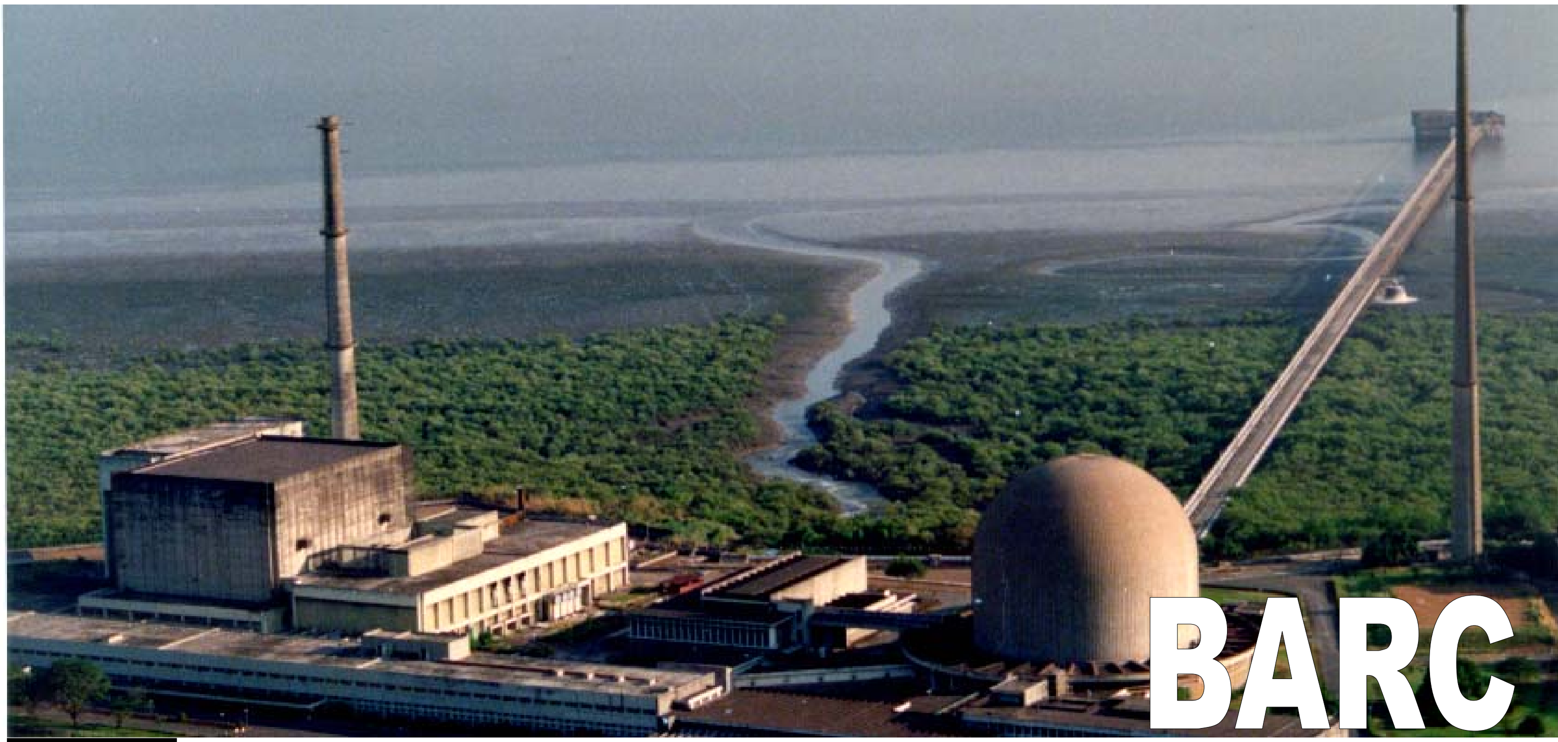

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Contents

BETTER COUNTER-MEASURES FOR CURTAILING WHOLE BODY RETENTION OF RADIOSTRONTIUM

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Introduction

Accidents are always sudden. They happen despite considerable developments in the safety techniques/warning systems, affecting not only the workers directly involved, but also the people around. This is evident from the reported article on the 15th anniversary of the Chernobyl nuclear accident, entitled: "*15 years on, Chernobyl survivors relive the nightmare*" by Philippe Coumarianos (Times of India, April 26, 2001). Herein, the author reports, that an estimated 15,000 to 30,000 people have died as a result of the nuclear explosion, which spewed radiation into the atmosphere equivalent to 500 times that of the atomic bomb dropped on Hiroshima in 1945. This is in direct contrast with the official figure that total fatal cases were only 29 workers.

Due to wide news coverage, public awareness of accidents involving radiation sources has increased. This has become a matter of great public concern because,

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unlike the other accidents, the impact of the nuclear fallout persists in the future for a long time to come. Besides, the scare of the dirty bomb from the terrorists' attack, has further aggravated the psyche of the public.

Radiological impacts in the event of any nuclear accident are mainly ascribed to the exposure to volatile radionuclides, mainly Radioiodine (*I) and Radiocesium (*Cs), which could be effectively transported through the atmosphere to the “far–field”, besides, causing immediate radiation hazard to the inhabitants in the “near–field” region. Radio-Strontium (*Sr) is another radio-nuclide, which also needs attention because of it's long $T_{1/2}$ of 28.5y (^{90}Sr) besides it's specific localization in bone. It can damage our bone-marrow, once it enters our body[1]. Apart from ^{239}Pu, which is basically fixed to the soil and has shown no significant transfer to man after the Chernobyl nuclear accident, only ^{137}Cs and ^{90}Sr have deposited on the ground and entered the biological cycle. Besides radioiodine induced damage to the thyroid gland in the early stages after the nuclear accident, these isotopes pose dominant radio-biological threat due to their getting recycled through plant–animal–human food chain.

*Sr is also formed in large quantities in the cores of nuclear reactors along with radioiodine and other radionuclides, which may be released in the atmosphere in the event of nuclear accidents. They are also inevitably released during nuclear weapons testing. Seventeen out of the total of twenty one isotopes of Sr are radioactive with their $T_{1/2}$ ranging from 200ms (^{97}Sr) to 28.5y (^{90}Sr). Because of it's biochemical similarity to Calcium (Ca), *Sr is avidly concentrated by the bone. Stable strontium can become an ideal choice for the reduction of *Sr–burden, but strontium compounds are known to be toxic[2]. It is therefore necessary to have some suitable counter–measure, which could prevent it's uptake by bone and also increase the excretion of *Sr from the body.

We have recently reported the development of a new in-house synthesized Calcium Based Compound (CBC)[3], which is twice as effective as Prussian Blue, a normally recommended agent, in enhancing the clearance of *Cs from *in vivo* system. The present study is our modest attempt in examining the effect of more convenient and effective agent/s compared to Calcium alginate, normally recommended for the decorporation of *Sr from our *in vivo* milieu[4].

Ca, which is the major component of bone and similar to Sr in it's biochemical properties, is the logical test element to be examined in this regard. Ca salts are more physiological and used regularly as dietary and pharmaceutical supplements in humans. We have therefore, examined the influence of some commonly used Ca salts for their comparison with Ca-alginate (CaA), after the administration of ^{85}Sr, either intra-peritoneally (*Sr–i.p.) or orally (*Sr–oral) to rats. This study with a two-fold purpose was, therefore, undertaken to assess:

(i) the efficacy of four common Ca salts: Ca-gluconate (CaG), Ca-lactate (CaL), Ca-Carbonate (CaC) and Ca-phosphate (CaP); in reducing the uptake of *Sr after it's entry *in vivo* milieu and
(ii) to ascertain the most suitable compound which could serve as a better substitute to CaA for decorporation of *Sr from *in vivo* system, besides examining the difference, if any, in the clearance of *Sr, administered either intra-peritoneally (i.p.) or orally.

Protocol

Age and weight matched Wistar rats (350 – 370g)*, housed individually, were divided into two groups. One group was administered ^{85}Sr, intra-peritoneally (*Sr–i.p) and the other group was given ^{85}Sr, orally (*Sr–oral). The *Sr–i.p. group was divided into five sub-groups with 5–6 rats in each. One sub-group served as control while other four sub-groups were experimental. Similarly, the *Sr–oral group was divided into control and four experimental sub-groups, as described below:

**Sr –i.p. Group (Intra-peritoneal administration of *Sr)*

Animals in this study group were administered intra-peritoneally, a single dose of *Sr (~40 KBq/rat - *Sr as $^{85}Sr(NO_3)_2$ – specific activity 12.29 mCi/g (92.13 MBq/g), obtained from Board of Radio-Isotope Technology, Turbhe Complex, Vashi, Navi Mumbai. They were then treated individually, except in the control group, with different Ca salts (equivalent to 9mg/mL/rat/d of elemental Ca), initially 2h post *Sr – injection and then once daily. All the Ca-salts except CaG, were administered orally as their suspensions because of their insolubility in water.

