Azadi Ka Amrit Mahotsav

ISAS WEBINAR SERIES : A FEW EXCERPTS

A SAGA OF INDIAN SELF RELIANCE THROUGH EXCELLENCE IN ANALYTICAL SCIENCES

ISAS WEBINAR SERIES : A FEW EXCERPTS

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MESSAGE

August 10, 2022

It is very satisfying to note that Indian Society of Analytical Scientists (ISAS) is coming out with a e-book titled:"Azadi ka Amrit Mahotsav ISAS webinar series: a few excerpts."

It goes to the highly impressive credit of the dynamism of the leadership of ISAS that, during the Covid Pandemic Period, when there was nation-wide lockdown and large gatherings were to be practically impossible, ISAS embarked on a continuous stream of very useful technical talk totaling over 75 technical talks, executed as a regular feature on Saturday Evenings, all of which enlisted participation of a large number of scientists, faculties and post graduate students.

Analytical Sciences is a typical area of multi--disciplinary science and technology activity, both by in its own technical content and the vast range of Sectors that the analytical sciences cater to, for ensuring Quality, Excellence, Utility, Safety, Efficiency, Progressive Development etc.

Incidentally, it is on a similar multi-disciplinary functional approach that the self-reliant Indian Nuclear Programme has established itself as an exemplary Landmark for India in World Parlance.

ISAS activities have been of great interest to me. ISAS has recently launched an e-Journal titled as *Journal of ISAS*, first of it's kind of an Indian Journal.

I am sure that the present e-book, titled: "Azadi ka Amrit Mahotsav ISAS webinar series: a few excerpts", will serve useful purpose to many budding scientists, academicians and student community.

I take this opportunity to convey my best wishes to ISAS, for all its activities that always promoted Excellence and Relevance.

(Dr. Dinesh Srivastava)

नाभिकीय ईंधन सम्मिश्र (आई.एस.ओ.:9001, 14001& ओ.एच.एस.ए.एस.:18001 संगठन) ईसीआईएल डाक, हैदराबाद - 500 062.
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Message from President ISAS

The Freedom of India was described, at midnight between 14th and 15 th August 1947, as a **Tryst with Destiny** and the Independent India was born on 15th August 1947.

This year we are celebrating the 75th Year of our nation's Independence, as Azadi ka Amrut Mahotsav to place our nation on the launch pad to a coveted position as a world leader amongst Technologically Advanced Nations.

It is only through the motto, of achieving High Quality Multi-Disciplinary Technologies, which are poised to sustain Progressive Excellence and Relevance in Science and Technology that are well integrated to the various sectors of National Development through an All Round Atma Nirbharta Policy, that such a world leadership is possible, at least by the time our nation completes 100 years of Independence in another 25 years.

Such an ambitious, but surely feasible, aim can be achieved only through Science and Technology and through Scientists and Technologies being empowered and actively involved in the execution, providing a free and fair echo system devoid of all kinds of roadblocks.

Tireless Efforts are essential to fruitfully develop a strongly integrated multi-disciplinary science policy and a closely monitored system of execution of such a periodically upgraded policy.

Analytical Science and Technology, being an innately multidisciplinary area of science that has already established an exemplary position in ensuring Quality, Excellence and Relevance in practically the entire Sectors of National Development, ISAS is in a highly advantageous position to show or lead the way for our Nation in attaining best levels of success in it's Multidisciplinary Tasks in the much needy times ahead.

ISAS has already set a Golden Example for the Nation, during the Tryst With the Destiny of Incapacitating Covid Pandemic Period, by keeping it's activities to the peak, by conducting

over 75 Science and Technology Webinars on every Saturday, from 2020 to 2022, which enlisted very active participation of a number of scientists, faculties, post graduate students from various parts of India.

ISAS also promoted leaderships in science and technology activities by conferring Awards on great scientific achievers, through ISAS Saastra Pitamaha Award, ISAS Sastra Tejas Award, ISAS Atma Nirbharta Award, ISAS LifeTime Achievement Award, ISAS Medal for best Indian Analytical Instrument Manufacturer, ISAS Best Analytical Scientist of the Year, etc which were all conferred upon the leading contemporary Scientists and Technologists of our great nation.

Further, ISAS also launched an e-Journal, **Journal of ISAS,** first of its kind of an Indian Journal, on the occasion of Indian Azadi ka Amrut Mahotsav.

Thus, ISAS is the only Indian Scientific Forum, which set a Golden Example for the Entire Indian Scientific Community showing how to remain positively active even during such an exigency like Covid Pandemic.

Therefore, ISAS feel very proud in presenting this Issue before a 4000 strong Analytical Sciences Community of our Nation, who are members of ISAS, and also open to the entire scientific community of India and everywhere through the ISAS Website, isasbharat.in, and also to the honourable President of India and the Prime Minister of India as well as to all the leading Scientific Policy Makers of our great Nation and Neeti Ayog.

I thank all the great Indian Scientists and Technologists who participated in and organised (former and current scientists from DAE and VSSC, two great Indian Organisations that symbolises Indian Atma Nirbharta) this marathon series of ISAS Webinars on the ISAS Platform and congratulates the Team of Dynamic Analytical Scientists and Technologists (former and current scientists from DAE,VSSC and Universities) who served in the ISAS Webinar Organising Committees and done an excellent work in editing and presenting **this Issue which is a humble offering to Bharat Mata, from Her children in ISAS.**

Vande Mataram.

Jai Hind.

Sd/- (09.08.2022)

(Dr. P. P. Chandrachoodan)

President, ISAS

Message from Chairman, ISAS Webinar Committee

With India reaching its 75 years of Independence, it's time to envigour ourselves by celebrating the Azadi we meaningfully utilised for 75 years. Azadika Amrit Mahotsav symbolizes the elixir of inspiration from the freedom fighters and is focused on what India has achieved so far and its importance, and rejuvenate our focus on what can be achieved in the coming future, to take India to the heights based on the foundations of Atmanirbhar Bharat, which has been built.

From the time of independence to today, our economy has developed a lot but it's not enough. Our goal must be set for India to become the largest economy in the world by the completion of its 100 years of Independence and become Vishwa Guru. Only through our collective resolve, well-laid-out action plans and determined efforts, all the decided plans can be achieved to make India more powerful than before socially, technologically, economically, and politically.

To commemorate Azadi Ka Amrit Mahotsav, ISAS, the Prime Society of Analytical Scientists in India is presenting a compilation of highly advanced scientific and technical talks delivered during the ISAS webinar series conducted in 2020, 2021 and 2022, defying the limitations imposed by the covid pandemic period, enlisting participation of many eminent Scientists in India working in different fields of Science and Technology.

The ISAS webinar series which commenced on 4th July 2020 completed 75 webinars by February 2022. The series was a grand success with very active participation of scientists, faculties, technicians, researchers and students from various parts of India eagerly listening to the highly interesting, thoughtful and knowledgeable lectures. The webinar series is highly appreciated by the scientific community of India and contributed to the main objectives of ISAS viz., Promoting Aatma Nirbharatha and Dissemination of Scientific Knowledge.

This commendable task was successfully carried out with the active participation of all members of ISAS HQ along with ISAS chapters of Kerala, Nagpur, Pune, Chennai, Belgavi, and Baroda under the able leadership of President, ISAS.

We thank all the great Scientists and Technologists who participated as Chief Guests and Speakers in the webinar series in ISAS Platform. We are especially grateful to the speakers who contributed their lectures for this compilation within a short time. We congratulate the team of vibrant Analytical Scientists and Technologists who served in the ISAS Webinar Organizing Committees and done an excellent work in organizing the webinars and in editing and presenting this Issue.

We are sure that this compilation of highly relevant, scientifically and technically advanced lectures, a part of the contribution by ISAS for Aatma Nirbharatha of our Nation, will be useful for the scientific community of India especially to the young brigade.

Jai Hind

(Dr. R. Rajeev)

Chairman, ISAS Webinar Committee

Message from Publisher and Adviser

Azadi ka Amrit Mahotsav (AKAM) is the saga of the rapid strides India took in the past 75 years to reduce imports of items and to achieve productivity in true sense to realise Atmanirbharta, self-reliance by multidimensional growth in science and implementation of the ideas employing technology through Industries. Indian Society of Analytical Scientists (ISAS) provides a nodal forum among the bodies involved in all round scientific growth of the country. The society provides an interface for exchange of novel ideas since its inception The Society almost four thousand members strong, widespread across the country has ten chapters. ISAS is one of the premier scientific body of its own kind devoted to all round scientific growth of the country through analytical sciences since its inception.

Basically, it was during the compulsive quarantine imposed by pandemic, to keep our activity alive we resorted to webinars by the Scientists, Academia, Technologists and Industries with expertise in the respective fields. The great success achieved by huge participation provided us impetus to continue it till completion of seventy - five webinars to commemorate Azadi ka Amrit Mahotsav. The knowledge sharing webinars were beneficial to a mammoth mass involved in R & D activities from wide spectrum across the country.

The webinars were organized every Saturday at 7.00 pm and were so much engrossing that discussion about the next topic and speaker became routine. The Scientists started missing it after the conclusion (after seventy- nine webinars) when we got ready for off-line conferences. IASC during March, 2022 was planned to be held at Munnar, Kerala due to improved situation. The webinar series was organised by HQ alone or in collaboration with various chapters like Nagpur, Kerala, Chennai, Pune, Belagavi, Hyderabad and Baroda.

It gives me immense pleasure on launching of e- version of AKAM: ISAS webinar series talks encompassing wide horizon of multidimensional topics right from nuclear medicines, lasers , mars orbital mission, e-waste, safe water, food for 10 billion people by 2050, atomic minerals-exploration and recovery, ayurvedic bhasmas, fluorosis, aquaculture, bio stimulants in agriculture, gems identification, helium exploration, radioisotopes, analytical techniques for trace elements, covid-19 and so many more. A glance through list of the webinar series gives the idea of the coverage. Of-course, constraints allow us to present a few excerpts only of the talks.

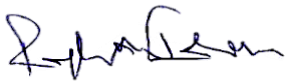
I am extremely thankful to the President, ISAS for his dynamism coupled with visionary concepts for fruition of the Azadi ka Amrit Mahotsav ISAS webinar series. My sincere thanks to the Chairman, webinar series and his efficient team at VSSC, Chairmen of Nagpur, Chennai, Kerala, Pune, Belagavi, Hyderabad and Baroda Chapters and their efficient team for their contribution to make the webinar series a grand success as per the requirements. I express my sincere thanks to Dr Nilima Rajurkar for her contribution in preparing AKAM ISAS WEBINAR series-A few Excerpts. My thanks are due to her efficient team especially to Dr Vijaylaxmi C Adya for her whole hearted cooperation. My sincere thanks are due to M/s KUNASH INSTRUMENTS Pvt. Ltd.

The journey begins here onwards for all of us to make a reality.

Sujalam, Sufalam, Malyaj Sheetalam!

Vande mataram!

Jai Hind!



