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NEWSLETTER

Contents

From the Director



Dear colleagues,

It is a matter of great honour for me to share my feelings and thoughts with each one of you through the BARC Newsletter for the first time after I assumed charge as the Director of the most prestigious research centre in the country. At the outset, I would like to take this opportunity to convey my sincere thanks and gratitude for the highly encouraging and reassuring congratulatory messages received from all of you in BARC as well as from the various eminent personalities and institutes outside BARC. Expectations of the people of our country from this great institute of ours have also been carefully noted through these congratulatory messages. Let me also take this opportunity to place on record my profound gratitude to our Chairman and all other eminent peer personalities for their appreciation, trust and confidence reposed on me to take over the responsibilities of steering the activities of this multi-disciplinary institution. I am also thankful to all my colleagues who have toiled with me over the years with total commitment and dedication for successful completion of various tasks, which have finally earned me this place of honour.

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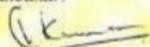
From the Editor...

With Dr Anil Kakodkar moving over to take the responsibilities of Chairman, Atomic Energy Commission, from Dr R. Chidambaram, Mr B. Bhattacharjee took over as Director of Bhabha Atomic Research Centre, one of the most prestigious R&D centres in the world in the field of Nuclear Science & Technology. Hailing from the 9th batch of BARC Training School, Mr Bhattacharjee has been the key person for successfully setting up the country's only uranium mill, Uranium Corporation of India, Jaduguda, which supplies the entire uranium needed for the Indian nuclear power programme.

A 'Padma Shri' awardee, Mr Bhattacharjee was earlier Director, Chemical Engineering & Technology Group, and Project Director, Rare Materials Project. He and his team successfully developed the highly complex High Speed Rotor (HSR) technology required for producing "strategic materials" for the nuclear energy programme, using indigenously developed instruments, components and equipment that were hitherto not available in the country. Design, installation and successful commissioning of HSR technology in the country has not only enabled India to produce some of the materials of strategic importance but also put India amongst the select band of countries in the world which have been able to develop the technology so far.

Not resting on his laurels, Mr Bhattacharjee has been executing two important projects—each one of which is again the first of its kind in the country – a desalination project coupled to nuclear power plant, and a Special Materials Project.

Needless to add, Mr Bhattacharjee is a worthy successor to an illustrious predecessor, Dr Anil Kakodkar.



BARC is recognised nation-wide as a cradle of science and technology - an ideal place in the country to give visions which are subsequently realised in mission mode through appropriate care and nurture of innovative ideas and creative designs. To ensure thriving of originality and creativity in the entire spectrum of our R&D efforts, maintenance of proper ambience in all our activities, covering basic science, applied science and engineering science should obviously deserve the attention of my senior colleagues.

Traditionally, we believe in the development of nuclear science and technology that addresses to the problems of the nation as a whole; we also believe in high peak science and technology with a narrow base, provided such science and technology has the potential to earn glory to the institution nation-wide, if not world-wide.

Accordingly, even at the cost of repetition, I would like to reiterate that our major concern is to improve the quality of life of our one billion plus people by systematic induction of nuclear science and technology which would not only allow us to achieve a sustainable growth of electricity generation in India but also contribute in a major way in the areas of health care, agriculture, food preservation, tracer hydrology, industry and research through radioisotopes and radiation technology. This also includes the task of supplying drinking water through nuclear desalination in water scarce areas in the country.

Pursuant to the mandate of the Department, BARC stands committed, on one hand, to extending full R&D support to all industrial units of DAE not only for their performance at high peaks but also for their growth. Simultaneously, on the other hand, it would be our prime responsibility to look ahead for what is further needed to be done in the field of nuclear science and technology to usher in its benefits to our common people. The success in the second part, namely, "what is to be done further" needs full exploitation of our inherent strength, namely, "togetherness coupled with international level of expertise in science and technology", both in the planning and execution of our R&D activities. Since we cannot afford to lose sight of

the fact that our resources are rather limited, we may, at times, have no option but to prioritise while we pursue our development efforts.

Our immediate priority is, of course, successful completion of the remaining tasks of the basic, applied and technological developments, including completion of the remaining portion of enhancing the infrastructure in this last year of the 9th Plan.

The results of our R&D efforts during the next five years or so, would be crucial for the development of nuclear science and technology in India. We have to fulfill our commitments towards ushering in the second stage of our nuclear power generation through Fast Breeder Reactors for which we need to accelerate our efforts for converting the various technologies involved at both the front end as well as the back end of the fuel cycle from lab scale to production scale. Similarly, there is also need to accelerate our programmes for utilisation of radioisotopes and radiation technology based on both nuclear reactors and accelerators. This includes creation of a new multi-purpose research reactor along with associated isotope processing facility. Our efforts to extend the benefits of nuclear science and technology to the common people in its non-power applications deserves more attention to our programmes on nuclear desalination as well as technology transfer as spin offs of the science and technology that have been established on a sound footing for our in-house needs.

One of the major tasks during the 10th Plan period would be to give a concrete shape to our programmes for generation of electricity from our vast thorium sources, using the AHWR route – a unique reactor concept essentially based on our existing PHWR system but incorporating a host of passive safety features along with innovative design simplifications for cost reduction. All the technologies needed at the front end as well as back end of these programmes would have to be completed along with visible progress in the construction activities for the AHWR itself.

Looking further at a slightly longer time frame, the 10th Plan also should initiate development work for some of the important areas that would be needed to establish Accelerator Driven Sub-critical Systems (ADSS) in the country which would also allow us to generate electricity, in addition to its potentials for transmuting long lived minor actinides to short life radio-nuclides and generation of fissile material, etc., through thorium U-233 route in ADSS route running in parallel to our programme of generation of electricity through Th-U-233 in third stage of FBR.