**Sr – Oral Group (Oral administration of *Sr)*

A single dose of *Sr (~40 KBq/rat) was administered orally to the rats in this study group. The animals from each sub-group, except the control group, received oral suspensions of three different Ca salts (CaG, CaL & CaP; elemental Ca = 9mg/rat/d) as mentioned above, initially, 2h after the oral administration of *Sr and then once daily. The control group was given glucose saline, orally, as placebo. For comparison, another sub-group of rats was given a suspension of CaA (Ca = 9mg/rat/d), 2h after the oral administration of *Sr, as a mixture of sodium alginate and Ca-Phosphate, normally used for the inhibition of ingested *Sr from gastro-intestinal system. This protocol of treatment was continued for the entire study period.

All the animals in both the i.p. and oral groups, except their control sub-groups, were also fed their respective Ca rich diets, containing 2% elemental Ca in the form of either CaG, CaL, CaC or CaP and also CaA. Control rats were fed the normal colony diet containing 0.4% Ca. All the rats, housed individually in separate cages, were fed their respective diets and water *ad lib* for 15 days.

Whole body retention (WBR) of *Sr in each rat was measured once daily in a specially designed Gamma counter [2] by placing the mildly anaesthetized animals in the well of the counter. This practice was followed for the entire study period of 15 days.

The organ bio-distribution of i.p. and orally administered *Sr (40 KBq/rat), to the rats, was initially studied at different time intervals by the same method as mentioned above.

Results

There is a significant variation, seen in the bio-distribution of *Sr (as percent administered dose) in the different tissues of rats after it's administration via i.p. and oral routes (Tables 1 and 2).

Table 1: Biodistribution of radiostrontium (*i.p.* administration)*

Time (h) Organs	5min	30min	1hr	2hr	3hr	4hr	6hr	24hr
Blood	8.7±0.1	5.3±0.1	3.9±0.1	4.1±0.2	1.7±0.2	1.9±0.3	0.9±o.1	0.6±0.2
Muscle	26.1±1	32.3±1	19.9±2	17.7±0.8	8.3±1	7.5±2	8.5±3	5.1±2
Bone	10.5±2	15.5±3	30.4±4	33.2±5	46.4±4	58±6	53.8±5	37.3±3
Liv&Gut	5.6±2	7.9±1	10.1±3	11.7±4	6.2±3	4.6±3	3.6±2	2.4±1
Excreta	4.9±3	0.9±0.5	2.8±2	1.7 ±0.5	1.1±0.45	1.4±0.2	1.9±0.5	15.2±5
Carcass	44.3±6	38±5	33±3	37.5±4	36.4±2	26.6±2	31.3±6	39.4±9

** Results are Mean ± SD (5-6 animals per time interval), as percent administrated dose.*

Table 2: Biodistribution of radiostrontium (oral administration)*

Time (h) / Organs	0.25	0.5	1	2	4	6	8	16	24	48	72	96	120	144
Blood	0.50 ±0.1	0.50 ±0.2	0.70 ±0.3	0.50 ±0.1	0.50 ±0.1	0.40 ±0.10	0.40 ±0.10	0.15 ±0.10	0.3 ±0.10	0.07 ±0.10	0.10 ±0.10	0.09 ±0.10	0.07 ±0.10	0.10 ±0.10
Muscle	2.20 ±1.0	2.7 ±0.8	4.90 ±0.9	2.80 ±0.4	3.10 ±0.5	3.60 ±0.1	3.50 ±0.9	1.90 ±0.70	2.80 ±0.30	0.70 ±0.10	1.10 ±0.20	0.70 ±0.10	0.60 ±0.1	0.80 ±0.10
Bone	2.40 ±0.6	5.80 ±0.3	14.0 ±1.2	19.0 ±1.2	34.0 ±3.2	47.0 ±1.2	46.0 ±2.5	66.0 ±2.7	65.0 ±6.2	54.0 ±4.2	62.0 ±3.6	65.0 ±4.0	61.0 ±4.2	59.0 ±3.7
Liver	0.70 ±0.1	0.30 ±0.1	0.40 ±0.1	0.30 ±0.09	0.20 ±0.1	0.20 ±0.04	0.30 ±0.05	0.08 ±0.01	0.1 ±0.02	0.07 ±0.02	0.07 ±0.02	0.05 ±0.1	0.05 ±0.01	0.05 ±0.01
Gut	94.5 ±2.2	88.0 ±3.5	80.0 ±2.4	76.0 ±1.8	60.0 ±3.2	47.0 ±1.2	47.0 ±5.2	4.30 ±1.4	3.00 ±1.1	3.30 ±1.5	2.00 ±1.3	1.80 ±0.80	0.6 ±0.3	0.5 ±0.02
Excreta	0.20 ±0.1	0.5 ±0.2	0.7 ±0.2	0.8 ±0.25	2.1 ±0.1	2.0 ±0.40	3.5 ±2.40	28.3 ±3.40	25.2 ±3.60	43.5 ±3.60	34.3 ±4.10	34.3 ±4.10	38.3 ±4.8	40.4 ±3.80

* Results are Mean ± SD (5-6 animals per time interval), as percent administrated dose.

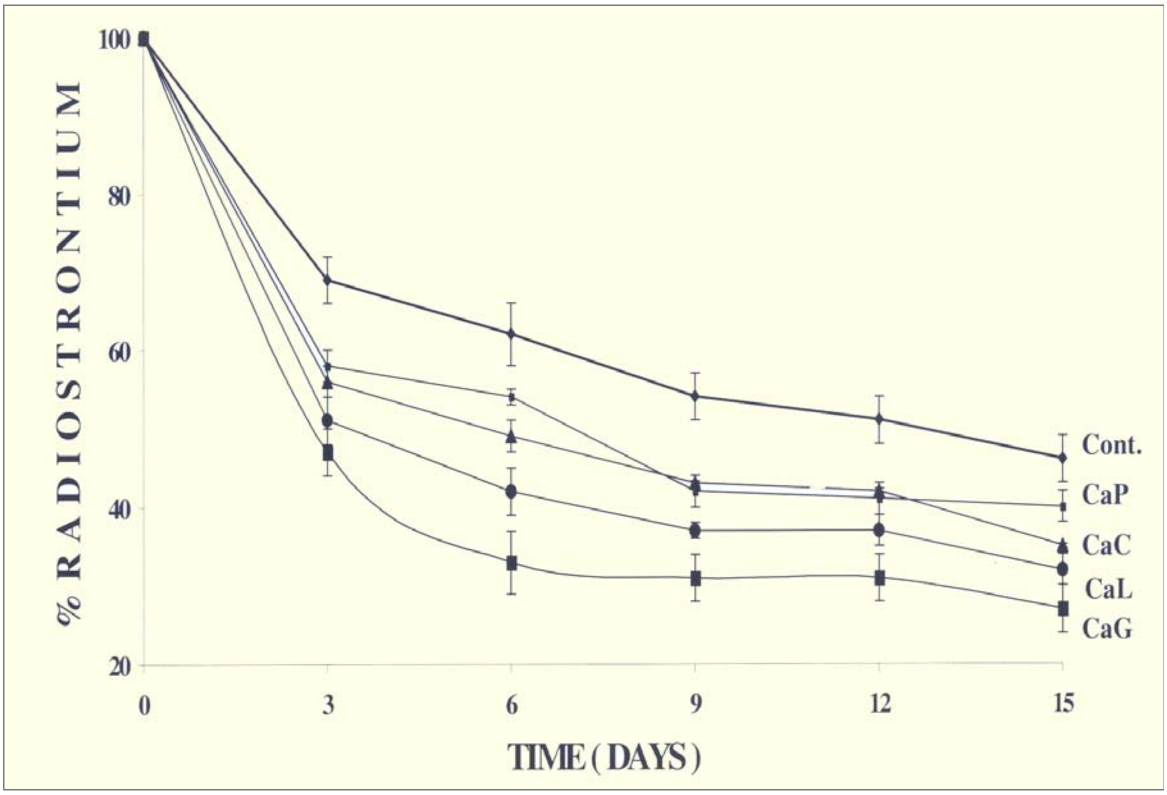

Fig. 1: Whole body retention of radiostrontium (i.p.)