Dr. Raghaw Saran

Publisher and Advisor

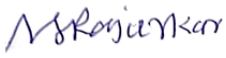
Editorial

On behalf of the Indian Society of Analytical Scientists and my co-editors, I am very much delighted to present the edited e-book entitled " Azadi ka Amrit Mahotsav ISAS Webinar Series: A Few Excerpts " which will be a mile stone for the researchers working in the frontier areas of science and technology. Our society is committed to continual innovation to better support the needs of our communities, ensuring the integrity of the research we publish, and championing the benefits of open research. Even in the difficult period of COVID, we conducted online webinars every week and were connected with scientific community all over India. On the occasion of Azadi ka Amrit Mahotsav celebrations, we will be presenting compilation of these webinars in the form of an e-book which projects the face of science and technology in India and its development through self-reliance. The book contains 24 articles which is a cross section of research from the scientists working in various fields at National Institutes, Universities and Industries which focus the light on some frontier subjects such as nuclear medicines, environmental studies, nanotechnology, biotechnology, atomic minerals, future of food and applications of analytical techniques. I am sure readers will definitely get enriched with the knowledge in various fields after going through this book.

I am very much thankful to Dr. P. P. Chandrachoodan, President, ISAS for entrusting the responsibility of compiling the webinar articles of eminent scientists in the form of a book. I would like to express my sincere gratitude towards Dr. Raghaw Saran, Vice president, ISAS and advisor for this publication for his constant guidance, and support in formulating this book. I am thankful to Dr. Rajeev Raghavan, Chairman, ISAS Webinar Committee for successfully organizing the webinars and giving the input for the compilation of the same. I wish to express

my special thanks to my co-editors : Dr. Vijayalaxmi Adya and Dr. Vinay Bhandari for their cooperation in bringing out this book. I am grateful to all the eminent speakers of the webinars who presented their articles in this book. I would like to put on record my sincere thanks to Rakesh Ranjan, Shivani Kantak and Vaibhav Parse for their technical support.

I am very much grateful to all the dignitaries for their messages on this auspicious occasion.



Dr. Nilima Rajurkar
Chief Editor

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Content

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

E-waste Management: Challenges and opportunities

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Abstract

The escalating environmental foci of the past couple of decades have directed considerable attention toward the incongruent issues arising from the disposal of durable consumer goods. End of life (EoL) electrical and electronic equipment (EEE) known as e-waste is one of the fastest growing areas of the international waste stream and is increasing at a much higher rate than all other waste streams. Safe management or disposal of electronic products are increasing significantly on a global scale and is becoming a major problem for many countries around the world. In this article, India's status on E-waste management is described based on recent surveys and statistics. The variety and projections in e-waste composition is also identified due to the technological improvement in the electronic industry, which introduces difficulty for the development of a universal, environmentally benign and sustainable recovery process. The collection and management of EEE waste remain a key challenge. This necessitates the shift to a more circular approach for the e-waste management sector. An overview of the practices followed in the country is presented and the manner in which they contribute to the sustainable management of e-waste is discussed.

Introduction

E-Waste is a topic of national importance to every country. According to the Global E-Waste Monitor 2020, the world generated a striking 53.6 Mt of e-waste, an average of 7.3 kg per capita in 2019. The growing amount of e-waste is directly linked to higher consumption rates of EEE, short product life-cycles, rapid technological advancement and few repair options.

Asia generated the highest quantity of e-waste in 2019 at 24.9 MT, followed by the Americas (13.1 Mt) and Europe (12 Mt), while Africa and Oceania generated 2.9 Mt and 0.7 Mt, respectively. Globally, by 2050, the rate of consumption of resources would be three times higher than the rate at which earth can replenish. Only an estimated 17.4 % of e-waste generated is taken for recycling with the rest going into landfills.

India ranks third amongst the largest e-waste producing countries, after USA, and China, with over 3.2 MT of e-waste generated in 2020 and only an estimated ~0.2 MT (5%) is taken for recycling. The factors that led to a growth of e-waste are digital transformation, Social and economic growth, rapid technology advances, dumping trash etc. Close to 90 per cent of the world's electronic waste — worth nearly $19 billion — is illegally traded or dumped each year, to destinations half way across the world. While the European Union, the U.S. and Japan are the primary origins of e-waste shipments, China, India, Malaysia and Pakistan are the main destinations, as per reports. In Africa, Ghana and Nigeria are the biggest recipients of e-waste.

E-waste contains precious and special metals, including gold, silver, palladium and platinum, as well as potentially toxic substances such as lead, mercury, cadmium and beryllium. Therefore, responsible end-of-life management of e-waste is imperative in order to recover valuable components and properly manage hazardous and toxic components. End-of-life management of e-waste includes reuse of functional electronics, refurbishment and repair of electronics, recovery of electronic components, recycling e-waste, and disposal. Reuse, refurbishment or repair of electronic products is most desirable since this option increases the life span of the electronic product and higher resource efficiency.

Although E-waste management is an intricate problem to tackle with, it also offers promising business opportunity of increasing significance. The fraction including iron, copper, aluminium, gold and other metals in e-waste is over 60%, while pollutants comprises 2.70 % (Widmer et al., 2005). Recycling of electronics allows for precious and special metals to be recovered, reduces the environmental impact associated with electronic manufacturing from raw materials, and ensures that hazardous and toxic substances are handled properly. Although there are clear benefits to recycling e-waste, the recycling rate of e-waste is relatively low, due to lack of recycling and regulatory infrastructure.

In India e-waste collection, transportation, segregation, dismantling, recycling and disposal are done manually by untrained labours in informal sector. The large share of e-waste (more than 90%) gets channelized to informal sector as they use low-cost rudimentary methods of processing to recover materials. Lack of consumer awareness is another reason for channelization of e-waste to informal sector. In addition, disposal of the e-waste in landfills results in loss of high amounts of valuable metals like gold, silver, copper etc. and also pose a risk because of toxic chemical compounds.

Challenges

The explosion of e-waste highlights its dual (and duelling) identities as both environmental scourge and potential economic resource. Though often laced with lead, mercury or other toxic substances, e-waste also contain valuable elements like gold, silver and copper. When e-waste is exposed to the heat, toxic chemicals are released into the air damaging the atmosphere; this is one of the biggest environmental impacts of e-waste. Those toxic materials can then seep into the groundwater there by detrimentally affect human health. Electronic waste can also contribute to air pollution.

The South Asian region has begun to recognise the importance of proper e-waste management. India is the only country in Southern Asia with e-waste legislation,although several other countries are in the process of enacting such legislations. In India, laws to manage e-waste have been in place since 2011, mandating that only authorised dismantlers and recyclers collect e-waste. A manufacturer, dealer, refurbisher, and Producer Responsibility Organization (PRO) were brought under the ambit of the E-Waste (Management) Rules 2016. The National Resources Policy also envisages a strong role for producers in the context of recovering secondary resources from e-waste. Legislation in India has been a driver for the setting up of formal recycling facilities, and there are 468 authorised recyclers in India as of 2021. However, the large majority of the waste is still handled by the informal sector. There are 31 authorised PROs providing compliance services, including the collection and channelization of e-waste to formal recycling facilities, as well as the administration of awareness campaigns. Enforcing rules remains a challenge, as do other aspects, such as the lack of proper collection and logistics infrastructure, limited awareness of consumers on the hazards of improper disposal of e-waste, the lack of standards for collection, dismantling of e-waste and treatment of it, and an inefficient

and tedious reporting process. In spite of legislation by Govt. of India, poor implementation of e-waste management and handling rules remains a key challenge.

Most of the e-waste handled by informal sector and formal recyclers facing dearth of e-waste. Most of the e-waste generated in the country ends up in the informal sector for recycling and disposal. Many workers function from homes to reprocess waste.

Moradabad in Uttar Pradesh and Seelampur in Delhi are the largest informal e-waste dismantling centres in India. Adults and children work in dismantling facilities without any safety precautions. E-waste recyclers use processes such as open incineration and acid-leeching to recover valuables. The majority of the e-waste collected in India is managed by this unorganized sector.

For instance, to extract metals from circuit boards, gas torches are used to heat circuit boards just enough to melt the solder, which separates the metal parts from the boards.

Metals are also extracted by soaking the circuit boards in open acid bath followed by manual scrapping to extract copper and precious materials next to open drains. This situation could be improved by creating awareness and improving the infrastructure of recycling units along with the prevalent policies. In order to mitigate the informal recyclers and promoting the formal recycling is a major challenge considering the cost effectiveness of informal and unscientific recycling practices in India. Huge capital involved in setting up the recycling facility and dearth of indigenous technology to extract precious metals from e-waste.

It is estimated that about half the circuit boards used in the appliances in India end up in Moradabad (Uttar Pradesh) also called Peetal Nagri. The circuit board recycling process involves either open burning of the circuit boards or using acid stripping. Following the chip extraction and burning, the boards themselves are burned in an open pit to retrieve the rest of the metal solder and copper. After burning, the ashes are floated in water to remove lighter ash. Another process involves utilizing nitric acid on the circuit boards to remove gold and platinum. There is a perceived need to increase the awareness level of consumers towards health hazards caused due to e-waste, disposal practices, environmental problems resulting out of poor disposal of e-waste and awareness towards legislative policies related to e-waste management in India.

Opportunities

E-waste is a rich source of metals such as gold, silver, and copper, which can be recovered and brought back into the production cycle. There is significant economic potential in the efficient recovery of valuable materials in e-waste and can provide income-generating opportunities for both individuals and enterprises. There is countless business opportunities present in the current waste sector, and these are not restricted to large companies with limitless capital. Small entrepreneurs and SMEs can also tap into the potential that the recycling sector holds.

Growing quantum of e-waste offers opportunities to entrepreneurs. E-Waste Management is on the verge of building an "Industry Sector". It opens up opportunities in setting up new business start-up as recyclers, dismantlers, e-waste collectors, and refurbisher. It is found that 1 MT of printed circuit boards (PCBs) recycling produces 120-150 gram of gold, whereas only 1 to 2 gm of gold can be recovered from 1MT ore extraction.

In a developing country like India, a holistic approach is required for better e-waste management, which means the formal and informal sectors need to work together. For example, the informal sector can be involved in the collection, segregation and dismantling while the formal sector can take responsibility for recycling, metal extraction and recovery, and disposal of e-waste safely and scientifically without causing damage to the environment and human health. A major advantage of good e-waste management is its cost effectiveness. Studies have shown that 1.2 kg of Cobalt can be extracted from 1 ton of its ore, whereas 35 to 40 kg cobalt can be extracted in pure form from 1 ton of waste smart mobile phone batteries. Therefore, an increase in the number of formal sector units with adequate infrastructure for recycling can be beneficial for a developing country like India, which is expected to support National Missions such as Make in India, Swachha Bharat, Digital India etc.