Finally, the single most important programme that needs to be assigned highest priority on continued basis is our human resource development programme. Extending the benefits of nuclear science and technology through induction of FBR, AHWR (or ADSS at a later stage) calls for newer ideas and innovative designs. We need to ensure sustained inputs of high quality young talents through our Training School programme with progressively more and more inputs through stronger linkages (either through bilateral or through BRNS programmes) with the academia and research institutions.

In summary, the task ahead of us is enormous but so is our strength that can make us achieve our targets through dedication and hard work. May be, what we need is a bit more of national pride in BARC and concern for the nation.

B. Bhattacharjee
Director

TOXIC AND TRACE METALS IN THANE CREEK

S. Sadasivan and R.M. Tripathi

Environmental Assessment Division

Trace Metals in the Environment

Trace metals are intrinsic, natural constituents of our environment. Apart from the natural sources, several anthropogenic ones also contribute to metal concentrations in the environment. Some of the anthropogenic sources of the metals in the environment are: mining, smelting, production and use of the compounds and materials containing the metals, burning of fossil fuels, waste dumping and leaching of waste dumps, urban run-off, sewage effluents and agricultural run-off. Toxic metals to a large extent are dispersed in the environment through industrial effluents, organic wastes, refuse burning, transport and power generation. They can be carried to places many miles away from the source depending upon whether they are in the gaseous form or as particulates. Another means of dispersal, especially in the hydrosphere is the transport of the effluent from catchment areas which have been contaminated by wastes from various industries.

The study of toxic and trace metals in the environment is more important in comparison to other pollutants due to their non bio-degradable nature, accumulative properties and long biological half lives. It is difficult to remove them completely from the environment once they enter into it. With the increased use of a wide variety of metals in industries and in our daily life, there is now a greater awareness of toxic metal pollution of the environment. Many of these metals tend to remain in the ecosystem and eventually move from one compartment to the other within the food chain.

There is considerable concern about the human health aspects of metal cycling in polluted coastal and inland waters that are in proximity to large population centres. In hydrosphere, trace metal concentrations are typically orders of magnitude greater in the sediments as compared to those in overlying waters. The capacity of the sediment to concentrate trace levels of most of the metals make them useful

indicators for monitoring purposes and for detecting sources of pollution in the aquatic system. The analysis of sediment cores may provide a historical record of the heavy metal burdens. Determination of elemental concentrations in the aquatic organisms provide information about bio-accumulation and bio-magnification processes. Many organisms including plankton and fish, indeed, act as bio-monitors. Compared to the sediments, marine organisms often exhibit greater ability to accumulate metals from the water column and are hence more useful for identifying the sources of contamination [5].

Extensive studies were carried out in our laboratory, over the years, on the metal pollution in Thane creek which acts as a major sink for various municipal wastes and industrial discharges from the adjoining areas. The industrial wastes not only pollute the creek waters but also pose a threat to the aquatic biota. Three locations in the creek were selected on the basis of effluent discharges and samples of water, sediment and biota collected and analysed. Salient results of these investigations are presented and discussed in this paper.

Thane Creek : A Profile

Thane Creek (TC), which is adjacent to Mumbai harbour bay, lies between latitude (19.5°N-19°N) and longitude (72.5°E-73°E). It is a triangular mass of brackish water which widens out and opens to the Arabian Sea in the South. The creek is narrow at the Northern end, where it is fed partially by river Ulhas. Along the east and west sides of the creek, many industrial units have come up. Thane creek is the ultimate recipient of all the liquid discharges from these industries. The discharges into the creek on its Western side are dominated by Mumbai city sewerage and effluents from the industrial complexes, including the textile mills of South and Central Mumbai, the petrochemical, fertilizer and thermal plants at Chembur and the pharmaceutical and chemical complexes at Vikhroli, Bhandup and Mulund.

The Trans-Thane Creek Industrial Area was developed as a chemical zone by the Maharashtra Industrial Development Corporation. The area houses a number of major, medium and small scale industrial units largely involved in the manufacture, storage and use of chemicals, petrochemicals, pharmaceuticals and fine chemical products, pesticide formulation, etc. Of the 1800 odd industries registered in the area, nearly 50 could be termed as major and the rest classified as small and medium scale. The effluent discharges both treated and untreated are let into the creek.

Results and Discussions

Concentrations of metals in creek water :

Concentrations of toxic and trace metals like As, Ca,

Cd, Cu, Fe, Hg, Li, Mg, Mn, Pb and Zn in creek water from the three locations showed a large variation. The toxic metals like Cd, As, Hg, etc., were found to be in ppb (ng/ml) levels while the metals like Ca, Mg, Fe, etc., were present in ppm ($\mu\text{g/ml}$) range reflecting their origins. In general, the concentrations of metals found in this study were 3-8 times higher than ambient values measured in unpolluted Indian coastal waters (Cu: $1-25 \mu\text{g/l}$, Fe: $2-16 \mu\text{g/l}$, Mn: $1-8 \mu\text{g/l}$) [3]. The distribution of Ca, Cd, Cu, Fe, Mg, Mn and Zn in the water samples from Airoli, Vashi and Trombay sites is shown in Fig. 1. It is evident from the figure that the levels of these metals increase from north to south from Airoli to Trombay. This is due to increased industrial effluent discharges as one moves south from Airoli.