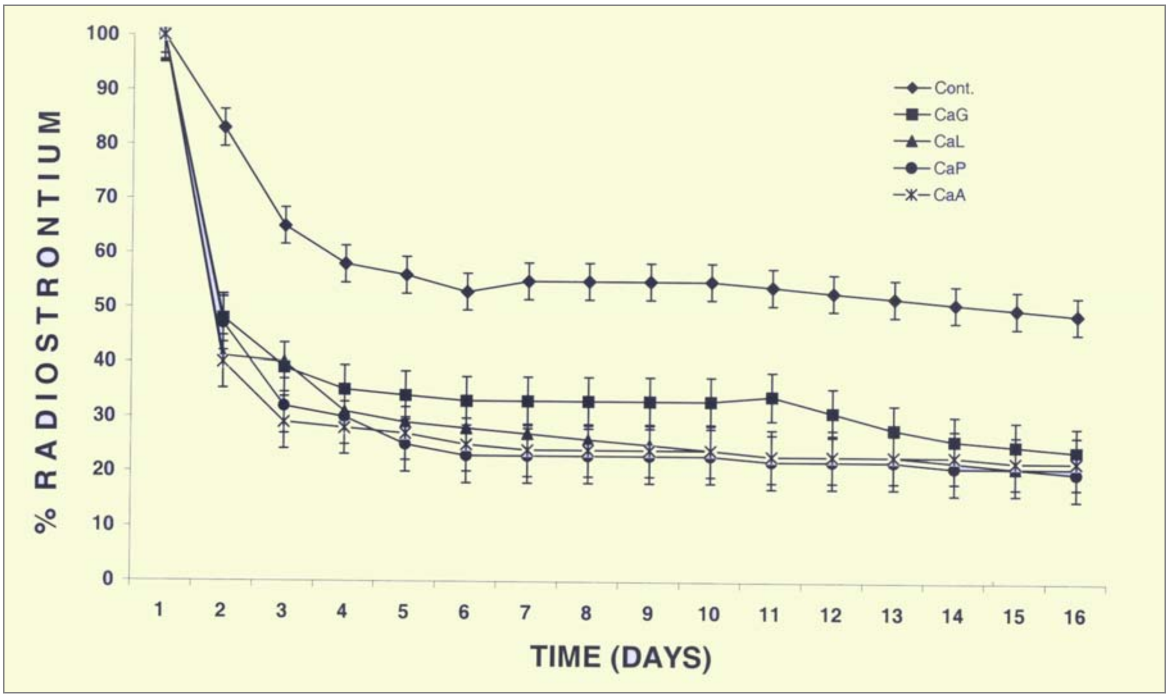

Fig. 2: Whole body retention of radiostrontium (oral)

It is noted that *Sr, when administered i.p., is immediately picked up by bone (10% at 5min.), reaching maximum (~58%) at 4–6h, while major proportion of orally administered *Sr is found in the gastro-intestinal lumen and reaches it's peak at ~16–24h in the bone. Variation is also noted in the reduction of *in vivo* uptake of *Sr by the Ca salts in both the groups of animals, particularly at 24–48h after *Sr–administration, though, WBR of *Sr does not change significantly in the control group of rats in both oral and i.p.–administered rats, as shown in Figs. 1 & 2.

It is noted that all the Ca salts and CaA, are equally effective in reducing the WBR of *Sr to ~50% at 24h in animals administered *Sr orally (Fig. 2). However, CaG, being available in an injectable form, and administered i.p., showed better efficacy than other Ca salts in curtailing *Sr–retention in animals given *Sr via i.p. route (Fig. 2). Figs. 1 & 2 also show that WBR of *Sr remains at ~20–30%, in both i.p. and oral groups of experimental animals compared to ~50% in control animals, in spite of the continuous treatment with Ca salts for 15days (Figs.1and 2).

Discussion

The radioactive isotopes of Strontium have always been a major concern in radiation protection. The Chernobyl accident contributed ~220,000Ci of ^{90}Sr to the environment [5] and one of the main radionuclides released from Mayak (one of the main Russian nuclear weapons facilities) into the Techa River, also happens to be ^{90}Sr (>26,000Ci between 1949 and 1995 [6]). In fact Tolstykh *et al*[7] (1998) reported concentrations of ^{90}Sr in six stillborn human fetuses and their mothers for whom the period of maximum concentration due to consumption of Techa river water occured at different times before pregnancy. It was noted that intrauterine death of two of the fetuses occured between 6–8 months after conception and the third suffered bone marrow disease, suggesting that, concentration ratios at term would have been greater, possibly by factors of 2–3. Currently, a research programme has been organized by the Joint Coordinating Committee for Radiation Research (JCCRER), with the aim of studying the relationship between health effects and chronic low dose and low dose-rate exposures to radiation in the population there [8].

*Sr once absorbed in the *in vivo* system, gets picked up by the bone and is retained there for a long time resulting in the irradiation of bone structures. The bone marrow is known to be a very radio-sensitive tissue exceeded only by the breast tissue [9-11]. In fact *Sr–induced osteosarcoma in animals [12] and the risk of leukemia in humans have also been reported earlier (NCRP Report No. 110, 1991).

The removal of the fixed *Sr from bone would be quite slow. Hence it's chronic irradiation could damage bone marrow and could be very harmful particularly for children. This is supported by the evidence that the radiation dose due to *Sr in bone to active bone marrow and to endosteal cells per unit concentration (Bq ^{90}Sr/g Ca or Bq/g tissue) varies with age. It may be higher for the new born than for the adult human by about 25% because the marrow spaces are smaller in infants and children. This factor gets reduced as the marrow spaces approach adult size [13].

*Sr, particularly ^{90}Sr, with it's long physical half-life of 28.5y and it's long effective $T_{1/2}$ of ~15y, poses great danger once it is released in the environment [2]. It emits a beta particle of fairly low average energy (0.54 MeV) and is accompanied by it's decay product, Yttrium-90 ($T_{1/2}$ ~2.67d) of much higher β–energy of 2.25 MeV & γ–energy of 2.186 MeV. It is therefore necessary to have some effective and convenient counter measure, which can be easily administered for preventing it's uptake by bone.

Treatment with stable Sr would be an ideal choice for reducing the WBR of *Sr, but Sr compounds themselves are quite toxic, hence they cannot be used in clearing skeletal *Sr. Besides alginates which are normally recommended to retard *Sr–uptake, several other compounds have also been tried to enhance the clearance of *Sr from *in vivo* milieu. Sodium alginate or commonly used CaA, a salt of alginic acid, is a jelly-like substance obtained from brown sea algae known as Kelp. Though it is effective in inhibiting *Sr–absorption from the intestine, it's highly viscous nature makes it difficult to administer. Also, it is unpalatable and is given as a single dose of 10–20g, mixed with syrup.

Ca, besides being a congener of Sr, is also an important and major component of skeleton; hence, Ca compounds have been considered to be a better choice in curtailing *Sr-uptake. This has been demonstrated by the present study, in which we have examined the influence of commonly used Ca compounds, which are easy to administer and do not cause any untoward effect on our metabolism, even if taken at the higher dose level of 2–3g/d whenever necessary. In fact, extra intake of Ca has been recommended to be beneficial particularly in young and elderly people.

There is a significant drop in the WBR of *Sr in both, *Sr–i.p. and *Sr–oral sub-groups of experimental animals, treated with Ca–salts compared to that in control animals. *Sr, whether administered i.p. or orally, seems to distribute similarly in the *in vivo* milieu, except in the initial stages of it's oral administration, when an appreciable amount of *Sr is still present in the gastro-intestinal tract (Tables 1 and 2) and takes more time to reach it's peak in the bone (16–24h) compared to that in *Sr–i.p. group (4–6h). This gives a good margin of time for instituting the administration of Ca salts in the event of an accidental release of *Sr.

WBR of *Sr is also at higher range at 24–48h in the *Sr–i.p. group of animals. CaG was found to be the most effective in *Sr – decorporation in this group, perhaps, the i.p. administration led to it's better bio-availability as compared to the other Ca salts (CaL, CaP and CaC), which were given as oral suspensions, because of their insolubility. However, all three Ca salts are seen to be equipotent in decreasing WBR of *Sr in the animals which were administered *Sr via oral route. This is also quite comparable to that noted in the rats treated with CaA as depicted graphically in Fig. 2. It is worth noting here, that there still exists ~20–30% of *Sr in both i.p. and oral groups of experimental animals compared to ~50% in control animals, remaining fixed in spite of the continuous treatment with Ca-salts for 15 days. It was further noted that *Sr activity was found to be present in the bone only and none of the other tissues were found to contain any significant amount of *Sr activity after 15 days of it's administration.