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Biosketch of Dr. Ratheesh

Dr. Ratheesh is director at C-MET, Hyderabad and life member of Materials Research Society of India. His research interests are: Microwave Ceramic, Microwave Laminates, Polymer-Ceramic

composites, Ultra Low Temperature Co-firable Ceramics, Antennas for NavIC and GPS, Laser Raman Spectroscopy, Structure-Property Correlation, E-waste Management. He has published several papers in this area in International journals. He is recipient of several awards: Alexander von Humboldt Fellow at Germany, BOYSCAST Fellow at USA, Lady Davis Postdoctoral Fellowship at Israel, DIST bilateral Fellowship at Australia, ELCINA-EFY National award for Excellence in Electronic Materials Hardware manufacturing 2016-17, PSN National Technology Award-2011 Excellence in Engineering, Young Scientist Award-2001 from Government of Kerala, Life Member, Materials Research Society.

ISRO's Mars Orbiter Mission: An Unparalleled Scientific Achievement

(ISAS webinar lecture on 14 August 2020)

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Abstract

India is the only country in the world to reach a Martian orbit in the very first attempt and thus, its maiden Mars Orbiter Mission (MOM) is an unparalleled accomplishment in the history of modern science & technology. The Indian orbiter, Mangalyaan with 5 in-house realized instruments on-board was launched by ISRO's reliable satellite launch vehicle, PSLV. The major challenges in the mission were the enormous distance to Mars that is moving at a great speed, cruising to it with minimum energy utilization in a trajectory being attempted for the first time and finally getting captured into a pre-determined Martian orbit. The success of MOM has demonstrated that India can do major scientific tasks in a quick, innovative and cost effective manner.

Introduction

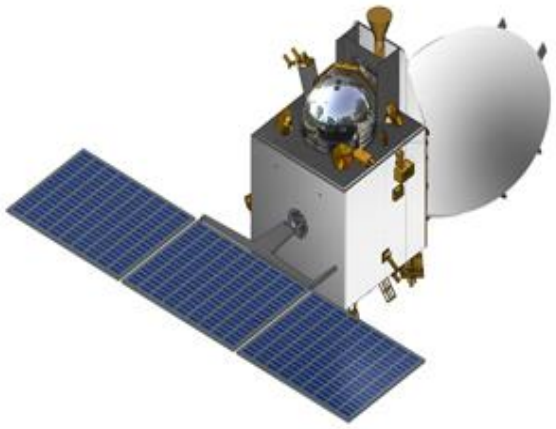
The red planet Mars, our neighbour in the solar system, is still an enigma to humankind. Ancient Romans named it after their god of war. In some parts of India, the horoscopic term *'chovva dosham'* – meaning problem with the position of Mars – is considered bad luck for marriages. Even a century back, there were speculations about rivers, habitats and a civilization on Mars. Now we have a better understanding of the planet, about its red colour being due to iron oxide as a major mineral of Mars or its thin atmosphere with 96% CO_2 as the major constituent. We also know that Mars is practically dry with no liquid water on its surface, though there is about 21 million km^3 of ice and solid carbon dioxide at the polar region. There is a hypothesis that three billion years ago, Mars had liquid water and microbial life on its surface. About 90% of methane on Earth is produced by microbes and therefore, methane can indicate the presence of life on Mars.

A flyby mission by the USSR launched on 10 October 1960 was the maiden attempt to Mars and it was a failure. In fact, no country except India was able to reach the Martian orbit in the very first attempt and the success rate of all the Mars missions put together has been less than 50%, due to the technological complexities involved. Almost all the Mars missions attempted to confirm the presence of methane and thereby life, present or past, on Mars. Some missions of NASA and ESA have shown ppb ranges of methane in Martian atmosphere; however, concordant results are eluding the search. The other major global interest of Mars are as a future habitat or intermediate station to distant planets, verification of the location and amount of water present in Mars and exploration for rare minerals

Mangalyaan, the Indian Mars Orbiter

ISRO's successful maiden Mars Orbiter Mission (MOM) is an unparalleled accomplishment in the history of modern science & technology. No other country has been successful in its first attempt to reach Mars. The main objective of the ISRO mission was to lay the foundations for indigenous capability for interplanetary missions and to develop the technologies required for it. The scientific objective of the mission was exploration of Mars surface features and Martian atmosphere using in-house realised scientific instruments.

The spacecraft named Mangalyaan, meaning *"Mars-craft"* had autonomous features because of the enormous distance to Mars, needing up to 24 minutes for 2-way communications.

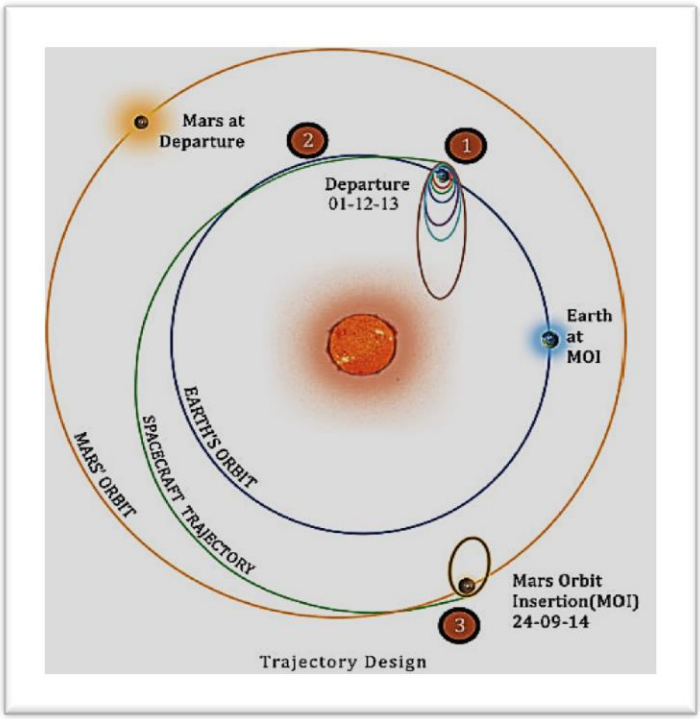


The mass of the spacecraft was 1340 kg that included 850 kg of propellant, comprising MON -3 (3 % NO + 97 % N_2O_4) as the oxidizer and MMH (monomethyl hydrazine) as the fuel. The scientific instruments on-board were (i) Methane Sensor (a short wave IR radiometer) (ii) Lyman

Alpha Photometer (LAP) (iii) Mars Exospheric Neutral Composition Analyser (MENCA), a quadrupole mass spectrometer (iv) Thermal Infrared Imaging Spectrometer (TIS) & (v) Mars Colour Camera. All the five instruments were indigenously developed and their total mass was 14 kg.

Journey towards the Red Planet

On 5 November 2013, Magalyaan was launched by ISRO's prestigious and most reliable satellite launch vehicle, PSLV into 250 x 23500 km elliptical orbit around Earth. The subsequent six orbit raising maneuvers and injection towards Mars were performed by the spacecraft propulsion module. Thereafter, for cruising to Mars with minimum energy (propellant) utilization, the trajectory of Mangalyaan was arrived at, based on thousands of simulations.



On 30 November 2013, the velocity of spacecraft was increased tangentially at (1) to take it into as elliptical orbit around the sun from (2) to (3), needing no energy to travel around sun. The meeting point of Mars was at (3) on 24 September 2014, 667 million km away, travelled in 300 days. The calculations and the performance of the propulsion system were so precise that only two minor orbit corrections with 0.8 kg propellant utilization were required in the 300 days of travel. Mars also arrived at the same time, at the same point.

Entry to Martian Orbit

On reaching the sphere of influence of Mars, the velocity of Mangalyaan was to be reduced from its sun orbital velocity of 22.1 km/s to 1.1 km/s to get captured into the pre-determined Martian obit. The important question was: will the engine work after its hibernation during the cruise phase of 300 days in deep space environment? A four seconds firing of the engine on T-2 days gave the exactly expected results and great confidence for the Mission. The major events on 24 September 2014 were: (i) at 06:56:32 hrs: the spacecraft was turned by 180 deg to reduce its velocity by 'reverse firing', (ii) between 07:17:32 to 07:41:46 hrs: the thrusters were fired for 24 min 14 s, and the velocity was reduced to 1.099 km/s (within 0.1% of the target, indicating a near perfect performance of the propulsion system), (iii) the spacecraft was turned back to normal position and (iv) at 08:00:00 hrs: confirmation of the orbit was received from Canberra, the first point of visibility. The first-cut analysis showed an orbit of 422 x 76994 km around Mars, against a prediction of 423 x 80000 km, a near prefect mission!

Conclusions:

The total cost of the Mission was approximately Rs. 450 Crore, making it the least-expensive Mars mission to date and it was realized in record time of 15 months. At the time of the lecture, the orbiter has performed for more than 4 years, much beyond the mission objective of 6 months in orbit. The success of MOM has demonstrated that India can do major technical tasks in a quick, innovative and cost effective manner. The vision, vitality and values which have become the hallmarks of ISRO in all areas of work are the basic reasons for this unparalleled accomplishment.

Dr. Ninan: Brief Biosketch

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Dr. Ninan is renowned chemical scientist and former deputy director of VSSC. After his 40 years of work tenure at VSSC, Ninan worked as Professor Emeritus at Indian Institute of Space Science and Technology. His research interests are polymer science, rocket propellants, solid state chemistry and kinetics. He has more than 200 publications having more than 5000 citations. His post-retirement interest is in the popularization of science among school children and university students.

NUCLEAR MEDICINE FOR THE DIAGNOSIS AND THERAPY OF CANCER

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Abstract

Nuclear medicine is a medical faculty used for the diagnosis of a large number of diseases. It also has a niche in the treatment of certain type of cancers. There are two imaging modalities available in nuclear medicine, SPECT and PET. Radiopharmaceuticals made using a gamma emitting isotope called ^{99m}Tc is used for SPECT imaging. PET uses radiopharmaceuticals labelled with radioisotopes decaying by positron emission tomography. Radiopharmaceuticals made of both α and β- emitting radioisotopes are used for targeted therapy. India is one of the early entrant in nuclear medicine and that leadership position continues.

Introduction

The quest to use radioactivity for disease management is as old as the discovery of radium by Marie Curie and Pierre Curie in the year 1898. Radium-226 was tried as a medicine to treat a variety of diseases but miserably failed. The treatment resulted in unwanted radiation exposure without any commensurate benefits and thus abandoned. The use of atomic bombs in Hiroshima and Nagasaki in August 1945 brought the widespread awareness of the damages of radiation making the people scary of the use of radioactivity. However, once the war ended scientists started working towards the beneficial uses of radiation and radioisotopes in medicine which were the bye products of the reactors made for making nuclear weapon materials. The result was the emergence of two important medical fields namely radiotherapy and nuclear medicine.

Nuclear Medicine

Nuclear medicine is a faculty of medicine in which radioactive formulations called ‘radiopharmaceuticals’ are administered to the patients. Radioisotopes decaying by β- or alpha

particles emission are used for therapy. Radioisotopes decaying by emission of β+ particles or emitting gamma photons are used for diagnostic imaging.