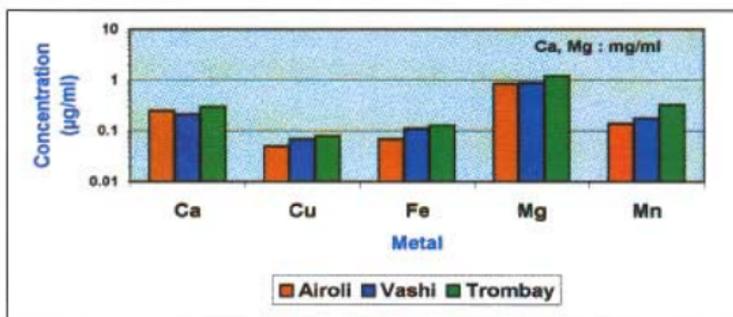


Fig.1a Concentrations of trace metals in sea water in Thane Creek

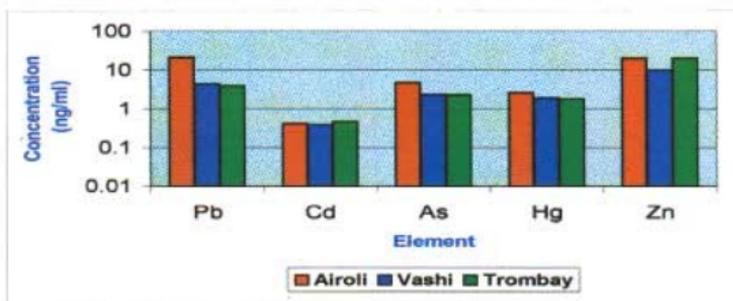


Fig.1b Concentrations of trace metals in sea water in Thane Creek

Concentrations of metals in sediments : Metals are not necessarily fixed by the sediments permanently, but may be recycled via biological and chemical agents both within the sedimentary compartment as well as in the water column. Behaviour of trace metals in the coastal marine sediments is largely related to their capacity for complexation with organic matter in truly dissolved, colloidal, macro particulate phases.

The distribution of metals Ca, Co, Cr, Cu, Fe, Mg, Ni and Pb in sediments at Airoli, Vashi and Trombay sites is shown in Fig. 2. It is seen from the figure that in general these concentrations decrease as one moves south from Airoli to Trombay. The concentration of toxic metals such as Cd, As and Hg in these sediments were similar at the three locations and were in the range of 0.1-0.3, 2-2.3 and 0.8-1.4 $\mu\text{g/g}$, respectively.

Concentrations of metals in suspended solids : Sediments get into the hydrosphere from the atmosphere, rivers and streams, glacial activity and ground water. Within the ocean, and to a lesser extent in lakes, the sediments move with the water, there

being a critical velocity of a water current below which a particle will settle, and above which the particles are transported. At the reduced flow rates and low velocities, suspended particulates settle down and get incorporated into the sediments. The chemical composition of the sediments reflect that of the overlying water column.

The suspended solids concentrations in Thane creek water were also measured at the selected locations. The levels were 13.6, 19.8 and 30.7 mg/l, respectively. In general, the levels of metals in suspended solids were found to be higher at Trombay site than those at Airoli and Vashi which can be attributed to increasing contributions from industrial effluents as one moves from Airoli to Trombay.

Concentrations of metals in biota : The aquatic environment is extremely variable and there are many factors which modify the effect of an element on the biota. The aquatic system near the industrialized areas contain large amount of heavy metals, which have marked ecological significance due to their toxicity, persistence and bio-accumulation.

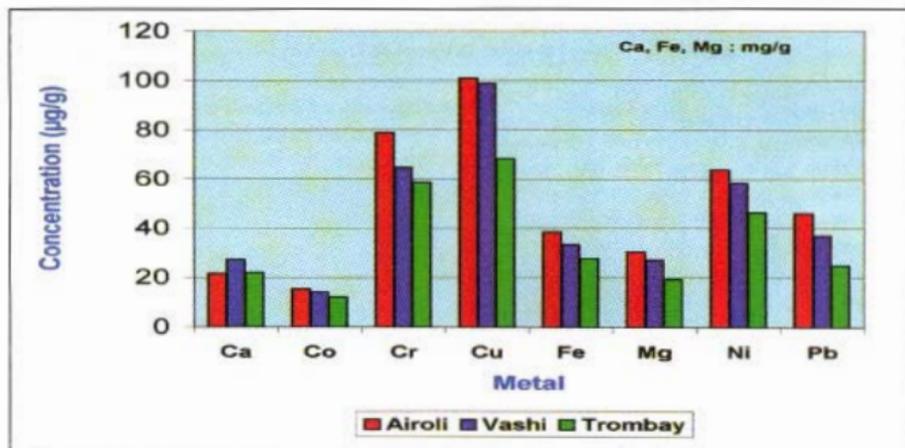


Fig. 2 Concentrations of metals in sediments at different locations in Thane Creek