The results of the present study provide clear evidence that any of the Ca salts studied is as effective as CaA in curtailing the WBR of *Sr, entering *in vivo* system via oral route and could therefore be conveniently used instead of CaA. Besides, Ca salts are physiologically more acceptable and can be easily administered in the form of tablet, syrup or suspension, compared to the difficulty encountered in administering alginates because of their highly viscous and unpalatable nature. It is therefore strongly felt that these common Ca salts which can be stored for a longer time in the tablet form without any loss of their potency can very well replace CaA. CaG, which is also available in the form of an injectable solution, could be administered intravenously in relieving acute radiotoxicity, for rapid clearance of *Sr.

Conclusions and Comments

1. Since the pharmacokinetics of *Sr is essentially comparable in both rats and humans as far as it's uptake by the *in vivo* system is concerned, this study could very well serve as a useful guideline for the decorporation-therapy in the event of any accidental release of *Sr.
2. Physiologically acceptable Ca salts have been demonstrated to be as effective as Ca-Alginate, normally recommended in curtailing WBR of *Sr[2].

References

1. A. Nilsson (1962). Histogenesis of ^{90}Sr-induced osteosarcomas. Acta Vet. Scand. 3, 185.
2. V. S. Jagtap, V.R. Sonawane, D.N. Pahuja *et al.* (2003). An effective and better strategy for reducing body burden of radiostrontium. J. Radiol. Prot. 23: 317 – 326.
3. D.N. Pahuja, *et al.* (2001). Development of new interventional strategies for possible replacement of Prussian Blue in curtailing the whole body retention of radio-cesium in the event of it's release. BARC Newsletter, No: 209, 1-9.
4. N. A. Beresford, R.W. Mayes, P. J. Maceachern, B.A. Dodd, C.S. Lamb (1999). “The effectiveness of alginate to reduce the transfer of radio-strontium to the milk of dairy goats,” J. Envior. Radioactivity 44, 43.
5. Y.P. Buzulukov, Y.L. Dobrynin. Release of radionuclides during the Chernobyl accident. In: Merwin SE, Balonov MI eds. The Chernobyl papers. Doses to the Soviet population and early health effects studies. Richland, WA: Research Enterprises; 1993: 3–21.
6. Y. Mokrov, Y. Glagolenko, B. Napier (2000). Reduction of the radionuclide contamination of the Techa River caused by liquid waste discharge from radiochemical production at the Mayak Production Association. Health Phys.79: 15–23.
7. E.L. Tolstykh, M.O. Degteva, V.P. Kozheurov, V.P. Kozheurov, D.S Burmistrov (1998). Strontium transfer to the fetus from maternal skeleton estimated on the basis of the Techa river data. Radiat. Prot. Dosim. 79: 307–310.
8. J.S. Puskin, C.B. Nelson (1995). Estimates of radiogenic cancer risks. Health Phys 69: 93–101.
9. P. Seligman (2000). The U.S–Russian Radiation Health Effects Research Programme in the Southern Urals. Health Phys. 79(1): 3–8.

10. A.I. Apostoaei, F.O. Hoffman, J.S. Hammonds (1998). Organ–specific risk coefficients for estimating excess lifetime risk of cancer incidence. Presented at the 43rd annual Meeting of the Health Physics Society, July 12–16, 1998; Minneapolis, Minnesota. Health Phy. 74 (Suppl.): S16.

11. C. Land, E. Gilbert, F.O. Hoffman, A.I. Apostoaei, B. Thomas (2000). Draft Report of the NCI-CDC Working Group to revise the 1985 NIH Radioepidemiological Tables. Bethesda, MD: National Cancer Institute, Radiation Epidemiology Branch; 2000.

12. A.H. Beddoe, F.W. Spiers (1979). A comparative study of the dosimetry of bone–seeking radionuclides in man, Rhesus monkey, beagle and miniature pig. Radiat Res. 80: 423–439.

13. F.W. Spiers, J.R. Whitwell. Theoretical comparisons of dosages from ^{90}Sr and ^{226}Ra in human and beagle bone. Paper 40. In: Lenihan JMA. Report No. CONF. 720818. Western Regional Hospital, Glasgow, Scotland; 1972.

MEMBRANE PROCESSES IN NUCLEAR INDUSTRY

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Membranes are synthetic barriers across which selective permeation of the desired species can be effected by synergizing the physico-chemical characteristics of the membrane surface and the driving force. Every phase of Nuclear Fuel Cycle requires concentration or selective separation involving aqueous systems. At present, these separations are carried out using chemical methods and ion exchange processes. A variety of membrane processes have been developed in the last two decades (as shown in Table-1) whence, one can choose the appropriate system depending on the stream and desired separation.

In this first part of the article we deal with only reverse osmosis, a workhorse in the desalination of brackish and sea water. At the same time it has shown good potential in the concentration of low level radioactive effluents.

Pressure Driven Membrane Processes

Among the membrane processes, the pressure driven ones have been used extensively because of

1. Ambient temperature operability
2. Suitability for high volume operations
3. Lower levels of energy consumption (as no phase change is involved)
4. Ability to support or replace some of the conventional energy intensive operations such as distillation, solvent extraction etc.

Starting from the front end of the nuclear fuel cycle i.e. mining stage to the back end, where, radioactive wastes are processed for safe disposal, membrane processes have indicated good potential. With advancing membrane development technologies, tailor-making membranes to suit a particular separation is becoming a reality. This article focuses only on some of the applications, which have already been demonstrated in the nuclear industry.

Reverse osmosis (RO)

Reverse osmosis is the most exploited membrane operation and is extensively used in brackish and sea water desalination and water recovery and recycling from effluents. In reverse osmosis as shown in Fig.1, the feed water is pressurized (higher than osmotic pressure)

Table 1: Membrane processes and their characteristics

Process	Type of membranes	Average poresize	Separation Mechanism	Driving force	Technology status
Reverse Osmosis (RO)	*TFCP / **CAB / ***CTA	5 - 10 A	Preferential sorption - capillary flow	Net applied pressure in excess over the osmotic pressure	Commercial
Nano-filtration (NF)	TFCP	10 - 30 A	Preferential sorption - capillary flow	Net applied pressure in excess over the osmotic pressure	Commercial
Ultra-filtration (UF)	Composite	30 - 100 A	Mainly sieve	Net pressure	Commercial
Micro-filtration (MF)	Composite	Above 100 A	Mainly sieve	Net pressure	Commercial
Electro-dialysis (ED)	Composite	Nonporous	Electrically driven	Applied EMF	Commercial
Diffusion Dialysis	Composite	Nonporous	Diffusion	Concentration gradient	Commercial
Osmosis	TFCP / CAB	5 - 100 A depending on system requirement	Diffusion	Concentration gradient	Bench scale
Liquid membranes	Selective liquid barrier	NA	Diffusion	Concentration gradient	Pilot scale trials
Bipolar Electrolysis	Composite	Nonporous	Electrically driven	Applied EMF	Pilot scale trials

** TFCP : Thin Film Composite Polyamide ** CAB : Cellulose Acetate Blend *** CTA : Cellulose Triacetate*

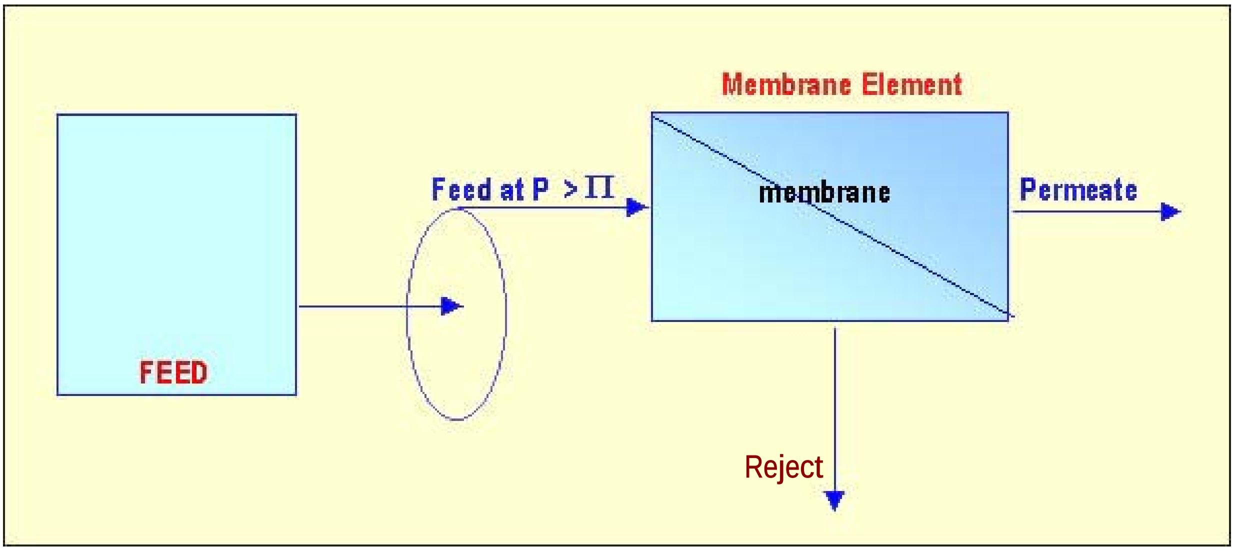


Fig.1: Principle of Reverse Osmosis

and forced through the membrane. Relatively pure water permeates through the membrane while a concentrated solution leaves as reject. This process is extensively used for the desalination of sea water / brackish water.