Diagnostic Nuclear Medicine

There are two imaging modalities, single photon emission computed tomography (SPECT) and positron emission tomography (PET). SPECT most commonly uses a radioisotope called technetium-99m having a half-life of 6 hours. Technetium-99m emits low energy (140 keV) gamma photons and is ideal for imaging. It gives low radiation dose to the patient as well as the attenuation of the 140 keV gamma photons in the body is minimal. Technetium-99m is eluted from $^{99}Mo/^{99m}Tc$ generator as and when needed in the nuclear medicine department. The generator can be used for a week as the half-life of ^{99}Mo is 67 hours. Molybdenum-99 used in the generator is produced in nuclear reactors.

Technetium-99m is part of the formulation of different radiopharmaceuticals which are used for imaging organs such as heart, liver, kidney and brain. It also has a major role in cancer management. or e.g. a bone scan using ^{99m}Tc-MDP (methylene diphosphonate) is used for imaging cancer patients suspected to have bone metastasis.

Patients needing investigations are injected with the specific radiopharmaceutical. After a predefined time, the radioactivity distribution within the body is measured using an instrument called gamma camera. A gamma camera contains a large NaI(Tl) crystals and the radioactivity emitting from the body of the patients is measured and processed to images. Modern gamma cameras have multiple heads containing the NaI(Tl) crystals which can move around the patient to collect tomographic images (Fig.1). A rough estimate is that over 20 million SPECT studies are done annually the world over using ^{99m}Tc radiopharmaceuticals.

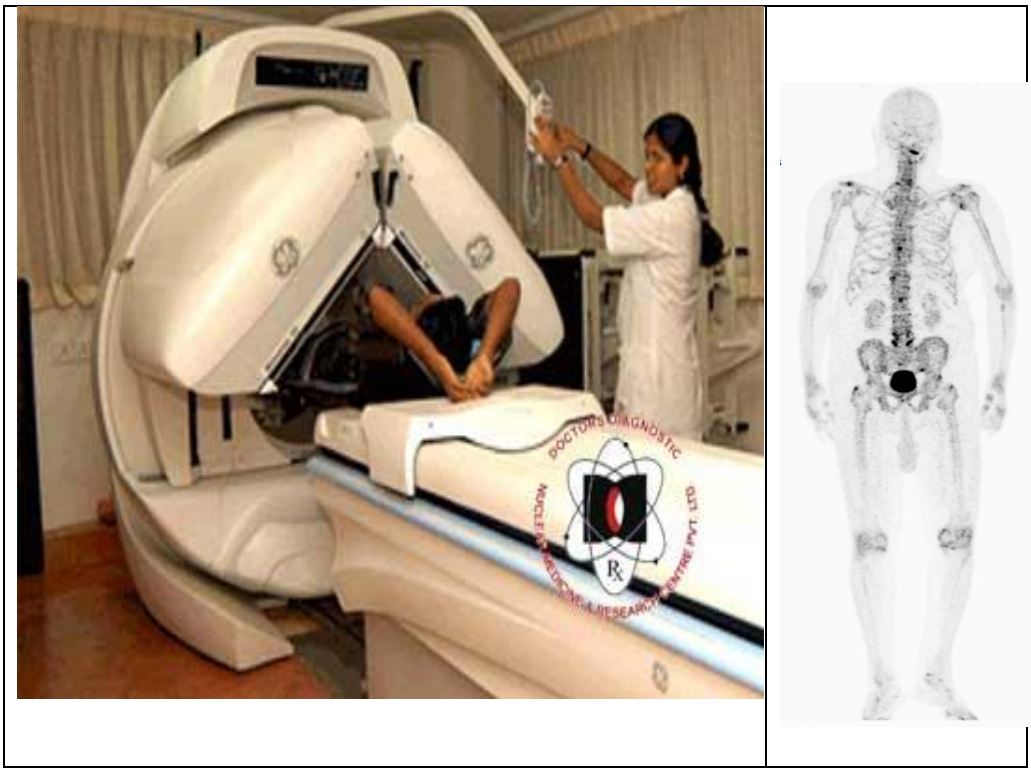

Fig.1. A patient undergoing SPECT imaging. The planar image on the right is of a patient injected with ^{99m}Tc-MDP (methylene diphosphontate). Abnormal uptakes seen in certain parts of the bone correspond to bone metastasis.

Positron emission tomography (PET)

PET imaging uses radioisotopes decaying by emission β+ particles or positrons. This mode of decay is common in neutron deficient isotopes. Neutron deficient isotopes are produced in cyclotron. A typical example is the use of fluoirine-18 having a half-life of 110 min. The positrons emitted by the decaying radionuclide after losing its kinetic energy annihilates with an electron and in this process emits two gamma photons in the opposite directions. A PET camera having scintillation crystals arranged in 360 degree is used to measure the radioactivity. A coincidence counting technique is used in which the two gamma photons are simultaneously measured and reconstructed to images. PET imaging has better resolution as compared to SPECT imaging.

The present trend is to use fusion imaging in which both PET and SPECT are fused with computed tomography (CT). PET-CT imaging is an essential part of cancer management and

used for staging, therapy response assessment and recurrence evaluation. The most common radiopharmaceutical used for this purpose is [^{18}F]fluoro-2-deoxy-2-D-glucose (FDG) which is a proliferation tracer and taken up by most fast growing cancers. There are other PET radiopharmaceuticals using both ^{18}F and ^{68}Ga radioisotopes. All PET radioisotopes with a few exception are produced in cyclotrons. A PET imaging study in a nuclear medicine department is shown in Fig.2.

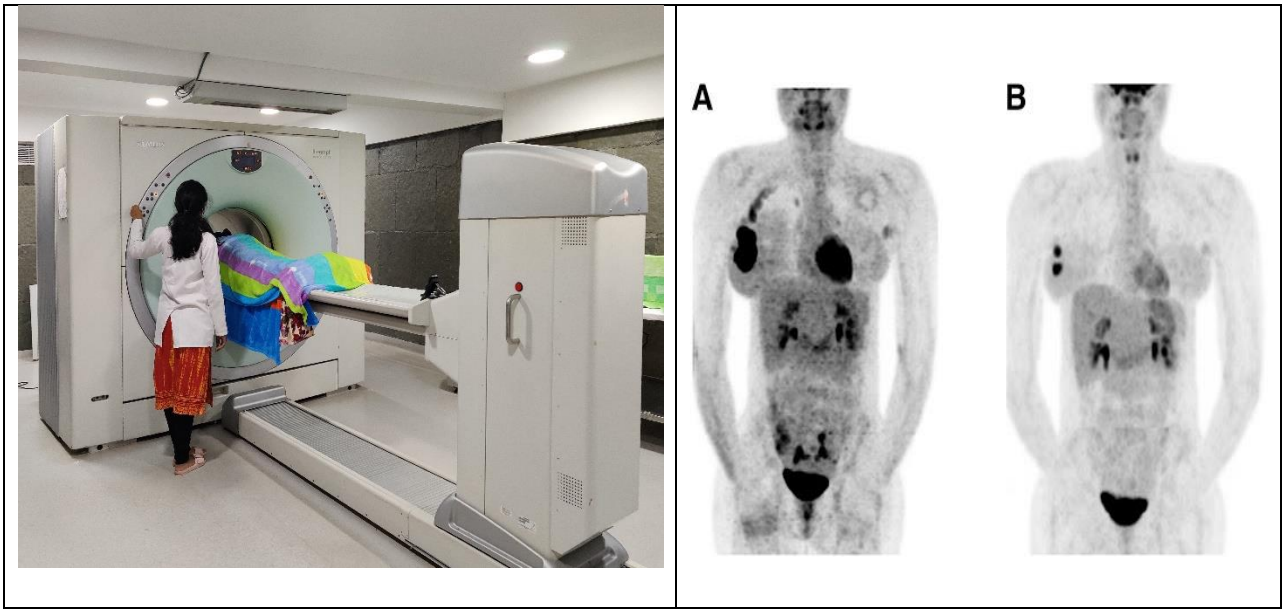

Fig.2: A patient undergoes a PET-CT imaging study (Left). The patient was injected with FDG and the images are acquired after an hour. The figure on the right shows the PET images of a patient before and after treatment. Significant reduction in the uptake of radioactivity is seen in the image on the right indicating that the tumour load has significantly reduced, an indication that the treatment is in the right direction.

Targeted radiotherapy of cancer

Targeted therapy is the delivery of radioactivity directly to the cancer cells where it decays and deposits the energy in the vicinity to kill them. Targeted therapy is known for more than eighty years and used for the treatment of thyroid cancer. A patient suffering from thyroid cancer undergoes a total removal of the gland and a large dose of iodine-131 is given orally to destroy the remnant cancer cells. Papillary and follicular thyroid carcinoma which are the major cancers of the thyroid are completely curable. This therapy is in practice since 1946. Unfortunately there were no other similar success stories for targeted therapy for a very long time.

Bone pain palliatives

Bone metastasis is a major problem during the final stages of cancer especially that of the breast and prostate cancer. The major manifestation is pain which reduces the quality of the life of the patients. Radiopharmaceuticals labelled with β- emitting radioisotopes are used as pain palliatives. These include, ^{153}Sm-EDTMP and ^{177}Lu-EDTMP. Radium-223, an alpha emitting radioisotope as $^{223}RaCl_2$ is also used as a bone pain palliation agent. These radiopharmaceuticals accumulate in metastatic bone and destroy the cancerous cells and reduce the pain.

Theranostic nuclear medicine

'Theranosis' is a term used for a combination of diagnosis and therapy of diseases. Though this term was never used, diagnosis and treatment of thyroid cancer using radioiodine (^{131}I) is the best example of theranostic medicine. The amount of activity to be injected in each patient is decided based on the diagnostic image obtained from the patient. Hence, this is also a 'personalized medicine'. Off late the radiopharmaceutical scientists have succeeded in developing a few theranostic pairs of radiopharmaceuticals. These radiopharmaceuticals use either peptides or enzyme inhibitors as carrier molecules to deliver particle emitting radionuclides to the cancer sites. These small molecules have the advantage that they accumulate in the tumour fast and the rest of the radiopharmaceuticals get excreted. Hence, the tumour to back ground ratio is very high.

These peptides or inhibitor molecules are labelled with diagnostic radioisotopes such as ^{18}F, ^{68}Ga or ^{99m}Tc. PET or SPECT imaging studies are done to visualize the tumours which is followed with the administration of high dose of β- or alpha particle emitting radioisotopes tagged with the same peptide or inhibitor molecules. Lutetium-177 is one of the most commonly used radioisotope for targeted β- therapy whereas ^{225}Ac is used for targeted alpha therapy. Lutetium-177 has a half-life of 6.73 days and emits medium energy β- particles. Actinium-225 has a half-life of 10 days and decays by emission of four alpha particles thereby delivering a large quantum of energy within the tumour cell.

Patients suffering from a rare cancer called neuroendocrine tumour (NETs) are one of the major beneficiaries of this innovative therapy. A peptide called DOTATATE is used for carrying the radioisotope to the tumour site. DOTATATE is an analogue of the somatostatin hormone.

Somatostatin receptors are overexpressed in patients suffering from neuroendocrine tumours. Hence, DOTATATE is an ideal vector to carry the radioisotopes to the tumour. ^{68}Ga-DOTATATE is used for PET imaging of NETs patients.