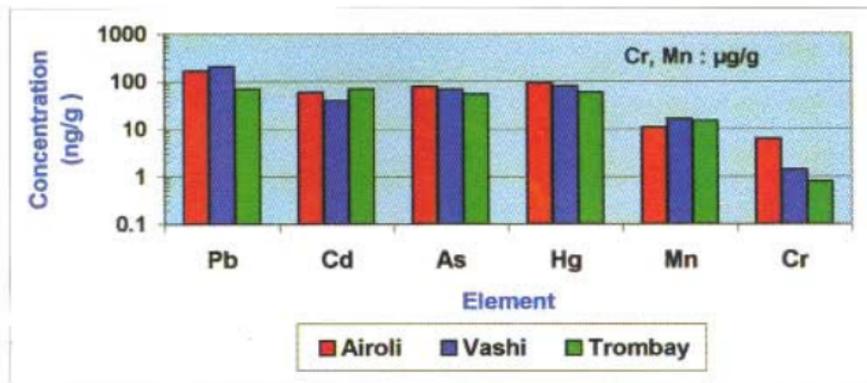


Fig. 3a Levels of toxic metals in fish samples in Thane Creek

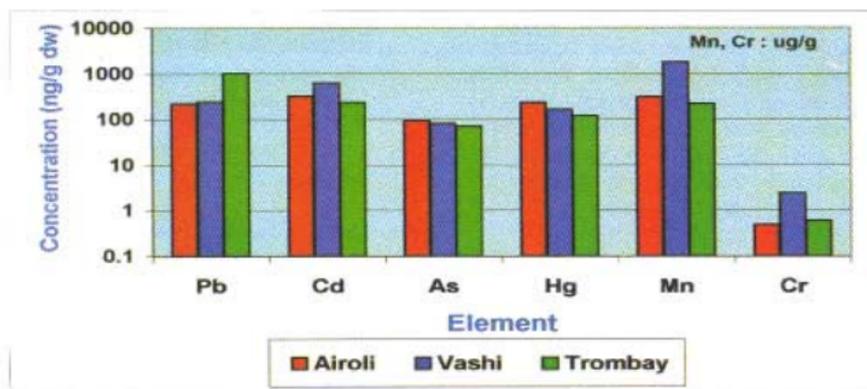


Fig. 3b Levels of toxic metals in crab samples in Thane Creek

Persistence of trace metals in the environment may have possibilities for environmental transformation into more toxic compounds. Any toxic compound accumulates in the biological system only when its rate of uptake exceeds the rate of elimination. The toxic compounds enter into the body of the organism from the surrounding medium and is accumulated in certain tissues by the phenomenon of bio-accumulation. Concentrations of trace metals in biota samples from different locations in Thane creek were estimated. The levels of toxic metals in fish and crab samples are given in Fig. 3a and Fig. 3b, respectively. It is seen that the levels of major metals

Ca and Mg are higher by a few orders of magnitude in comparison to toxic metals such as As, Cd, Cr, Pb and Hg. The levels of toxic metals in crab samples are much higher than those in fish samples.

It is known that cationic elements in general follow co-precipitation with MnO_2 colloids, and anionic elements follow co-precipitation with $Fe(OH)_3$ colloid. A correlation between Co with $Fe(OH)_3$ and Ni with Mn in Mn nodules from deep sea has been established [2]. In Thane creek sediments, Co to Fe ratio varied in the narrow range of $(3.9-4.4) \times 10^{-4}$ where as in fishes the variation was over a much higher range

(180-3200) $\times 10^4$. This shows that some fish species can preferentially concentrate Co as compared to Fe. In our earlier study [4], it was found that upto 95% of total mercury in fishes was associated with organic component (methyl mercury). The higher concentrations of heavy metals in Thane creek area due to liquid effluent discharges from industrial units situated on the shores show a possible organic association and there is, therefore, a need to determine the organic fractions of all these metals in Thane creek waters and marine organisms.

Transfer factor of metals : The 'Transfer Factor' is the ratio of the level of the trace element in the concentrating matrix (e.g. fish) to the concentration in the ambient matrix (e.g. sea water) under equilibrium conditions. The transfer factor is a general term and there are many specific terms used to describe the transfer between two typical matrices. Concentration by physical, chemical and biological processes is represented by a number generally known as 'Concentration factor'. This concentration factor is also a general term whereas other specific terms as bio-accumulation factor (B_p) and distribution coefficient (K_d) for biota and sediments are used.

Distribution coefficient (K_d) : Coastal marine sediments are a major repository as well as potential source of trace metals. Sediments are sinks for many inorganic and organic pollutants transported through the water column from various sources. Due to their particle reactivity, trace metals tend to accumulate in sediments [1], and, as a result, may persist in the environment long after their primary source has been removed. Distribution coefficient is expressed as the ratio of the concentration of an element in the sediment in (g/ kg) dry weight to the concentration of the element in sea water in (g/L) under equilibrium conditions. The distribution coefficients of different metals at different locations in our study area were calculated. A wide range in K_d values were observed for different metals. The K_d values (L/Kg) for major metals like Mg, Ca varied between 16 and 128. Maximum K_d value of 5.5×10^5 was observed for Fe at Airoli site. The K_d values for highly toxic metals like As, Hg, Cd and Li varied between 237 and 952, while the maximum K_d values for the metals of industrial importance like Cu, Mn, Pb and Zn observed at these

locations were 2180, 4500, 8409 and 8000, respectively. The distribution coefficients of industrially important metals are given in Fig. 4. The variation in K_d values of different metals can be attributed to the solubility of the metal in water (less soluble is the metal, higher will be the K_d value) as well as contribution of industrial source at a specific site.

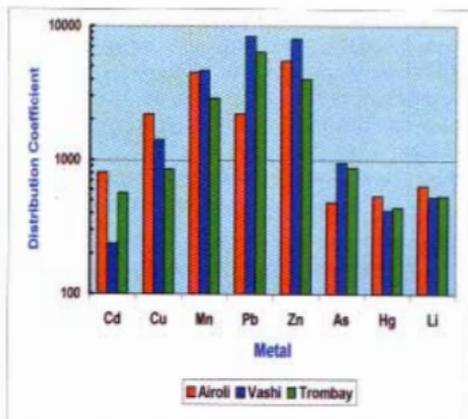


Fig. 4 Distribution coefficient of industrially important elements in sediment at Thane Creek

The mean distribution coefficients (K_d) for sediments in our study area were in the increasing order of 535, 1482, 4015, 5670, 5833, 3.6×10^5 for Cd, Cu, Mn, Pb, Zn and Fe, respectively. The bio-accumulation factors observed for marine organisms in the creek for Pb, Cu, Cd, Fe, Mn and Zn were 67, 387, 557, 1260, 2187 and 4172, respectively. It is clear that Pb is relatively more enriched in sediments compared to that in fishes.