Reverse osmosis separation is essentially controlled by the surface of the membrane and hence the feed solution requires conditioning, to minimize damage to the membrane material as well as membrane surface, with respect to physical, chemical and bio-contaminants. A variety of membranes are available for reverse osmosis applications based on both cellulose acetate (CA) and thin film composite polyamides (TFCP) in about four main configurations as shown in Fig.2.

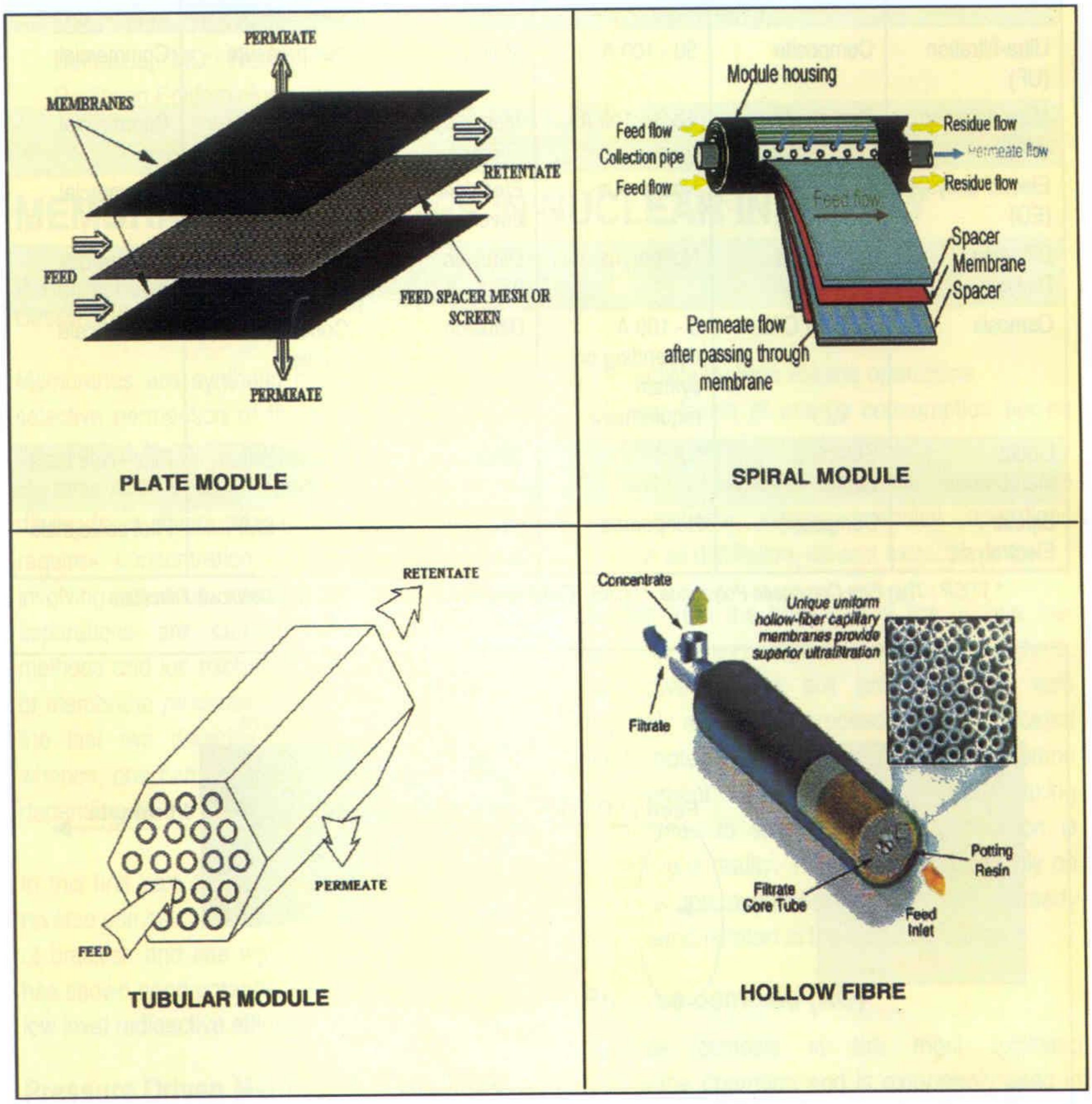


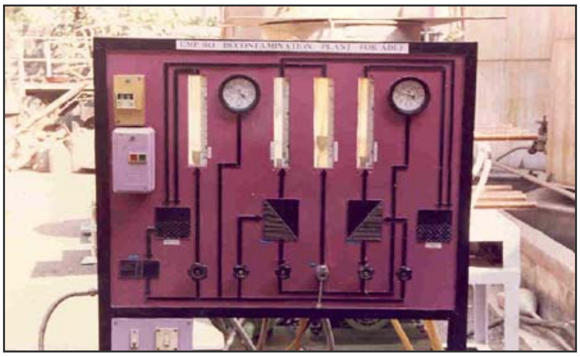
Fig. 2: Different configurations of Reverse Osmosis modules

Each of them have their own limitations and unique advantages. The type of application and the design objectives basically govern the selection of the membrane and module configuration.

Large volumes of low level aqueous effluents produced by the nuclear reactors require high volume reduction factors with reasonable decontamination factors. Reverse osmosis is extensively used in this context. RO processing always results in two streams; one a low volume concentrated stream and the other a high volume decontaminated stream. The basic considerations that govern the design of RO systems is high volume reduction with desired decontamination and minimum secondary wastes in terms of used modules, spent cleaning solution and other supporting accessories. Depending on feed, the process generates a concentrated stream and a permeate water stream with a decontamination factor of about 10 or more in a single stage process. Higher values are achievable for alpha emitters owing to their larger atomic / molecular size.

Presently RO forms part of waste treatment scheme for the low level radioactive effluents. The waste stream is pressurized and passed through a series of membrane elements arranged in a staggered configuration. About 90% of the waste volume permeates through the membrane with a specific activity lower by an order of magnitude thus accounting for volume reduction factor of 10 and a DF of 10. After the successful demonstration of an RO plant at the effluent treatment plant (ETP), a large scale plant has been set up and commissioned as part of the WIP, Trombay. The design involves staggered configuration of modules to balance hydrodynamic requirements and high volume reduction.

Uranium metal plant is one of the important constituents of a nuclear industry where nuclear grade metallic Uranium is prepared for use as nuclear fuel. Like all other hydrometallurgical plants, uranium metal plant also produces considerable quantities of metal bearing liquid effluents, which are radioactive in nature. Ammonium diuranate filtrate (ADUF) effluents generated in uranium metal plant contains around 40,000 ppm ammonium nitrate and small amounts of dissolved and suspended Uranium and it's daughter products. The beta activity levels due to ^{234}Th and ^{234}Pa are significant and require processing before disposal at sea. The treatment of ADUF by reverse osmosis, was found to be useful, in concentrating activity in small volume while making a larger volume of the decontaminated effluent suitable for direct disposal. Unlike normal desalination plants where dissolved solids are sought to be removed, in UMP, the aim was to separate ammonium nitrate from the radioactive species. This is essential to achieve high volume reduction factor in the presence of about 40,000 ppm of ammonium nitrate. TFCP membranes are not suitable in this



RO plant for effluent treatment in uranium metal plant (UMP)

regard, as they exhibit very high solute rejection for nitrates. Since cellulose acetate membranes have poor rejection characteristics for nitrate, it was decided to exploit this weakness for achieving the desired result. Accordingly, a demonstration plant was operated at UMP using CAB membranes in spiral configuration. We could achieve very good decontamination factor (in the order of 20 –50) with fairly high decontamination factors for a feed specific activity varying from 10^{-3} to 10^{-4} µ Ci/ml levels.