Therapy using ^{177}Lu-DOTATATE is done if the tumour load is high, distributed and inoperable. 200-250 mCi of ^{177}Lu-DOTATATE is used for each cycle of therapy. Part of the ^{177}Lu-DOTATATE accumulates in the tumour and the remaining gets excreted in a few hours. The radiopharmaceutical accumulated in the tumour is not redistributed and decays completely in the tumour cells thereby killing them. 4-5 cycles of therapy are done which provide relief to the patients. Likewise, ^{68}Ga-PSMA (prostate specific antigen inhibitor) is used for imaging and ^{177}Lu-PSMA is used for the treatment of inoperable prostate cancer. Very little side effects are exhibited in these sort of therapies. The treatment is done in an outpatient ward and the patient is released on the same day.

Status of Nuclear Medicine in India

Thanks to the visionary leadership of Homi Jehangir Bhabha, the first nuclear reactor in Asia, Apsara became critical on 4th August 1956. Nuclear medicine in India started immediately thereafter with the setting up of an isotope program. The commissioning of the CIRUS reactor in 1960 and Dhruva reactor in 1985 increased the capacity of production of radiosiotopes significantly.

The Radiation Medicine Centre (RMC) was established adjacent to the Tata Memorial Hospital in Parel, Mumbai. RMC was in the forefront to establish nuclear medicine and also provided trained manpower for running nuclear medicine departments not only in India but also in many other countries. The first medical cyclotron was set up in RMC in 2002 starting PET imaging in India.

Nuclear medicine is well-established in India with 415 nuclear medicine departments operating in major hospitals and as independent units. Most of these centres operate SPECT, PET and therapy. As of today, there are more than 330 PET-CTs as well as four PET-MR machines. There are 100 SPECT-CT and 206 SPECT/planar cameras. The training of nuclear medicine physicians and technologists is now done by many of the major Institutes and Hospitals.

India has 23 cyclotrons making PET radiopharmaceuticals. But these cyclotrons are distributed in 11 states. On a conservative estimate, India needs about 100 cyclotrons to cover the supply of PET radiopharmaceuticals in the country. At least half of the present cyclotrons are run by private entrepreneurs and this trend will continue in future. There is a good business potential in radiopharmaceuticals production and PET-CT imaging.

Dhruva is the only research reactor available for radioisotope production in India. This reactor is in the 40^{th} year of operation and will be due for decommissioning in a few years. Hence, building a high flux ($>5x10^{14} n.cm^{-2}.s^{-1}$) reactor is an essential need to sustain the continued growth of nuclear medicine in India. The efforts by the Department of Atomic Energy to build the new reactor in the public-private-partnership (PPP) mode need to be accelerated, the fruition of which will put India as major player in radioisotope and radiopharmaceuticals field in the World.

About the Author

Dr. M.R.A. Pillai Ph.D.; D.Sc. is a radiopharmaceutical scientist with over forty-five years of active academic and research experience. He held positions in BARC; BRIT; University of Missouri Columbia (UMC), International Atomic Energy Agency (IAEA) and at the Homi Bhabha National Institute. He published over 250 journal papers, three books and edited 14 books for the IAEA. He is currently working as Group Director, Molecular Group at Cochin and supporting cyclotron and nuclear medicine programs of the group. He travelled to 55 countries mostly to extent technical support to their programs related to isotope production and radiopharmaceuticals.

Environmental Remediation by Nanomaterials: A Photocatalytic Approach

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Abstract

Environmental pollution is one of the main problems that today world is facing. Pollution contaminates air, water and soil also. Best solution to tackle this problem is to reduce or stop the use of methods and processes that causes increases in pollution. Novel methodologies which involve recent technologies are constantly being explored for the environmental remediation of air, water, and soil. Varieties of materials can be used in environmental remediation. Wide varieties of approaches can be exploited for this purpose. As compare to classical technologies nanotechnology has gained a lot of attention in recent decades due to the unique physical properties of nanoscale materials. Higher surface to volume ratio of nanomaterials enhances their reactivity compared to their bulkier counterparts. Among the many possible ways of water remediation are filtration, absorption, adsorption, chemical reactions and photocatalysis. Photocatalysis based water remediation can be carried out with the help of natural energy source, i.e., solar energy which removes the persistent organic pollutants in water using different photocatalysts.

This article has focused on recent advancements in the use of nanomaterials for the environmental remediation of a variety of water pollutants by photocatalysis.

Introduction

The rise in population increases the load on natural resources. The excessive use of natural resources and particularly of water by selective countries also of great concern. The extensive use of natural resources has threatened the ecosystem by continuous human interference and unplanned exploitation of resources. Climate

change is a major issue which is related to the depletion of these resources. In order to ensure the uninterrupted water supply requires novel and innovative technologies which also reduces global water pollution load. The long-term development of the global water situation is closely connected to the growth of the world population and global climate change. It is predicted that world population will be nearly 6.3 billion people in 2050. Tremendous increase in droughts also responsible for reduction in water sources. Chemical and biological weapon by terrorist attacks also adds loads on in water resources planning.

Several physical and chemical techniques are available like boiling of water, distillation, use of different derivatives of chlorine, ultraviolet light, low frequency ultrasonic irradiation, reverse osmosis, deionization etc. for the treatment of water.

During the past few decades, a lot of research were done to use different polymeric materials, natural and synthetic ion exchangers including zeolites and metal ions as bactericides for water disinfection.

Removal of most of the organic water pollutants and air matrices is still a great challenge where most of these conventional methods get failed. Hence techniques with nanomaterials are used in waste water treatment

1 Nanotechnology in environmental remediation

1.1 Environmental Remediation by conventional methods

To tackle environmental contamination in soil, wastewater andgroundwater many remediation technologies have been developed for treatment of contamination by various pollutants [1]. For reduction of contamination to a safe level various physical, chemical and biological technologies can be used individually or in combination with one another. To ensure proper selection, the design, and adjustment of the remediationtechnology is of prime importance [2]. Air stripping, carbon adsorption, biological reactors or chemical precipitation are typical conventional methods available for treatment of water trench, pump waters etc.

One of the drawbacks of these methods is production of highly contaminated waste which increase in operation cost.

1.2 Nanotechnology for waste water treatment

Varieties of nanomaterials are used for water purification process. Most commonly used are dendrimers, metal-containing nanoparticles, etc. These materials have a wide range of physico-chemical properties which increases their use in separation and reactive media for treatment of waste water.

Conventional techniques are already reported for water purification. These methods have their limitations, therefore more cost effective and robust methods should be used for water purification and for tackling environmental problems.

Varieties of nanomaterials are now available for use in environmental remediation. Recently phocatalysis by nanomaterials shows promising results in purification of water.

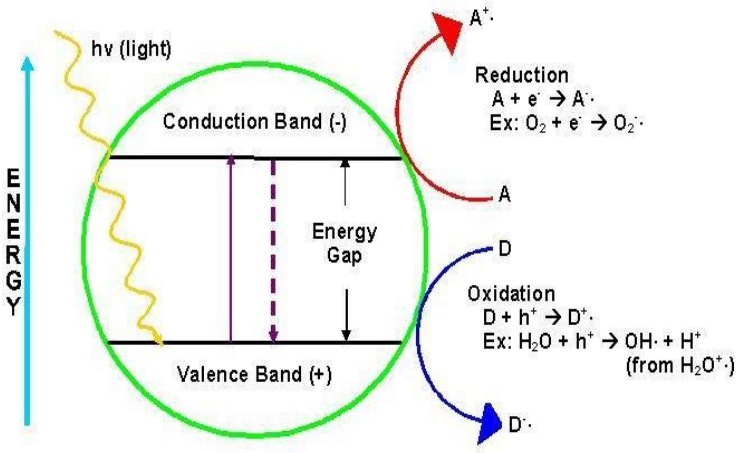
1.3 Photocatalysis

Photocatalytic is one of the several advanced methods which can be used to tackle these problems. Photocatalysis as a green technology has the potential to bring the high-performance water detoxification at affordable rates using solar active advanced materials with sustainable approach. This method is a blend of natural processes and methods developed by human being. Photocatalytic oxidation processes generate highly reactive hydroxyl radicals and other strong oxidants, which are capable of mineralizing pollutants into harmless substances. This is a typical irradiation process where excitation ofcertain metal oxide semiconductors result in electron–hole pairs formation. Photocatalysis is effective in degradation of pollutants like synthetic dyes, biocides, and other chemicals. The technology is very promising not only for dye degradation but also for biological decontamination as well. It can purify the air by destroying pathogens, volatile organic compounds (VOCs), and odors.

This writ-up covers scientific and technical knowledge of photocatalysis and its

applications in treating wastewater containing different dyes. This also covers some general areas which need more research in the near future. **Photocatalysis** is the activity occurring when a light source interacts with the surface of semiconductor materials, the so called **photocatalysts.**

A typical photocatalysis mechanism is represented as follows.



Properties of Photocatalyst are depend on following factors

- **Physical and chemical properties** – morphology of catalyst, its size, energy level structure,etc.
- **Photoreactors design** – manual or automatic stirred reactors,source of light, etc.
- **Operational parameters-** pH, reaction time, frequency of light source, concentration of impurity are the other relevant parameters.

Advantages to use Photocatalysis for waste water remediation

- The oxidant used is atmospheric oxygen which reduces the consumption of expensive chemicals.
- This is cleaner process and not produces sludge.

- Photocatalytic reaction may be driven by sunlight
- Decompose of organic pollutants and bacteria

Steps involved in photocatalysis

Transfer of the reactants in photoreactor. It can also be spread on surface so that it can adsorb on surface.

- Photons are incident on surface or on solution so that it can be adsorbed on phase.
- Desorption of the products
- Removal of the products from the interface

1.4 Typical Semiconductor Metal Oxide Nanoparticles for Visible Light Photocatalysis

TiO_2- TiO_2 shows excellent photo activity under UV irradiation.

Solar Radiation contains only 2-4% UV light, rendering TiO_2 inactive towards major portion of sunlight.

Various methods to improve the efficiency of TiO_2 in visible light:

- Dye sensitization
- Metal & Non-metal doping
- Composite semiconductors
- Nano sized

Iron nanoparticle

- Zerovalent Iron nanoparticles in the range of 10-100 nm are nowadays use for nano remediation.

Nanoscale iron particles shows high efficiency for the detoxification of varieties of organic pollutants like chlorinated organic solvents, chlorinated

organic pesticides and PCBs [1].

- Bimetallic nanoparticles are also another group used in nano remediation. Bimetallic of iron platinum (Pt), gold (Au), nickel (Ni), and palladium [3] are the potential nanomaterials used in waste water remediation. The combination of metals to form a nanoparticle increases the kinetics of oxidation reduction (redox) reaction, therefore catalyzing the reaction.
- Carbon nanotubes (CNT) - In recent years carbon nanotubes are used in waste water treatment industry.