Bio accumulation factor (B_p) : Metal concentration in the sediments does not represent the metal bio-availability. Metals are accumulated in certain organs of various biota. However, not all organisms accumulate metals and not all metal accumulating organisms can serve as bio-monitors because some organisms are capable of maintaining a fixed body regulated trace metal levels irrespective of the sediments. High metal concentrations pose danger to the organisms especially to those living on the sediments and which enter the food chain. B_p is

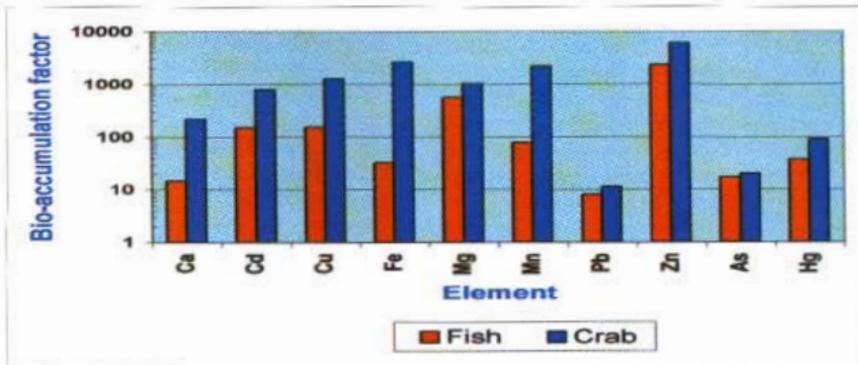


Fig. 5 Bio-accumulation factors of elements in fish and crab at Airoli

Table-1
Correlation Matrix for Metals in Suspended Solids in Trombay Sea Water

| | Ca | Mg | Fe | Co | Zn | Mn | Cu | Cr | Pb | Cd |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
| Ca | 1.00 | | | | | | | | | |
| Mg | 0.94 | 1.00 | | | | | | | | |
| Fe | 0.89 | 0.85 | 1.00 | | | | | | | |
| Co | -0.02 | 0.03 | -0.23 | 1.00 | | | | | | |
| Zn | 0.71 | 0.63 | 0.69 | -0.65 | 1.00 | | | | | |
| Mn | 0.56 | 0.58 | 0.77 | -0.18 | 0.31 | 1.00 | | | | |
| Cu | -0.35 | -0.35 | -0.43 | 0.63 | -0.59 | -0.23 | 1.00 | | | |
| Cr | -0.31 | -0.38 | -0.26 | -0.19 | 0.01 | -0.15 | 0.63 | 1.00 | | |
| Pb | 0.14 | 0.15 | 0.21 | 0.33 | -0.11 | 0.37 | 0.74 | 0.60 | 1.00 | |
| Cd | 0.36 | 0.22 | 0.24 | 0.20 | 0.23 | -0.04 | -0.07 | -0.28 | -0.02 | 1.00 |

expressed as the ratio of concentration of a metal in the organism in (g/kg) wet weight to the concentration of the same in sea water in (g/L) under equilibrium conditions.

The bio-accumulation factors for Ca, Cd, Cu, Fe, Mg, Mn, Pb, Zn, As and Hg for fish and crab were calculated for the three sites and are plotted in Fig.5.

The large variation seen in accumulation factors can be attributed to type of biota, age of biota, local industrial sources and chemical nature of the metal. In general, higher bio-accumulation factors were observed for crab samples for all sites as compared to fish.

Correlation between Metals

Elements which are strongly correlated at a receptor site indicate a likelihood of similar originating sources, size fraction and/or transporting agencies from source to receptor site. The correlation matrices for different trace metals for sediment, water, suspended solids and biota samples were calculated. A typical correlation matrix for suspended solids in water samples for Trombay region is given in Table-1. It is seen that a good correlation exists among major metals, namely, Ca, Mg, Fe, Mn and Zn. A good correlation of Pb with Cu and Cr as well as Cr with Cu indicate the contribution of these metals from industrial sources. In sea water samples from Vashi, a good

correlation among major metals, i.e. Ca, Mg, Fe and Mn, was also observed.

Daily intake of metals through marine food for Mumbai population was calculated. An average daily consumption of 14 g of marine food was taken for this purpose with a wet to dry mass ratio of 3.7. The daily intake of metals from ingestion and inhalation pathways were reported in our earlier studies [6,7,8]. The daily intake of toxic metals like As, Cd, Hg, Mn and Pb through fish worked out to be 0.25, 0.22, 0.42, 52.9 and 0.57 μg , respectively. The contribution of marine component to the total intake of these metals works out to be 2.58, 8.15, 3.36, 2.39 and 1.61 %, respectively which is not significant.

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BARC DEVELOPS DIAPHRAGM-TYPE SELF-SHORTING SHOCK ARRIVAL SENSOR

In shock wave experiments, the velocity of the shock waves is calculated by the time intervals which are obtained from electrical signals generated from self shorting shock arrival sensors mounted at the pre-determined positions. These sensors require the following features for its effective application.

- ◆ Element to precisely sense the shock wave and be able to deform to cause electrical short-circuiting.
- ◆ Precise and controlled gap between the deforming element and fixed element to prevent variations in the measured time-lag.
- ◆ Consistency in the diaphragm and gap thickness to minimize errors.

With these objectives, a few types of self-shortening shock arrival sensors were designed; finally, single central wire, diaphragm type of sensor was qualified for usage and they were manufactured at Central Workshops. Fig.1 shows this single-wire, diaphragm type self-shortening shock arrival sensor.

