Workshop on "Monitoring of Metals and Gases in Plants with Special Reference to Bryophyte Physiology & Climate Change", 17–20 December, 2012, Bareilly, U.P., India

Topics :

- To highlight new knowledge related to Climatic changes and environmental sustainability.
- To discuss issues conerning increase in CO_2 and response on metal tolerance, C sequestration and physiology of mosses.
- Use of non-invasive tools (Photosynthetic Efficiency Analyzer) to measure the status of plants under elevated CO_2 and metals as well as screening for tolerant species.
- To enhance collaboration and networking among experts in the various monitoring groups working towards environmental sustainability.

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S & T ACROSS THE WORLD

STUDY FINDS PERMAFROST THAW, GLACIER MELT RELEASING METHANE

Methane from underground reservoirs is streaming from thawing permafrost and receding glaciers, contributing to the greenhouse gas load in the atmosphere, a study led by scientists at the University of Alaska Fairbanks has found. The study, published online on May 2012 in the journal *Nature Geoscience*, is the first to document leakage of deep geologic methane from warming permafrost and receding glaciers, said its lead author, Katey Walter Anthony. Release of methane into the atmosphere from any source is troubling because methane has far more potent greenhouse powers than carbon dioxide, climate scientists say. Methane has more than 20 times the heat-trapping power of carbon dioxide, University of Alaska Fairbanks researchers said. Scientists have speculated about such methane releases and modeling has predicted that it would happen as the cryosphere - the earth's layer of ice and frozen ground - softens and melts, Walter Anthony said in a telephone news conference. "But no one had ever shown that it was occurring or that it was a widespread phenomenon," she said. "This paper really is the first time that we see with field evidence that this type of geologic methane is escaping as the cryosphere retreats." The leaking geologic methane identified by Walter Anthony and her colleagues comes from such sources as underground coal beds and conventional natural gas reservoirs. Those are fossil fuels that energy companies target in drilling operations. It differs from the methane streaming from decaying plant and animal matter at the bottom of warming Alaska lakes, a phenomenon that Walter Anthony has studied for about a decade. Walter Anthony said it is too early -to estimate how much methane is leaking from underground reservoirs. The study stems in part from Walter Anthony's observations over the past few winters of lakes in Arctic Alaska that had large patches with no ice, where one could expect to find it. Ultimately, researchers confirmed that underground methane was venting from two types of sources in Alaska - one of them being 50 lakes in the northernmost region, and the other being along the edges of rapidly receding glaciers in southern Alaska. In Greenland, they found methane streaming out of areas where the ice sheet had retreated over the past 150 years, Walter Anthony said. Field work, which included aerial surveys, long winter hiking treks and other tasks, took place from 2008 to 2010, according to the university. The discoveries of venting methane from below the earth's surface coincide, to some extent, with known petroleum and coal deposits, Walter Anthony said. The first lake where she and her team found underground methane to be preventing normal winter freezing was near the Inupiat Eskimo village of Atqasuk in northern Alaska, where locals have long known about that area's deep coal deposits and where the village name translates to "the place to dig the rock that burns."

HOW MOSQUITOES SURVIVE COLLISIONS WITH RAINDROPS

When a storm rolls in, mosquitos have to battle raindrops that are close to their size but with a mass up to 50 times that of the average mosquito (equivalent to the difference between human and a school bus). How mosquitoes contend with these drops of doom is the subject of a study in June, 2012 issue of the *Proceeding of the National Academy of Sciences.* David Hu, a professor of mechanical engineering and biology at Georgia Institute of Technology, and his team have devised some rather unorthodox methods to determine how mosquitoes survive such watery collisions. Using a high-speed camera, Hu's team bombarded *Anopheles* mosquitoes with drops of water and caught the resulting action at 4000 frames per second (a typical film camera only records 24 frames per second.) They found that mosquitoes are actually quite good at dealing with raindrops, even when receiving a direct hit between the wings. Mosquitoes are very light compared to the mass of the raindrop and this means the drop pushes the mosquito down rather than breaking over it. Because

the drop's speed doesn't change very much, little force is transferred to the mosquito. Compare that with a drop hitting a larger insect, like a dragonfly; the drop would break on its back, and the resulting force would transfer into the insect's exoskeleton. What's more, the mosquito has hydrophobic hairs on its body and sprawling legs that create drag. This lets it slip put from under the raindrop before meeting a wet end. However, Hu's team also found that the mosquito isn't completely safe from forces generated when colliding with a raindrop. As the drop comes in contact with the mosquito it accelerates the mosquito sharply downward to match the drop's terminal velocity of nine meters per second. This happens over the distance of only about a 10 mm which puts an enormous amount of pressure on the insect's body, up to 300 gravities worth (2942 m/s^2). For comparison, a jet fighter pilot accelerating out of a loop de loop, experiences only about nine gravities (88 m/s^2). This rapid acceleration also produces the greatest risk to mosquitoes: flying close to the ground. When hit by a raindrop, they would accelerate into the ground with great force and without sufficient time to slide out from underneath. And this is where the practical application of Hu's research comes into play. In recent years, we've seen the invention of many exceedingly small military aircraft, known as Micro Air Vehicles, or MAVs. If these vehicles become as small as mosquitoes, they would become subject to the same dangers as flying insects, including rainstorms.

BLOWING ITS COVER : CRYSTALLIZED VOLCANIC ROCKS

The chemical fingerprints of erupted crystalline minerals are a record of activity in the bowels of the volcano before it blew. In a study appearing in the May, 2012 issue of *Science* journal, the researchers report that crystals of the silicate mineral orthopyroxene from 1980 and from subsequent eruptions trace various injections of magma, as well as other chemical changes, within the bowels of the volcano. The crystals contain concentric rings of differing chemical composition. Some orthopyroxene crystals, for instance, have a magnesium-rich core surrounded by an iron-rich rim; others have an iron-rich core and a magnesium-rich rim. Each type of crystal zonation can record the conditions of the magma reservoir from which it emerged. "We chemically fingerprint each of those zones to determine how they formed," says lead study author Kate Saunders, a volcanologist of the University of Bristol in England. The outer rim of an orthopyroxene crystal, she says, represents the most recent stage of crystal formation and typically grew just months before the crystal's emergence in volcanic ejecta. That allowed the researchers to make precise estimates of when, and how, the crystals acquired their chemical forms. "Mount Saint Helens is really good — because the samples, we know exactly when they erupted," Saunders says. In several cases, a flurry of crystallization matched up well with internal activity at the volcano, as inferred from seismic records. For instance, crystals with iron-rich rims increased in number in the weeks and months leading up to the May 1980 eruption, as earthquakes shook the mountain with low-frequency seismic waves. Such long-period quakes, Saunders says, are characteristic of magma giving off gas. "Previously it's been reported that iron-rich rims on orthopyroxene are due to changes in the water content of the magma, so it makes sense that if we've got degassing or fluxion of water or CO_2 through the system, we may get more iron-rich rims," she says. Other crystals with magnesium-rich rims seem to mark an influx of hot magma from deep reservoirs just before eruption. Those events are also captured in the seismic record, but the root cause of the tremors is not always clear from seismology alone. That is where the crystals can provide important corroboration—or critical insight into ancient eruptions, for which seismic records do not exist. In the case of Mount Saint Helens, the study's authors "are providing fairly convincing arguments that the periods of enhanced seismicity are related to inputs of magma," says Timothy Druitt, a volcanologist at Blaise Pascal University in Clermont-Ferrand, France.