1.5 Characteristics of nano photocatalyst

- Small Size
- High Surface area
- Adsorption potential
- Low cost to prepare and use
- High stability (Biologically and chemically inert)
- Non-toxic to the environment and humans
- High efficiency
- Effectively activated by sunlight

Photocatalytic Decomposition of pollutants

- Utilization of nanosized TiO_2 photocatalyst dispersed on substrates with high surface area
    - Spreading on ground to collect sunlight
    - UV light in sunlight is sufficiently strong to decompose them by TiO_2 photocatalysis
    - Nanoparticles are necessary for photocatalyst with high activity

1.6 Environmental risks of using nanomaterials

Despite their wide range of potential applications of nanomaterial's, dark side of these materials should be considered. Some of these materials are very toxic

hence toxicological risk assessment is required. Very less literature is available related to toxicity of nanomaterials [1]. In response to these concerns, various scientific communities are trying to gain more knowledge in exposing their toxicological effects on human [4] andecological health [5].

Conclusion

Contamination in soil, wastewater and groundwater is big problem we are facing nowadays. To tackle these problems many remediation technologies are developed but few conventional technologies are affordable and effective for removal of contaminants from water and wastewater. If we consider cost removal efficiency of certain pollutants like persistent organic pollutants these have many disadvantages. Therefore, environmental remediation by nanotechnology with conventional technologies gives appreciable results.

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Bio sketch Dr. Avinash V. Bharati

Dr. Avinash V. Bharati has done M. Sc. in 1991, and Ph. D. in January 2000, from PGTD of Chemistry, RTM Nagpur University, Nagpur. He is Associate Professor with 30 years of teaching experience. He is a registered guide in RTM, Nagpur University, Nagpur. Till date, 7 students have been awarded Doctoral Degree under his guidance. His area of interest is Synthetic Organic Chemistry, Nanotechnology and Environmental Sciences. He has published more than 25 research papers in reputed journals of high impact factor. He has authored five books on 'Engineering Chemistry', 'Material Chemistry' and 'Energy and Environment' for engineering students. He has delivered several guest lecturers in different seminars in many institutions and participated in seminars, workshops and symposia. Currently, he is BOS member in Applied Sciences and Humanities, RTMNU, Nagpur. He is also the Chairman of Indian Society of Analytical Scientists, Nagpur Chapter.

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

"Role of Natural Immunity and Vaccine in Management of Contagious Diseases".

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Former Head, Immunology & Hyperthermia Section, Bhabha Atomic Research Centre,
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Abstract

The mini review focuses on the current pandemic caused by the virus named SARS-CoV2. The review highlights the data derived from the recognised websites and leading peer reviewed articles from medical journals. The review specifically addresses the issues like, preexisiting immunity to SARS-CoV2, mortality data for SARS-CoV2 and the robust natural immunity to SARS-CoV2. It also dwells into the validity of the diagnostic test for SARS-CoV2 and the efficacy of the vaccine developed against SARS-CoV2.

Introduction

The current paper is based on Summary of the Presentation done by me at ISAS Hyderabad chapter webinar, entitled "Role of Natural Immunity and Vaccine in Management of Contagious Diseases".

World Health Organisation (WHO) insists on scientific findings and not rumours to understand the current health crisis caused by SARS CoV2. Our beloved PM also believes in discussion (Tarka) to come to a conclusion. He beautifully quotes the debate between Mandana Mishra and Adi Shankara, where there is no scope for retribution or anger. The following 6 scientific reasons based on peer reviewed scientific papers is a sincere attempt to deliberate scientific data derived from high impact publications, related to Influenza like Illness (ILI), caused by SARS CoV2.

Results and Discussion

1. Definition of Pandemic is not met as per WHO: The old definition of Pandemic "An influenza pandemic occurs when a new influenza virus appears against which the human population has no immunity, resulting in several simultaneous epidemics worldwide with enormous numbers of deaths and illness" has been changed to "An

influenza pandemic occurs when a new influenza virus appears against which the human population has no immunity" during the 2009 Swine Flu pandemic.

The following papers prove the existence of robust pre-existing cellular and humoral immunity to SARS-CoV2 due to the immunological cross reactivity with other human corona viruses. The statement by WHO "No immunity to the current virus" is not appropriate.(References: Cell181:1489, 2020, Science370:1272/1339,2020 and BMJ 2020;370:.doi.org/10.1136/bmj.m3563, Nature 2020;584:457-62. Nat Rev Immunol 2020; 20:457-8.) When you cannot defend Pandemic whole thesis of Experimental medicine, Experimental vaccine, Experimental RT PCR Tests become questionable.

2. It is ILI and no increased mortality: (i)It is Influenza like Illness (ILI) as per WHO, health ministry, CDC USA and Lancet (Vol 395 May 16, 2020 https://doi.org/10.1016/S0140-6736 (20)31052-7) and Para 4(b) of this letter. No increased mortality in India due to ILI which includes covid19, for the year 2020. Estimated Influenza associated respiratory and circulatory deaths in India was 1.5 lakh in 2010(population of 120 Crore) and same or less in 2020 (140 Crorepopulation) including the current flu, Covid19 (Journal Global health doi: 10.7189/jogh.10.010402). Insignificant death rate due to Covid 19 in India has been implicated due to the immune training of Indian population in the publication authored by the Director General of CSIR (medRxivdoi: https://doi.org/10.1101/2020.07.31.20165696).

   (ii)CDC(DOI: https://doi.org/10.5888/pcd18.210123), studied very large number (540,000) of Covid patients. Figure 1 and Table 1of this document are the core contents of the presentation. Figure clearly tells that Co morbidity is the real reason for death. More than 99% Covid deaths had at least one comorbidity and less than 1% healthy people died of Covd. It means healthy people do not die of the disease more than ordinary Flu and why they need Vaccine. Further Vaccines are never tested on people with Comorbidity, children, lactating and pregnant ladies.

(iii) Omicron which has the dual traits of increased transmissibility and mild clinical symptoms offers to be a Christmas gift as a Mother Nature's Vaccine for the current Flu. Similar statement was made by the Dr Angelique, who is the Chair of South African medical Association, who identified Omicron. This Vaccine from Nature is efficient, safe, and very economical. All the medical establishments of the world concur that it is mild, but spreads rapidly. Virus spreading is a common feature, as we live in a viral planet. We have estimated 10^31 viruses in the planet whose weight is more than combined weight of whole plants and animals on the planet. Our body has > 350 trillion viruses and or DNA is composed of .8% viral DNA. The ability of Omicron to spread very fast is a bless in disguise and can be used to deliver this Vaccine from Nature very fast to the population at large.

(iv)Leading journal science (Science 370:1272/1339,2020) has mooted the idea of using mild corona viruses as Mother nature's Vaccine: Polyclonal IgG antibodies against 4 cold corona viruses (Co) targeted wider range of epitopes of SARS CoV2 Spike protein because of antigenic cross reactivity. Natural Vaccination: universal vaccine against current as well as future CoVs using Corona virus 229E which was identified 60 years back.The statement in the journal "*Could pre-existing immunity to the common cold viruses be more protective than future vaccines? Without studying the question, we won't know,"* needs to be considered *(BMJ 2020; 370:m3563).*

There are 6 identified human Corona viruses which have epitopes cross reacting with current CoV2. Four seasonal Human Corona Viruses (HCoVs) cause cold symptoms in humans are: 229E, NL63, OC43, and HKU1. All these viruses are genetically much distinct than the SARS CoV2. SARS CoV1 (which caused the 2003 flu) has less than 80% genetic identity with SARS Cov2 but still mounts a robust T cell response against Cov2. The current variants of CoV2 (Delta, Omicron) have more than 99.5% similarity to the original Wuhan virus. (Nature 2020; 584:457-62). It means our Innate and adaptive immune system can take care of these jmutants very efficiently.

3. Virus Mapping for Causal Relationship with the disease as per Established Procedure not done: Dying with virus (as confirmed by cases using RTPCR test) and dying of

Virus are two different things. Virus Mapping for Causal Relationship with the disease as per Established Procedure not done to prove the cause of the current ILI, which is accepted by the authors of the original paper on the characterization of Wuhan virus (N Engl J Med 2020;382:727). Even Koch's postulates for the 21st century, as suggested by Fredrick and Elman Clinical Microbiol Reviews 9:18, 1996 are not met. It means we do not know which organism or agent is causing the current flu as per Medical Microbiology principles. Para 4(b) further supports this theory.

4. (a) RT PCR does not detect infective virus/ not specific and error prone: When you have not mapped the virus and not isolated the pure Virus from the original patients how can you design a test or Vaccine? The original RT PCR paper on SARS CoV2 (Euro Surveill.2020; https://doi.org/10.2807/1560-7917.ES.2020.25.3.2000045, Article submitted on 21 Jan 20 / accepted on 22 Jan 20 / published on 23 Jan 20) were written and conducted "without having virus material available,"RT PCR test does not detect infective virus/ not specific and error prone due to cross reactivity with other identified human corona viruses (see para 1 above). No correlation between viral load and disease severity as per ICMR. Contamination at various levels, transport and technical factors contribute to errors as per ICMR.This test is Not approved by FDA to test a virus, Not approved by manufacturer of the test to diagnose virus.The test cannot detect active Virus (The Nobel Laureate Dr Mullis).The statements in the RT PCR report like a) Results from RT PCR assay should be interpreted with other laboratory & clinical data. b) This test cannot rule out diseases caused by other bacterial & viral pathogens, clearly support the above statements and demonstrate beyond doubt the unreliability of RT PCR test.

   (b) (CDC) has decided to discontinue RTPCR testing after 31 December 2021. Similarly, the letter dated July 21, 2021 (attached) was given to laboratories and other concerned in the country. https://drive.google.com/file/d/12K5dS8An3t9RUGvxp9jWl32Qy9DCjh60/view?usp=drivesdk.CDC admitted that the RTPCR test did not distinguish between Covid and flu viruses. This means that in the last 52 years, flu patients have been diagnosed with Covid. As a result, millions of crores of Covid victims were registered. Based on this,

it was said that the disease spreads rapidly.Last week's news paper states the need for about 2 RTPCR tests before sequencing to establish infection with SARS CoV2. They use the technical words like S gene drop or S gene target failure. When people can't understand difficult words they think its right. In simple words because of mutation spike protein equivalent RNA sequence can't detected because of multiple mutation at the spike protein region. I am at a loss to describe the implications of this statement.

5. We have already achieved Population (herd) Immunity to Virus by Mother Nature's vaccination: We have already achieved Population (herd) Immunity to Virus. a) Via Natural Immunity to cross reacting other human corona viruses b) Robust long lasting Natural immunity to the current SARS CoV2 virus. T cells that are reactive to the N protein of SARS-CoV2, 17 years after the outbreak of SARS in 2003 (Long Lasting) Nature 2020;584:457-62. Please also refer to publications listed in Para 1.

6. Efficacy of Vaccine: Unlike pharmaceuticals, for which present illness drives demand, it is the "perception of risk" for disease that creates desire for vaccination. Health and economic Risk benefit analysis of the vaccination programme needs to be done based on the following scientific data.