It consists of a brass tube of 3 mm in diameter with an integral diaphragm of 0.15(\pm 0.005) mm thick at one end and a total length of 30 mm. A centrally fixed copper wire is positioned at a distance of 0.020/0.025 mm from the diaphragm inner face and this wire is isolated from the brass tube by an electrical insulator. The different elements of the sensors were fixed with one another by a suitable adhesive. The process

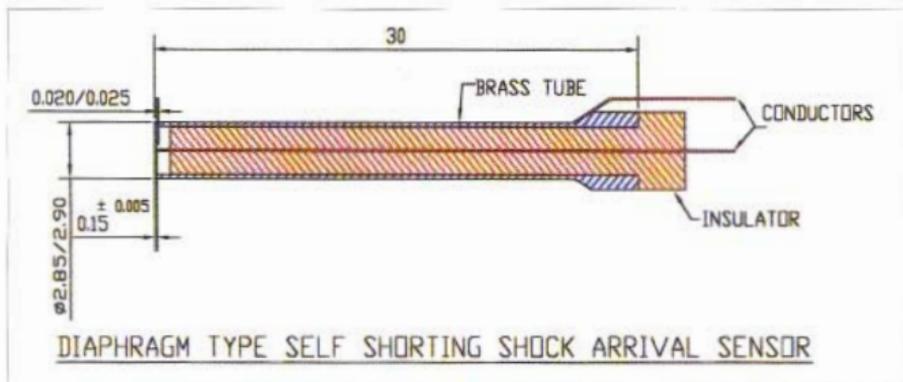


Fig. 1

for machining precise diaphragm thickness at the deeper portion of the brass tube with controlled geometrical and dimensional tolerances, measurement of the same without deforming the diaphragm, maintaining the required geometrical and dimensional features on the central wire, proper fixing/adhesion and assembly of the different elements of the sensor were critical operations to be carried out to obtain the required quality of the self shorting shock arrival sensor. To ensure the gap between the

diaphragm and the wire, radiography was used and proper technique was developed to get reliable radiography result.

Nearly 50 sensors were used for the actual experiments and their performance was found to be satisfactory.

This development ensures the in-house manufacturing capability of self shorting shock arrival sensors.

TRAINING PROGRAMME ON 'APPLICATION OF NEUTRON ACTIVATION ANALYSIS IN FORENSIC ANALYSIS'

A week-long Training Programme on 'Application of Neutron Activation Analysis (NAA) in Forensic Analysis' was organised jointly by the NAA Unit of CFSL, Hyderabad (BPR&D) and Analytical Chemistry Division (ACD), BARC, during February 12-16, 2001.

The objective of the Training Course was to expose the forensic scientists to recent advances in the use of Neutron Activation Analysis for trace elemental characterisation of evidentiary materials, which has proved to be of immense value in forensic investigations. The programme consisted of a series of lectures, hands-on practicals as well as demonstrations in Radiochemical and Instrumental

Neutron Activation Analysis with associated gamma-ray spectrometry. Role of the analytical techniques like Atomic Absorption Spectrophotometry, Anodic Stripping Voltammetry, EDXRF, DCP & ICP-AES, etc, were also covered in the lectures.

The experiments emphasised the applications of NAA to real life case samples of forensic interest, i.e. in the field of Ballistics, Toxicology, Source correspondence to decide commonness of origin or otherwise, Narcotics, White collar crimes, Suspected electrocution cases, Documents, etc.

Fourteen participants from different State and Central Forensic Science Laboratories attended the

programme which was the in-service training course, mainly for the forensic scientists throughout country. Four scientists from BARC also attended the technical lectures and practicals.



Inauguration of the training programme on 'Application of NAA in Forensic Analysis'. (Left to right) Dr N. Chattopadhyay, Deputy Director, NAA unit, CFSL, Hyderabad at ACD (Programme Coordinator); Dr J.P. Mittal, Director, Chemistry & Isotope Group, BARC; Dr P.K. Mathur, Head, Analytical Chemistry Division, BARC; and Dr A.K. Basu, Assistant Director, NAA Unit, CFSL, Hyderabad at ACD.

Dr J.P. Mittal, Director, Chemistry & Isotope Group, BARC, inaugurated the Workshop/Training Programme by stating the objective and utility of the course. He emphasised the potential application of Neutron Activation Analysis (a highly sensitive nuclear technique) in Crime investigation and other areas like food, agriculture, etc.

Dr P.K. Mathur, Head, Analytical Chemistry Division, BARC, formally welcomed the participants who came from different parts of the country to attend the programme. In his Welcome address, Dr Mathur pointed out the importance and relevance of this course for the forensic scientists. He also stressed the objective and utility of the Course.

Dr. N. Chattopadhyay, Deputy Director, NAA Unit of CFSL, Hyderabad, BPR&D, MHA, Govt. of India and Programme Co-ordinator, in his Introductory address, gave a brief account of salient activities of the NAA Unit functioning at ACD, BARC, since its inception. Dr A.K. Basu, Assistant Director, and Dr A.B. R. Tripathi, Junior Scientific Officer, NAA Unit of CFSL, Hyderabad and other personnel of the NAA Unit at ACD were also closely associated with the organization of the Programme. On the final day, i.e.,

16th February, 2001, after group discussion and feedback from the participants, Dr P. K. Mathur, Head, ACD, BARC, presented the certificates to the participants. Dr Mathur, in his Valedictory address, stressed the importance of taking precautionary steps as given in the laid out guidelines and preserving the integrity of valuable exhibit samples while referring cases to the NAA Unit.

Dr. V. K Mehrotra, Director, CFSL, Hyderabad, BPR&D, MHA, Govt. of India, rendered his full administrative and financial support which enabled successful organisation of the meet. Overall, the programme was thought provoking and the lively discussions were highly appreciated by the participants.