Reverse osmosis is a very useful process for concentrating the aqueous effluents or for recovering water. Since the process of separation is based on physico-chemical mechanism, it does not require any significant addition of extraneous chemicals. In certain specific situations, the concentrate could be a useful source for recovering some valuables. Even though they are capable of withstanding a significant amount of radiation dose, synthetic polymeric reverse osmosis membranes cannot handle acidic or alkaline solutions beyond the 4 – 9 pH range. Efforts are in progress to develop membranes, which can withstand higher acid / base concentrations.

IAEA / RCA MEETING FOR SENIOR MANAGERS FROM END USER DEPARTMENT ON 'APPLICATION OF ISOTOPE TECHNIQUES TO GROUNDWATER CONTAMINATION'

An IAEA/RCA Meeting on 'Application of Isotope Techniques to Groundwater Contamination' was organized for senior managers from end user departments at Sun-n-Sand hotel, Juhu, Mumbai during 7 –9 April, 2004.

The meeting formed part of an RCA project on 'Isotope techniques for groundwater contamination studies in urbanized and industrialized areas'. The main purpose of the meeting was to discuss the emerging issues of groundwater contamination of groundwater systems of the member states in the region. The meeting was also expected to provide participating senior executives from enduser departments with knowledge, advantages and utility of isotope techniques in tackling groundwater contamination problems. The meeting was thus a new initiative as it was directed towards the end user managers.

17 delegates from 9 countries in the region including 5 national participants attended the meeting. Dr Pradeep Aggarwal, Head Isotope Hydrology, IAEA, Vienna and IAEA Expert Dr Andrew Herczeg from CSIRO, Australia, also participated in the meeting.

The meeting was inaugurated by Mr B. Bhattacharjee, former Director, BARC. Mr Bhattacharjee in his inaugural address, stressed the role of isotope techniques in investigating groundwater contamination. Dr V. Venugopal, Associate Director, RC &

Mr B. Bhattacharjee, former Director BARC, delivering the inaugural address. Seen on the dais (left to right): Dr S.V.Navada, Head IHS, IAD, Dr P. Aggarwal, IAEA, Dr V .Venugopal, Associate Director RC & IG and Dr K. Raghuraman, Head, ISD, DAE & RCA National Representative

Participants of the IAEA/RCA meeting

Group, BARC, Dr K. Raghuraman, Head, International Studies Division, DAE and RCA National Representative and Dr Pradeep Aggarwal, IAEA spoke during the inaugural function. Dr S.V. Navada Head, Isotope Hydrology Section, Isotope Applications Division, BARC gave the vote of thanks.

During the technical programme of the meeting, Dr Pradeep Aggarwal, (IAEA) delivered an overview of isotope techniques in hydrology and Dr Andrew Herczeg, (Australia) presented a lecture on 'Isotopes in groundwater contamination studies'. Country presentations were made by the participants on various issues on groundwater contamination in the region. The following common issues were identified from individual presentations from each country

- Salinization of groundwater
- Pollution from landfills/ industrial/mine/ agricultural wastes
- Geogenic contamination such as Arsenic, Fluoride etc.

The issues were prioritized on the basis of their importance within each member state.

Group discussions on the following common issues were also made:

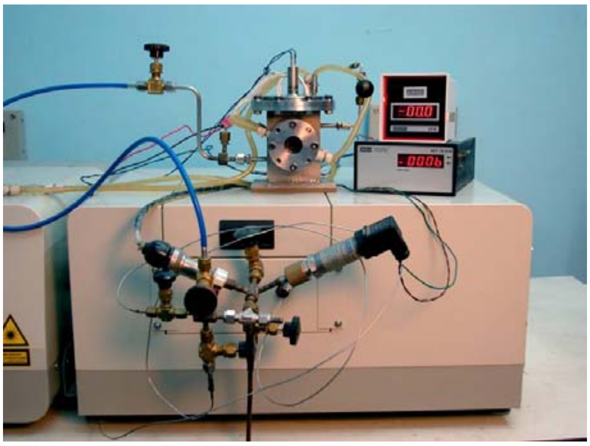
- Evaluation of information needs for each issue
- Identification of areas where isotopes add value to existing knowledge
- Determination of actions to be initiated and where IAEA could help.

The following recommendations were made to the agency:

- To Improve awareness of isotope methods to end user managers through promotion and education. Organization of national workshops.
- To provide easy access mechanisms for disseminating results and clearly articulate the value of isotope techniques.
- To improve access to analytical facilities either through subsidized analysis or provision of laboratory facilities in-house.
- End user training including provision of expert services to educate and train personnel in solving specific problems.

BARC SUPPLIES AN IR CELL TO INDIAN OIL CORPORATION, FARIDABAD, FOR *IN SITU* HIGH - PRESSURE HIGH TEMPERATURE FOURIER-TRANSFORM INFRARED SPECTROSCOPY STUDIES ON CATALYST SURFACES

Applied Chemistry Division has developed an indigenous cell system, made completely of stainless steel, for in situ high-pressure high-temperature infrared spectroscopy studies on catalyst surfaces. The cell enables a required pretreatment and subsequent exposure of a catalyst surface to reacting gases at



A stainless steel cell for in situ FTIR studies of catalytic processes, under the high-temperature and high-pressure reaction conditions.

temperatures up to 400 °C and in a wide range of pressures from 10^{-4} torr to ~10 bar. The transient species formed during the process can be recorded simultaneously to give vital information about the transformations in chemical bonds, occuring at the catalyst surface as a function of time and other reaction parameters. The changes occuring in the catalyst framework, particularly in case of microporous and mesoporous alumino-silicate materials, as a result of lattice substitutions and on incorporation of guest moieties in their host matrices are also amenable to investigation, using this cell.

An IR cell of this kind, fabricated at the Center for Design and Manufacture (CDM), BARC, has been supplied to the R & D Centre, Indian Oil Corporation, Faridabad, along with peripheral accessories at a total cost of Rs.18 lakhs.

2ND ASTROSAT WORKSHOP ON BLACK HOLE ASTROPHYSICS

The 2nd ASTROSAT Workshop on Black Hole Astrophysics was held at the BARC Training School Hostel during 10 - 16 May, 2004. It was the second of a series of Workshops, organized to create awareness among scientists in the country, about the research potential of the Indian ASTROnomy SATellite mission ASTROSAT, scheduled for launch in mid 2007. The Workshop was attended by about 80 participants from various research institutes and universities. 20 invited lectures on black hole astrophysics and high energy astronomy were delivered during the workshop and the participants were given extensive hands-on training in the analysis of X-ray data collected by various satellite missions. Twenty-two high-end Personal Computers with internet connectivity were installed at the venue for this purpose. In his inaugural speech, Dr V.C. Sahni, Director, Physics Group, BARC and Director, CAT highlighted the excitement in the field of high energy physics both from massive cosmic accelerators and man-made machines. He also emphasized the need for multi-wavelength studies of the cosmos by satellite-based observatories like ASTROSAT and ground-based detectors like the Mt. Abu based gamma-ray telescope, TACTIC. The Workshop, which was fully funded by the Indian Space Research Organization was organized jointly by the Department of Astronomy and Astrophysics of TIFR and NRL-HARL Division of BARC.

REPORT ON "CONFERENCE ON NEUTRON SCATTERING (CNS-04)"

A Conference on Neutron Scattering (CNS-04) was held at Bhabha Atomic Research Centre (BARC), Mumbai, India, during January 2-4, 2004. It was financed and sponsored by the Board of Research in Nuclear Sciences (BRNS), Department of Atomic Energy (DAE), Government of India. There were about 150 participants including 15 invited speakers from Austria, France, Germany, Spain, Switzerland, UK, Japan and South Korea. In all, 27 invited talks and 80 contributory papers (all posters) were presented.

The Conference began with an inaugural function. Dr M Ramanadham, Head, Solid State Physics Division (SSPD), BARC and also the Chairman of the Conference Organizing Committee, welcomed the participants from India and abroad. In his keynote address Dr V.C. Sahni, Director of Physics Group, BARC & also Director, Centre for Advanced Technology, Indore, recounted the seminal contributions of several past colleagues to the Indian neutron scattering programme, some of whom were present in the audience. In his presidential address, Prof R. Chidambaram, Principal Scientific Advisor to the Government of India and also DAE Homi Bhabha Professor recalled the highlights of the neutron scattering research at BARC over the past 40 years, while also mentioning the parallel role of various complementary techniques. In his inaugural address, Dr Anil Kakodkar, Chairman, AEC & Secretary, DAE, Govt. of India, unfolded some policy initiatives, which including plans to upgrade and expand national collaborations to continue support to and augment the neutron scattering programme, and also to complete unfinished agenda. Finally Dr V.C. Rakhecha, the Conference Convener, proposed a vote of thanks to all concerned for their vital contributions in the organization of the Conference.