    (a) As per CDC definition of Vaccine most of the covid vaccines do not qualify to be vaccines. They can be called as Experimental Gene Therapy: Vaccine is a product that stimulates a person's immune system to produce immunity to a specific disease, protecting the person from that disease. This so-called COVID-19 "vaccine" does not provide the individuals who receive the vaccine with immunity to COVID-19, nor does it prevent the transmission of this disease. It does not meet the CDC's own definition of a vaccine. This COVID-19 experimental gene therapy is only designed to minimize your symptoms if you were to be infected with the COVID-19 virus.

    (b) Will covid-19 vaccines save lives? Current trials aren't designed to tell us. None of the current vaccine trials are designed to detect the prevention serious sickness and hospitalization (BMJ

2020;371:m4037http://dx.doi.org/10.1136/bmj.m4037). Vaccination had no effect of new cases and Countries having more fully vaccinated people have more number of cases. CDC reports increased number of hospitalization in vaccinated people (Increases in COVID-19 are unrelated to levels of vaccination across 68countries and 2947 counties. European Journal of Epidemiologyhttps://doi.org/10.1007/s10654-021-00808-7.

(c) Selection of volunteers for vaccination is not appropriate as complete spectrum of host immunity is not done. Volunteers are selected if they are RTPCR negative, seronegative but their T cell memory response not done, A decline in serum antibodies in convalescence covid patients may not reflect waning of immunity, but rather a contraction of the immune response with the development and persistence of T cell and B cell memory (Nature 2020; 584:457-62 T cells that are reactive to the N protein of SARS-CoV2 17 years after the outbreak of SARS in 2003 (Long Lasting). Rapid generation of durable B cell memory to SARS-CoV-2 spike and nucleocapsid proteins in COVID-19 and convalescence. *Science Immunology* 2020:Vol. 5, Issue 54, eabf8891.Covishield uses Meningococcal vaccine as control which is not appropriate.

(d) Results of First Trial on Covishield Vaccine efficacy (Lancet 2021; 397: 99–111) indicated that in the unvaccinated group percentage of healthy people are 98.41(1.59% Sick People) and in Vaccinated group 99.39 people are healthy (0.61% Sick people), a mere **1% increase** of healthy people in Vaccinated group or 1% increased disease symptoms in Unvaccinated. This 1% increase in Unvaccinated refers to Cold, cough, Body ache, Fever, loss of appetite and NOT serious respiratory Disease or death. (BMJ 2020;371:m4037 http://dx.doi.org/10.1136/bmj.m4037). The above symptoms every body experience 2 to 3 times a year on an Average. By Math'sJugglery this 1% increase is made into an efficacy of **61%**. The absolute risk reduction of 1% is the real Answer and not the Relative Risk reduction of 61%. Do you think it is a great Vaccine which protects

us from ordinary symptoms 1% more than Unvaccinated? Calculation: (1.59 – 0.61) ÷1.59 x 100= 61%.

Bio sketch of Dr Balakrishna Poduval

After M.Sc. in Biochemistry from University of Mysore, Selected for the BARC training School on a National basis and obtained his PhD related to BCG Immunotherapy from Mumbai University.

Dr Blakrishna Poduval was Former Professor, Homi Bhabha National Institute (HBNI), Former Head, Immunology & Hyperthermia Section, Bhabha Atomic Research Centre(BARC). PhD guide at HBNI and Mumbai University. He along with his team at BARC has contributed immensely to original knowledge in the area of Immunology and Critical care medicine related to Inflammation, Heatstroke Acute Radiation Syndrome and Septic Shock. His team also has original contribution in the area of Cancer and Radiation Biology.

45 peer reviewed high impact publications relating Cancer, Radiation Biology, Immunology, Stress biology.

Listing in International Medical Encyclopaedia article on Heat stroke (Hyperthermia).

HELIUM POTENTIAL OF INDIA AND CURRENT EXPLORATION STRATEGY

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Abstract

Helium is a unique gas with a wide range of important medical, scientific and industrial application. This review article presents a brief overview of the natural sources for commercial helium gas extraction, the global helium market scenario, helium prospective geological domains in India and the status of helium exploration in India.

Introduction

Helium (He) is a colourless, odourless, tasteless, non-toxic, inert, monoatomic gas which cannot be artificially produced by any chemical or physical methods. It is the second lightest and second most abundant element in the outer space after hydrogen. The boiling point (- 268.9°C) and melting point (-272.2°C) of helium are the lowest among all elements and it is characterised with high thermal conductivity (0.15 W/mK). Helium finds wide range applications in fundamental science (cryogenics, material science), medical appliances (MRI technology), cutting edge technologies viz. He-Ne laser, superconductivity (as refrigerant) and magneto hydrodynamic studies as well as in many advanced strategic sectors like space technologies, defence applications and nuclear technology (as coolant, neutron detector). Other industrial uses are in balloons, car airbags, arc welding, leakage detection, barcode reader and fiber optics. In India, the medical sector, premier research organisations such as Department of Atomic Energy (DAE), Indian Space Research Organizations (ISRO) and Defence Research and Development Organization (DRDO) along with Indian Universities are the prime consumers of helium. The demand for He in India is presently met by imports mainly from the USA and therefore, identifying indigenous helium resources and developing in-house expertise in large scale recovery and production is high on agenda to make India self-reliant.

This article deals with the historical aspects of the discovery of helium, its demand, sources on earth, and prospective geological domains in India and its exploration strategy for future.

Historical perspectives

Helium coming out from uranium ore was discovered by Sir William Ramsay, Per Teodor Cleve and Nils Abraham Langlet in 1895. Large reserves of helium were found during 1903, in natural gas fields in parts of the United States, especially in Dexter, Kansas where an oil drilling operation produced a non-inflammable gas. The gas sample analysis revealed composition as 72% N_2, 15% CH_4, 1% H_2, and 12% of unidentifiable gas by volume (1.84% of which was found to be He). Thus it was established that the American Great Plains has large quantities of He, available for extraction as a by-product of natural gas. This enabled the USA to take the lead for supply of helium. The USA produced more than 90% of helium in the world for many years. Canada, Poland, Russia and other nations produced the rest. Additional plants came up in Ras Laffan, Qatar, and Skikda, Algeria between 2004–2006. Algeria subsequently became the second leading producer of helium. Helium prices doubled during 2002 to 2007, and as on February, 2022 the price of helium is Rs 1900/m^3 , i.e. 4 times higher than that of 2011 (Rs 450/m^3) and similar trend is expected in coming years.

Natural sources of helium

Helium is obtained from three sources viz. atmosphere, earth's crust and the mantle. Its abundance in the atmosphere is 5.2 ppm by volume but commercially extractable concentration of He (0.03-7 vol.%) is expected mainly from crustal sources. Helium with its light weight and small size of atom easily escapes in space. Helium has two stable isotopes (*^{3}He- 0.0002%* ; *^{4}He-99.9998%).* He-3 is rare and 'Primordial' in the mantle of the Earth, while the 'prolific' He-4 is *both radiogenic and primordial.* Radiogenic helium comes from the alpha decay of ^{235}U, ^{238}U and ^{232}Th. ^{3}He/^{4}He ratio in atmosphere is found to be 1.4 x 10^{-6}.

He isotopes greatly vary depending on its origin. The He-3 is mostly associated with tectonic and volcanic active areas of the Earth. The significant terrestrial sources of He-3 are mid-ocean ridges and subduction zones along converging plate margins. The other alternative source of He-3 is thermal neutron capture by Li-6, especially in claystones (^{6}Li(n,α) ^{3}H(β)→^{3}He). This is possible only in the upper few metres of the earth's crust. Large concentrations of radiogenic He-4 are released from granitic bedrocks or sedimentary basins which contain high amounts of

radioactive elements (U & Th). Approximately, 75% of ^{4}He is generated upto 10 km of the crust due to preferential partitioning of incompatible U & Th isotopes in the crust. The crustal sources of helium include natural gas fields, oil field brines, geothermal fields associated with high heat generating granites, groundwater, mineral deposits, hydrothermal solutions, volcanogenic degassing, lakes, ice, sediments and coal seams. A small proportion of helium is also present in mantle sources (mainly magmatic He-4 resulted from the decay of U and Th). The noble gases are brought into crustal reservoirs from the mantle and the atmosphere. Thus, the stable isotopes of He are present in association with other stable noble gas isotopes such as: ^{20}Ne, ^{21}Ne, ^{22}Ne, ^{36}Ar, ^{38}Ar and ^{40}Ar. They are either radiogenically or nucleogenically concentrated in the crust, mantle or atmosphere.

^{3}He/^{4}He ratio is important input for guiding the exploration strategy as it shows the binary mixing of mantle/crustal helium sources and can be used to trace the source of helium on earth.

Helium market and demand

Helium prices increased before the COVID-19 pandemic, and even though the pandemic has affected the market, it is likely to bounce back as the world begins to recover out of the pandemic. Crude helium price for Government users was $3.10 per cubic meter and for non-government users was $4.29 per cubic meter during fiscal year 2020. The global helium market has been estimated worth ~$10.6 billion in 2019 and is expected to grow at a compound annual growth rate of 11% and reach ~$15.73 billion by 2023.

Helium is a significant cryogenic commodity. Liquid helium finds use in cooling magnets in MRI/ventilator machines and supercomputers. The major share of world's helium supply goes into MRI scanners (~30%) and manufacture of hard disks and semiconductors (~20%). The massive data centres of Big Tech companies like Google, Amazon, Facebook and Netflix are the heavy users of helium. It is forecasted that over the next decade or so, this market segment is likely to be one of the fastest-growing to supplement the unappeasable appetite for data.

The U.S.A presently account for ~40% of the global He-supply. The U.S. Federal Helium Reserve (FHR) in Amarillo, Texas, which has been the single largest source of world's helium for the past 70 decades, is now exhausted. Consequently, helium prices have been increasing.

The demand-supply imbalance may lead to a helium price boom as very few mines have been discovered and finding a substitute for helium appears unlikely.

Helium prospective geological domains in India

The annual consumption of helium in India is presently ~0.15 billion cubic feet (equivalent to ~2.3% of annual world He consumption) and most of it is imported from USA. The natural gas and oil fields of USA, Algeria, Poland and Russia are rich in He (3−7 vol%). In contrast, the natural gas reservoirs in India are lean in He (~ 0.05 vol%). Hence, there is an urgent need to look for helium from crustal sources in India. The geothermal provinces in India in West Bengal, Jharkhand, Meghalaya, Assam, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Chhattisgarh, Maharastra, Gujarat and Andaman and Nicobar Islands are rich source of helium as the granites exposed in these areas are marked by high concentration of uranium and thorium **(Table-1**).

Table 1. Helium concentration in different geothermal areas in India (Chaudhuri et al. 2019).