CHAIRMAN, ATOMIC ENERGY COMMISSION, FELICITATED



Dr Anil Kakodkar, Chairman, Atomic Energy Commission, is being felicitated by Chief Justice of India at New Delhi

Justice Gopal Singh Charitable Trust organised a special function at New Delhi on February 25, 2001, to felicitate Dr Anil Kakodkar, Chairman, Atomic Energy Commission, for his outstanding accomplishments in the field of nuclear technology. The Hon'ble Chief Justice of India, Dr A.S. Anand, presented a citation and traditional felicitation to Dr Anil Kakodkar.

A TWO-DAY MEET ON 'NUCLEAR MATERIAL ACCOUNTING AND CONTROL AT DAE FACILITIES / PLANTS'

Nuclear Recycle Group and Nuclear Fuels Group of BARC jointly organized a two-day Meet on 'Nuclear Material Accounting and Control at DAE Facilities/Plants' at BARC during February 28-March 1, 2001. Dr Anil Kakodkar, Chairman, Atomic Energy Commission inaugurated the Meet. Mr K. Balu, Director, Nuclear Recycle Group, highlighted the relevance of the Meet and Mr D.S.C. Purushotham, Director, Nuclear Fuels Group, BARC, in his key-note address, presented the methodology of NUMAC and various aspects of accounting practices adopted internationally. Different units of DAE, namely NPCIL, NFC, IGCAR and BARC participated in the Meet.



Dr Anil Kakodkar, Chairman, Atomic Energy Commission, inaugurating the two-day meet on 'Nuclear material accounting and control at DAE facilities/plants'. Seen along with him are (at right) Dr K. Balu, Director, Nuclear Recycle Group, BARC, and (at left) Mr D.S.C. Purushotham, Director, Nuclear Fuels Group, BARC

There were six invited talks and twenty-six technical presentations by eminent speakers and specialists in the field. The proceedings were concluded with the Panel Discussions bringing out the highlights of the two-day discussions and with some recommendations. The meeting was organized by Mr D.D. Bajpai, Head, Fuel Reprocessing Division, BARC, and Dr

V. Venugopal, Head, Fuel Chemistry Division, BARC. Mr N. Varadarajan of Nuclear Recycle Group, BARC, was the Secretary of the Meet.

ORIENTATION COURSE FOR ENGINEERING GRADUATES AND SCIENCE POST GRADUATES (OCES-45)



Dr Anil Kakodkar, Chairman, Atomic Energy Commission, having discussion with Mr V.K. Bhatia and Dr V.K. Manchanda of BARC during his visit to the examination centre at New Delhi.

Like in the past, the written test for the intake of trainees to the 45th batch of the Orientation Course for Engineering Graduates and Science Post Graduates (OCES-45) was held on February 24 and 25, 2001 at 19 centres across the country in twelve different engineering and science disciplines. This year more than 25,000 applications were received and, of this, 20,340 candidates appeared for the written test. This one-year OCES course is the main source of trained manpower for the country's prestigious nuclear programme. The top management of DAE personally monitors the programme and is fully involved in the admission process. Dr Anil Kakodkar, Chairman, Atomic Energy Commission, visited the examination centre at New Delhi.

NATIONAL SCIENCE WEEK CELEBRATIONS

National Science Week was observed from February 26 to March 2, 2001 at BARC and other locations. A Journalists' Workshop on the focal theme 'Information Technology' was organised in the Computer Division at BARC. Mr H.K. Kaura, Head, Computer Division, and his colleagues explained to the journalists and the electronic media the state-of-the-art research and development in computer science and technology at BARC. Achievements of BARC in information technology and related areas were brought to public attention through the Workshop.



Mr H.K. Kaura, Head, Computer Division, BARC, with the journalists.

Coupling the Science Day theme of 'Information Technology' with the theme of the year 'Women Empowerment', a seminar was organised at BARC on 'Information, Communication and Education for the Empowerment for Women'. Dr A.M. Samuel, Director, Bio-Medical Group, BARC, presided over the seminar. Ms Sudha Bhawe delivered the keynote address. The panelists were Ms Sucheta Dalal, Dr K. Malini and Ms Uma Ganesh.

On Science Day, February 28, 2001, Ms Rashmi Rastogi addressed the students of Atomic Energy Junior College (AEJC), on IT during their assembly. Women scientists from BARC, Dr Lalita Dhreshwar, Dr Susan Eapen and Dr Pushpa Rao

interacted with school students at the Nehru Science Centre on Science Day. An 'Atom Quiz' was held in the Nehru Planetarium. Dr Ramola D'Cunha, Dr Hari Kumar and Dr B.S. Tomar participated in 'Meet the Scientists' programme with an active question-answer session with the students.



Dr A.P. Jayaraman speaking at the seminar on 'Information, Communication and Education for the Empowerment for Women'. Seated right to left are : Ms Sudha Bhawe, Ms Uma Ganesh, Dr A.M. Samuel, Dr K. Malini and Ms Sucheta Dalal.

An interactive session on 'What is Science?' was conducted at Modern English High School, Dadar, in collaboration with National Centre for Science Communicators. Dr A.P. Jayaraman and Mr A.P. Deshpande conducted the session. 400 students of AEJC visited BARC during Science Week. On March 28, 2001, an On-the-Spot 'Atom Quiz' contest was conducted at BARC for students of the Cathedral and John Connon School. Mr A.K. Anand gave away the prizes.

A panel discussion on Food Irradiation titled 'Face to Face' was held at BARC. The panelists were Mr Sobale, Sr. Food Inspector, FDA, Dr P.S. Chauhan, Advisor, Heavy Water Board, Dr Madhusudan, BRIT, and Dr A.K. Sharma, FTD. The chairperson was Dr A.M. Samuel. This programme was meant to familiarize the staff of BARC with the advantages of food preservation by radiation and the achievements of this Centre in this field.