In the first scientific session on structure and dynamics in disordered systems, Prof J. Colmenero (UPV, San Sebastián, Spain) spoke on the crossover from Gaussian to non-Gaussian behavior associated with α-relaxation in glass forming polymers; Dr Arantxa Arbe (CSIC, San Sebastián) on direct observation of crossover from α-relaxation to Rouse dynamics in a polymer melt in the intermediate length scales region and Dr A.K. Soper (ISIS, UK) on finding the structure of disordered materials by combining neutron diffraction data with computer simulations. In the post lunch session, Dr K.R. Rao (Ex-Director, Solid State & Spectroscopy Group, BARC) spoke on "National facility for neutron beam research" with a historical account of neutron beam research (NBR) in India and Dr P.S. Goyal (IUC-DAEF, Mumbai Centre) highlighted the achievements of Inter University Consortium for DAE Facilities (IUC-DAEF) in promoting NBR amongst the university community. After these facility talks, participants visited Dhruva reactor. There was an evening talk "Reminiscences of early years of neutron scattering" by Dr P.K. Iyengar, former AEC Chairman, who founded the neutron scattering programme in India. On the second

Inaugural address by Dr Anil Kakodkar, Chairman, AEC. Others sitting on the dais are (from left): Dr M. Ramanadham, Dr V. C. Sahni, Dr R. Chidambaram and Dr V. C. Rakhecha.

day in the first session on neutron optics, interferometry and small-angle neutron scattering, Prof. Helmut Rauch (Atom Institut, Vienna) surveyed quantum physics experiments including off-diagonal geometrical phases, confinement-induced phases and quantum contextuality and showed novel USANS results. Dr A.G. Wagh (SSPD, BARC) covered neutron spinor phase experiments involving geometric & dynamical phases in cyclic evolutions, the direct verification of Pauli anticommutation and the observation of Pancharatnam phases and interference amplitudes in noncyclic evolutions; Dr Mukul Gupta (PSI, Switzerland) described a horizontal geometry time-of-flight neutron reflectometer AMOR at SINQ/PSI with polarized/unpolarized option, and Dr V. K. Aswal (SSPD) brought out the suitability of Small Angle Neutron Scattering (SANS) to study aggregation in micellar solutions. In the next session on atomic and molecular motions, Dr J. Tomkinson (ISIS) talked on neutron spectroscopy of molecular vibrations and of the opportunity to probe phenomena like catalysis; Dr Mala Rao (SSPD) surveyed inelastic neutron scattering and lattice dynamics studies with progressively increasing complexity and Dr S. Mitra (SSPD) dwelt on stochastic molecular motions in condensed matter as studied by quasi elastic neutron scattering (QENS) investigations. In the next session on "Neutrons in Biology" Dr M-C Bellissent-Funel (LLB, France) spoke on a combined neutron scattering and molecular modeling approach to study internal motions in proteins, Dr I. Tanaka (JAERI, Japan) on neutron protein crystallography at JAERI and Dr M. Ramanadham (SSPD) spoke on single crystal neutron diffraction studies at BARC, especially on hydrogen-bonded systems. In the last session on structure studies, Dr P. S. R. Krishna (SSPD) spoke on inverse methods to refine structure of disordered materials, Dr A. Das (SSPD) on magnetic ordering in systems with competing interactions and Dr Rajul R. Choudhury (SSPD) on crystal structures and phase transitions in triglycine family of ferroelectrics. In the evening, the participants were entertained with a "Bharatnatyam" dance-drama presentation, which was followed by conference dinner.

On the third day, the first session was on neutrons in magnetism. Dr L. Pintschovius (IFP, Karlsruhe, Germany) presented cold neutron triple axis and SANS data on the itinerant magnetic system MnSi and claimed partial magnetic order at and even considerably above a critical pressure p_c where T_c goes to zero. Dr B. Roessli (PSI) showed the power of full polarization analysis in inelastic neutron scattering to discriminate different magnetic modes. Dr S.M. Yusuf (SSPD) showed the usefulness in magnetic studies of combined macroscopic, neutron depolarization (mesoscopic) and neutron diffraction (microscopic) measurements, with examples from CMR perovskites. Dr Tapan Chatterji (ILL, Grenoble, France) reviewed spin dynamics of bilayer manganites and argued for a generic non-Heisenberg behavior in optimally doped ferromagnetic $La_{1.2}Sr_{1.8}Mn_2O_7$. The second session of the day was on magnetism and small angle scattering. Prof K. Motoya (Tokyo University of Science, Chiba, Japan) described magnetic correlation, spin wave excitation and glass alloys, studied by QENS and time resolved SANS. Dr A. Wiedenmann (HMI, Germany) discussed magnetic contrast variation in SANS using polarized neutrons, permitting analysis of weak magnetic fluctuations. Dr S. Mazumder (SSPD) talked on the characterization of porous materials by SANS and of the need to account for multiple scattering effects. In the last session on novel studies, Dr C. Rueegg (PSI), dwelt on spin dynamics and phase transitions across quantum critical points in the spin dimer compound $TlCuCl_3$ and Dr Y.N. Choi (KAERI, S. Korea) described the possibility of using bent perfect crystal monochromators in both parallel and anti-parallel geometries of diffraction. In the concluding session Dr K.R. Rao presented the summary of the conference.

The contributed papers were displayed as posters on all the three days of the conference. slow dynamics in concentrated reentrant spin-These covered different aspects of structure, dynamics, neutron optics and neutron interferometry. In addition, there were some posters on neutron activation analysis and neutron scattering techniques. The variety of materials studied was quite wide and can be attributed to strong collaborations within India, between BARC and the university system, mediated by the IUC-DAEF. Overall, the participant response to the conference was excellent and the conference was a grand success. Given the sizeable neutron scattering community in India that will continue to grow, it would be beneficial to hold such meetings more frequently in India, on a regular basis. The Conference Proceedings are being published as a special issue of PRAMANA - Journal of Physics.

52ND NATIONAL WORKSHOP ON RADIOCHEMISTRY AND APPLICATIONS OF RADIOISOTOPES, NAGARJUNA UNIVERSITY, GUNTUR

The 52nd BRNS-IANCAS National Workshop on 'Radiochemistry and Applications of Radioisotopes' was held at the Centre for Biotechnology, Nagarjuna University, Guntur during February 2-10, 2004. Fifty four delegates from various departments of the university, colleges in Guntur, Tenali, Bapatla, Vijayawada, Ongole, Narasaraopet, Visakhapatnam and Nandigama participated in this workshop.

The Workshop was inaugurated by Dr V. Venugopal, Associate Director, Radiochemistry & Isotope Group; Head, Fuel Chemistry Division, BARC and President, IANCAS in a function that was presided over by Prof L. Venugopala Reddy, Vice Chancellor, Nagarjuna University, Guntur. Prof Reddy complimented BARC for conducting workshops at universities and colleges, which would enable people to appreciate the beneficial aspects of nuclear radiation in general and nuclear power in particular. He mentioned that in a power starved country like India, nuclear power is bound to play

an effective role in the future. Dr V. Venugopal explained the objectives of IANCAS in popularizing radiochemistry and application of radioisotopes as subjects in academic institutions through lectures and experiments. Dr G. A. Rama Rao, the coordinator of the workshop, gave a brief on the course content of the workshop on behalf of IANCAS..

After the inauguration function, a half-day seminar was arranged on 'Relevance of Nuclear Power' The seminar assumed importance in the wake of opposition to Uranium mining in Nalgonda, the neighbouring district of Guntur. The seminar was conducted by Dr S.K.L. Ramakumar, FCD, BARC. The speakers in this seminar were Dr Venugopal, Dr Arun K. Sharma, Head, FTD, BARC, Mr T. Vijayakumar, Director, Vijayawada Thermal Power Station (VTPS), Mr A. Anjaneyulu, President, Chamber of Commerce, Guntur Chapter, Mr Gadde Mangaiah, President, Tobacco Growers Association, Guntur. Various merchants of cold storage plants for spices in Guntur joined the seminar. Speaking on the occasion, Dr Venugopal described the abundance of resources in the country and pointed to the need to adopt nuclear power as an alternative for sustained development in the country. Dr Sharma highlighted the beneficial role of nuclear radiation in the development of several varieties of seeds and irradiation of food products to improve storage conditions. Mr Vijayakumar explained the contribution of thermal power in feeding the grid and also stressed on the need to look for other sources of power, to meet the ever-increasing demand for power. Mr Anjaneyulu enquired about the details of cost effectiveness in processing chilly and other food products. The workshop was conducted for 8 working days with lectures in the morning session supported by experimental work in the afternoon. The demonstration experiment on the use of radioactive isotope (Iodine-131) in studying the uptake of the nutrients by the green gram plant, drew wide appreciation from the participants.