SEMINAR ON 'RADIOTRACER AND SEALED SOURCE APPLICATIONS IN INDUSTRIAL TROUBLE- SHOOTING AND PROCESS OPTIMISATION'

Mangalore University and Bhabha Atomic Research Centre had entered into a Memorandum of Understanding on February 21, 1994, which was renewed on February 22, 1999 for 5 more years, to strengthen the programme and laboratory infrastructure needed to undertake new R & D work useful for industrial applications of radioisotopes in the country. One of the important objectives of the MoU is to set up a radioisotope centre in Mangalore University.

Mr Gursharan Singh, Head, Isotope Applications Division, BARC, was the course convener, and Dr. H. M. Somasekhara, Head, University Science Instrumentation Centre, was the course secretary.

Dr. N. Ramamoorthy, Chief Executive, BRIT and Associate Director, Isotope Group, BARC, was the Chief Guest of the function.

Prof. S. Gopal, Vice Chancellor, Mangalore University, presided over the function.

More than 80 participants from the following industries/companies/institutions attended.

1. Mangalore Refinery & Petrochemical Ltd.
2. Mangalore Chemicals & Fertilizers Ltd.
3. Kudremukh Iron Ore Company Ltd.
4. New Mangalore Port Trust
5. BASF India Ltd.
6. Chemical Process Industries
7. Radiography Testing Companies
8. Karnataka Regional Engineering College
9. Teaching staff and research fellows from the post graduate departments of Mangalore University and others

After the seminar, an expert group meeting was held for follow up action.

Based on the discussions in the seminar and suggestions from the participants during the panel discussion, various collaborative programmes between Mangalore University and BARC are envisaged.



Inauguration function of the seminar. (From left to right) : Dr H.M. Somasekhara, Prof. S. Gopal, Dr N. Ramamoorthy and Mr Gursharan Singh

A one-day seminar on 'Radiotracer and Sealed Source Applications in Industrial Troubleshooting and Process Optimisation' was jointly organised by University Science Instrumentation Centre, Mangalore University; BARC, Mumbai; Board of Research in Nuclear Sciences; and Department of Atomic Energy on January 25, 2001 at Mangalore University, Mangalore, to interact and get the feedback from the user industries about their requirements.

BARC CONDUCTS 'ATOM QUIZ' AT KOCHI

BARC conducted an 'Atom Quiz' at Kochi on January 6, 2001 in collaboration with Labour India at their Mega Quiz 2001. Fourteen 10th standard students representing fourteen educational districts of Kerala state, having won at the district level, participated in the finals. The quiz programme was conducted by



Dr Y.S. Rajan inaugurates the Mega Quiz 2001 programme. On the dais (left to right) are Dr A.P. Jayaraman, BARC, Dr Sebastian Paul, MLA, Prof. S. Sivadas and Mr Santosh George Kulangara

Dr A.P. Jayaraman, Head, Media Relations Section of Library & Information Services Division, BARC, with audio, video and transparencies.

The Mega Quiz programme was inaugurated by Dr Y.S. Rajan, Scientific Secretary to the Principal Scientific Secretary, Government of India. The top three positions in Atom Quiz were won by (first) S. Chandrashekhar, Thiruvananthapuram District, (second) Meera Annam Baby, Ergakulam District, (third) Gayathri R. Pathanamthitta District. Dr Y.S. Rajan gave away the prizes to the winners.

BARC SCIENTISTS HONOURED



- Dr Jai Pal Mittal, distinguished Scientist and the Director of Chemistry & Isotope Group, BARC, has been elected into the Fellowship of the Third World

Academy of Sciences (TWAS) in recognition of his outstanding contribution to Science and its development in the Third World.

TWAS is a non-governmental, non-political and non-profit making organization established in 1983 as an International forum uniting distinguished scientists from the South for the purpose of promoting

scientific capacity and excellence for sustainable development in the South.

Some of the other distinguished Fellows of the TWAS are Dr R. Chidambaram, Prof. C.N.R. Rao, Prof. Sukh Dev, Prof. M.G.K. Menon, Prof. M.M. Sharma; Prof. Yuan T. Lee (Taiwan); Prof. Ahmed H. Zewail and Prof. Mostafal El Sayed (Egypt).

- Dr (Ms) Anu Kamat of Food Technology Division,



BARC, was awarded the 3rd prize for the Best Poster Paper Presentation in the First International Conference on "Global Sustainable Biotech Congress 2000 A.D.", held at Nagpur University, Nagpur, during November 26, 2000-December 1, 2000. The Award was for the paper, "Detection of *Listeria monocytogenes* in food products by DNA probe" by Dr A. Kamat, Dr K.K. Ussuf and Dr D.R. Bongirwar.

- Dr Arun Kumar Pati of Theoretical Physics



Division, BARC, was conferred the title of Honorary Research Fellow by the Senate of the University of Wales in the School of Information, Bangor, UK. He has also been

selected as an Associate of Center for Philosophy and Foundations of Science (CPFS), New Delhi. Dr Pati has been working in the frontier areas of physics such as Geometric Phases, Quantum Mechanics & Quantum Computation and Information Theory. He was a member of Isaac Newton Institute of Mathematical Science, Cambridge, UK and a member of UK Quantum Computing Network. He has received "Young Physicist" award in the year 1996 from Indian Physical Society (IPS), Calcutta, for his original contribution to the theory of Geometric Phases. He has also been elected as an Associate of Indian Academy of Science (IAS), Bangalore, for the year 1998-2001.

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