Many schools and colleges in and around Guntur had sent invitations for conducting one-day workshops. The IANCAS resource persons Dr A.V.R. Reddy, Dr (Ms) Veena Sagar, Mr T.V. Vittal Rao and Dr G.A. Rama Rao visited fifteen institutions in and around Guntur and gave lectures and conducted experiments which benefited a total of 2020 students.

Interactive session at the workshop

The valedictory session was presided by Prof L. Venugopala Reddy, Vice-Chancellor, Nagarjuna University, Guntur, with Dr P.R. Vasudeva Rao, Associate Director, Chemical Group, IGCAR, Kalpakkam as the Chief Guest. Prof Luther Das, Registrar, Nagarjuna University, Prof Ramdas, Emeritus Teacher in Biotechnology, Nagarjuna University spoke on the occasion. Prof Das thanked IANCAS for choosing Nagarjuna University for organising this workshop. Prof Ramdas lauded the role played by such workshops in bringing out the beneficial aspects of radioisotopes in biosciences. Dr Vasudeva Rao donated a set of GM Counter and Gamma Spectrometer and the sealed radioisotope sources to Dr Sambasiva .Rao through the Registrar and hoped that the instruments would be put to good use in the Centre as well as in educating younger students from schools and colleges. Dr (Ms) Veena Sagar, the practicals coordinator of the workshop, proposed a formal vote of thanks to the local organisers and various agencies in DAE, responsible for the success of the workshop.

DAE - BRNS SYMPOSIUM ON NUCLEAR PHYSICS

The DAE - BRNS Symposium on Nuclear Physics will be held this year at the Banaras Hindu University, Varanasi - 221 005, India. During Dec. 6-10, 2004. The symposium format consists of invited talks, short oral presentations and posters. The topics to be covered during the deliberations at the symposium include the following

a. Nuclear Structure
b. Low and medium energy nuclear reactions
c. Physics with radioactive ion beams
d. Intermediate energy nuclear physics
e. Relativistic nuclear collisions and QGP
f. Nuclear matter and equation of state
g. Nuclear astrophysics
h. Accelerators and nuclear instrumentation

Ph.D. theses on the above topics submitted / awarded during the last one year are also invited for presentation. A two page thesis abstract should be sent following the above guidelines. The best thesis presentation will be awarded a prize by the Indian Physics Association (IPA).

Pre-Symposium orientation programme for students on the topic, "Computational techniques in nuclear structure physics" will also be held.

DAE SOLID STATE PHYSICS SYMPOSIUM

The 49th annual DAE Solid State Physics Symposium, sponsored by the Board of Research in Nuclear Sciences, DAE, will be held this year at Guru Nanak Dev University, Amritsar, during December 26-30, 2004. The scientific deliberations at the symposium will cover a wide spectrum of research activities in the field of condensed matter physics, in the form of invited talks, invited seminars, Ph.D. thesis presentations and contributed papers.

Subject categories

a. Phase Transitions
b. Soft Condensed Matter including Biological Systems & Liquid Crystals
c. Nano Materials
d. Experimental Techniques, Instrumentation & Solid State Devices
e. Liquids, Glasses & Amorphous Systems
f. Surfaces, Interfaces & Thin Films
g. Electronic Structure & Phonons
h. Superconductivity
i. Transport Properties
j. Semiconductor Physics
k. Magnetism including Spintronics

Novel Materials including Single Crystals (New topic introduced this year).

For further information, please contact or write to:
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भा.प.अ. केंद्र के वैज्ञानिकों का सम्मान / BARC SCIENTISTS HONOURED

डॉ. संगीता, तकनीकी भौतिकी एवं प्रोटोटाइप इंजीनियरी प्रभाग, भापअ केंद्र को "नैशनल अकादमी ऑफ साइन्सिज़, इन्डिया"(एन ए एस आइ) का सदस्य चुन लिया गया है। सिन्टिलेशन डिटेक्टर्स, लेज़र्स, नॉन-लीनियर ऑप्टिकल डिवाइसिज़, पाइरोइलेक्ट्रिक डिटेक्टर्स, एकोस्टिक ट्रांसड्यूसर्स तथा ट्रांसमिटिंग विन्डोज़ के रूप में प्रयोग के लिए एकांकी क्रिस्टल की वृद्धि एवं

ऑप्टिकल पदार्थों का चरित्रीकरण इनके क्षेत्र की विशेषज्ञता है।

The National Academy of Sciences, India (NASI) has selected Dr Sangeeta of Technical Physics & Prototype Engineering Division, BARC, as it's member. Her field of specialization is the single crystal growth and characterization of optical materials for use as scintillation detectors, lasers, non-linear optical devices, pyroelectric detectors, acoustic transducers and transmitting windows.

डॉ. संजय सी. गडकरी, तकनीकी भौतिकी एवं प्रोटोटाइप इंजीनियरी प्रभाग को "नैशनल अकादमी ऑफ साइन्सिज, इन्डिया" का सदस्य चुन लिया गया है। डॉ. गडकरी पतली/मोटी झिल्ली पर आधारित गैस सैन्सर एवं विभिन्न एकांकी क्रि स्टल प्रौद्योगिकी के विकास पर काम कर रहे हैं। उनकी सामयिक रुचि के क्षेत्र में इन्डस-। एवं इन्डस-।। के समकालिक विकिरण स्त्रोत तथा अति शून्य आधारित विशलेषक उपकरणों के लिए बीमलाइंस् का विकास शामिल हैं।

Dr Sanjay C. Gadkari of Technical Physics & Prototype Engineering Division has been selected as member of *The National Academy of Sciences, India.* Dr Gadkari has been working on the development of technology for thin/thick films based gas sensors and various single crystals. His current interests include development of beamlines for synchrotron radiation sources INDUS-I and INDUS-II, and ultra high vacuum based analytical instruments.

डॉ. डी.के. असवाल, तकनीकी भौतिकी एवं प्रोटोटाइप इंजीनियरी प्रभाग को "नैशनल अकादमी ऑफ साइन्सिज, इन्डिया" का सदस्य चुन लिया गया है। डॉ. असवाल ने आक्साइड सुपरकन्डक्टर तथा विशाल चुंबक प्रतिरोधक पदार्थों की पतली/मोटी झिल्ली तथा एकांकी क्रिस्टल के क्षेत्र में अनेक योगदान दिए हैं। इन्होंने हाल ही में अविष्कृत मैगनेशियम-डि-बोराइड सुपरकन्डक्टर पर भी काम किया है। इस समय वे मोलिक्यूलर बीम एपिटेक्सी एवं थरमोइलेक्ट्रिक पदार्थों का उपयोग कर, एच टी एस/सी एम आर मल्टिलेयर्स, मेटालिक-मल्टिलेयर्स पर काम कर रहे हैं।

Dr D. K. Aswal of Technical Physics & Prototype Engineering Division has been selected as member of *The National Academy of Sciences, India.* Dr Aswal has made several contributions in the field of thin/thick films and single crystals of high temperature oxide superconductors and colossal magnetoresistive materials. He has also worked on recently discovered magnesium-di-boride super-conductor. Currently he is working on HTS/CMR multilayers, metallic-multilayers using molecular beam epitaxy and thermoelectric materials.

डॉ. जी. रवि कुमार, तकनीकी भौतिकी एवं प्रोटोटाइप इंजीनियरी प्रभाग को "नैशनल अकादमी ऑफ साइन्सिज, इन्डिया" का सदस्य चुन लिया गया है। डॉ. रवि कुमार विभिन्न सुपरकन्डक्टिंग पदार्थों में वोर्टेक्स पदार्थ की भौतिकी पर काम कर रहे हैं। इन्होंने एलेक्ज़ान्डर वोन हुमबोल्ट स्नातकत्व प्राप्त किया तथा फोर्सशुंगज़ेन्ट्रम कर्लस्रुहे, जर्मनी में भी काम किया है।

Dr G. Ravi Kumar of Technical Physics & Prototype Engineering Division has been selected as member of *The National Academy of Sciences, India.* Dr Ravi Kumar has been working on the physics of vortex matter in various superconducting materials. He was also a recipient of the Alexander von Humboldt Fellowship and worked at the Forschungszentrum Karlsruhe, Germany.

Edited and published by Dr Vijai Kumar, Head, Scientific Information Resource Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085.

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