Sl.	Location & State	Nature of Sample	Temperature (°C)	Helium (in ppm)
1	Baratang, Andaman & Nicobar Islands	Mud Volcano	Ambient	*2,000*
2	Garampani, Assam	Hot spring gas	37.10	*8,000*
3	Borpung Nambour, Assam	Hot spring gas	36.70	*3,000*
4	TattaPani, Chhattisgarh	Hot spring gas	95.0	*2,000*
5	Tuwa, Gujarat	Hot spring gas	63.00	*7,600*
6	Unai, Gujarat	Hot spring gas	-	*68,900*
7	Manikaran, Himachal Pradesh	Hot spring gas	94.20	*<100*
8	Kasol, Himachal Pradesh	Hot spring gas	69.40	*<100*
9	Tattapani, Himachal Pradesh	Hot spring gas	54.60	*3,000*
10	TattaPani Bathing Ghat, Jammu and Kashmir	Hot spring gas	55.00	*1,600*
11	TattaPani Meherot, Jammu and Kashmir	Hot spring gas	45.10	*11,500*
12	Tantloi (main spring), Jharkhand	Hot spring gas	66.00	*13,000*
13	Suraj Kunda, Jharkhand	Hot spring gas	52.00	*9,400*
14	Arnala, Madhya Pradesh	Hot spring gas	-----	*7,900*
15	Tural, Maharastra	Hot spring gas	62.00	*17,400 to 30,500*
16	Koknere, Maharastra	Hot spring gas	58.00	*10,000 to 21,200*
17	Unhavre, Maharastra	Hot spring gas	70.00	*15,000 to 24,300*
18	Akoli, Maharastra	Hot spring gas	54.00	*23,600*
19	Ganeshpuri, Maharastra	Hot spring gas	52.00	*21,300*
20	Pali, Maharastra	Hot spring gas	43.00	*29,200*
21	Sov, Maharastra	Hot spring gas	42.00	*28,300*
22	Salbardi, Maharastra	Hot spring gas	42.00	*33,000*
23	Sativli, Maharastra	Hot spring gas	52.0	*15,900*
24	Jakrem, Meghalaya	Hot spring gas	46.40	*9,200*
25	Attri, Orissa	Hot spring gas	54.80	*11,600*
26	Taptapani, Orissa	Hot spring gas	40.90	*7,200*
27	Tarabalo, Orissa	Hot spring gas	41.80	*5,100*
28	Bakreswar Agni Kunda, West Bengal	Hot spring gas	69.10	*18,800*
29	Bakreswar Khar Kunda, West Bengal	Hot spring gas	66.00	*13,600*

Rate of generation of helium from the uranium and thorium isotopes in deep seated environments of the earth are found to be 1.03×10^8 atoms/ m^3/s and 2.43×10^{10} atoms/m^3/s respectively. Helium being a highly diffusive gas, the radiogenic He generated from these radioelements interacts with the deep circulating fluids in the Earth. Therefore, the relationship between heat and helium is considered to be an important indicator to estimate helium potential of the large heat sources beneath the Earth viz. geothermal reservoirs.

Variation in total volume of helium generation in different rock types like granite, carbonate, shale, and hot shale as a function of geological time have been studied by Brown 2010 and Pereira 1980 to assess the possibility of extraction of helium generated from the radio-elemental concentrations in these rocks **(Fig.1, Table 2**).

Geologically, the Himalayan belt, Son-Narmada lineament, Aravalli fold belt, Naga-Lushi, West coast regions, Andaman & Nicobar volcanic arcs, Cambay basin and the cratonic provinces of Peninsular India are the potential geothermal provinces of India favourable for helium exploration (**Fig. 2**).

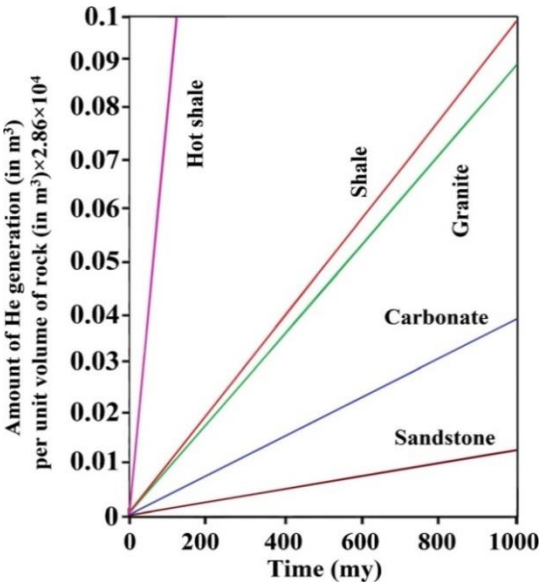

Fig. 1 Variation in total volume of He generation in various rocks with different geological time (modified after Brown 2010; Pereira 1980)

Table 2 Variation in U and Th content in crustal rocks (Brown 2010 and Pereira 1980)

Sl.	Rock type	Rock nomenclature	U- Content (in ppm)		Th content (in ppm)	
			Average	Range	Average	Range
1	Igneous	Alkaline	8.20	0.10–19.70	17.20	0.60–35.00
		Intrusive Silicic extrusive	5.00	-	–	–
		Granitic	4.80	2.20–7.60	21.50	8.00–56.00
		Gabbroic	0.80	0.20–3.40	3.80	–
		Basaltic	0.40	0.10–1.00	1.60	0.20–5.40
2	Sedimentary	Shale	4.20	3.20–8.00	4.80	10.20–13.10
		Limestone	2.10	0.30–9.00	2.20	1.10–7.50
		Sandstone	1.30	0.50–3.20	3.40	1.00–9.00
3	Metamorphic	Schist / gneiss	2.90	0.20–11.00	8.60	0.10–27.00
4	Soil	-	1.13	0.27–2.08	6.94	4.03–14.10

Gas emanating from some thermal springs in the geothermal provinces often contain significant amount of helium and can be extracted from these springs. There are more than 300 hot springs located in different parts of India and many of them release gases rich in helium (> 1 vol.%). Commercial recovery of helium from such thermal spring gas source is possible if flow rate of helium is optimum for recovery. These hot springs are considered as a source of geothermal power. The geothermal zones of India have moderate to high geothermal gradient (47-100^{0}C) and heat flux (78-468 mW/m^2). There are many regions in the country that are characterised with high geothermal gradient (> 60°C) and high heat flux (> 200 mW/m^2) for the utilisation of green geothermal energy **(Table-3)**. Moreover, there are reports of high values of lithium (Li) and boron (B) associated with deep seated hot spring geothermal waters in India and other parts of the world. Thus, targeting the geothermal resources has two (02) fold importance: (a) generating green geothermal energy and (b) extracting He, Li and other associated metals from geothermal water.

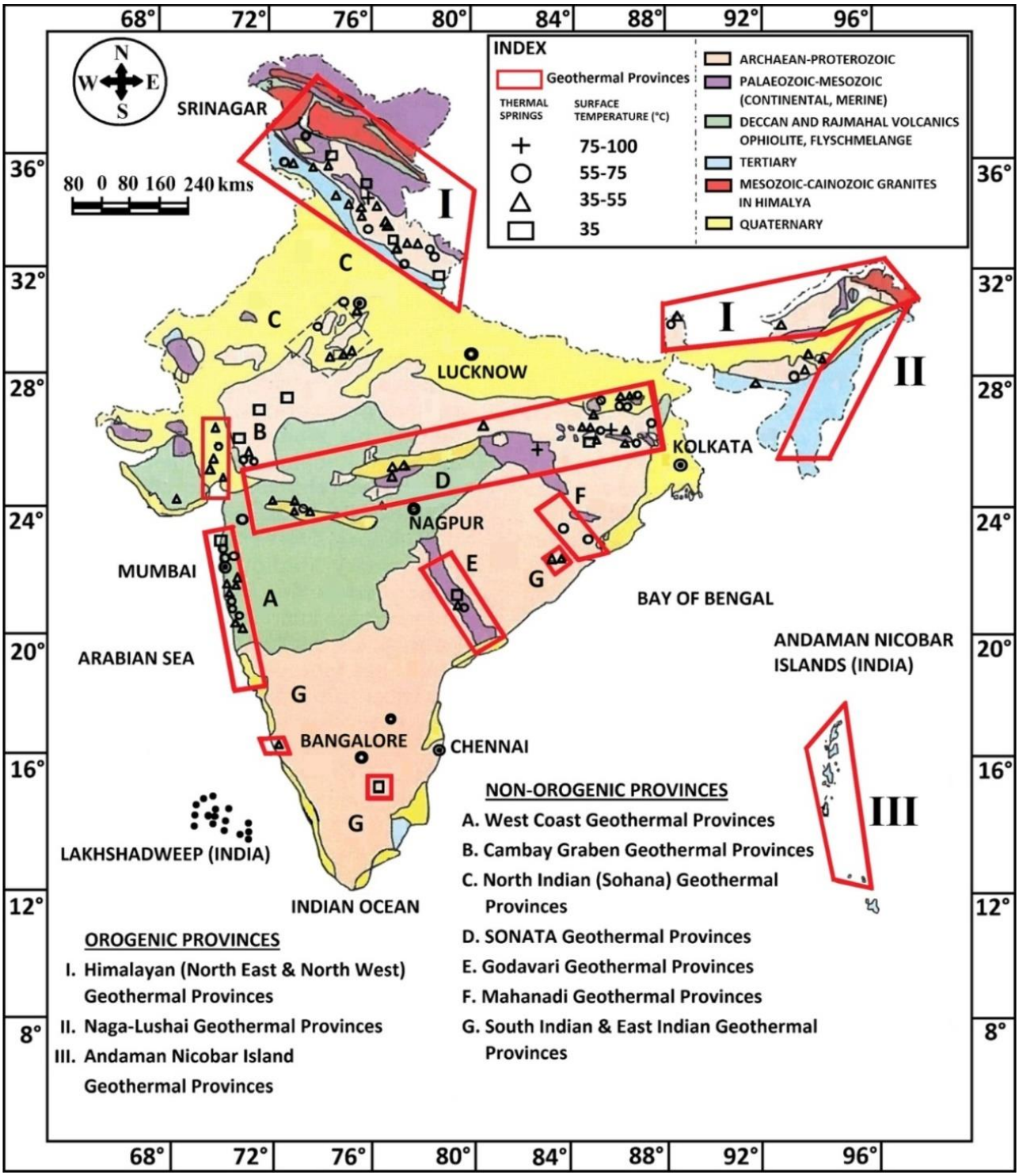

Fig. 2 Geothermal provinces in India (modified after Thussu 2002; Krishnaswamy 1975)

Table- 3 Heat flow, geothermal gradient, geothermal reservoir temperature and hot spring temperature of some well- known geothermal areas of India (Thussu 2002; Chandrasekharam 2000; Shanker et al. 1991)

Sl.	Geothermal provinces	Heat flow mW/m^2	Geothermal gradient (°C/km)	Geothermal Reservoir temp. (°C)	Hot spring temp. (°C)
1	North Western Himalayan Zone	200	100	150–220	30–98
2	North East Himalayan Zone	130 ± 30	60 ± 20	–	–
3	North Indian Geothermal Zone (Sohna-Delhi and Aravalli geothermal zone)	100 ± 25	45	–	–
4	Cambay Graben	75 ± 18	50	150–175	40–90
5	West Coast	130 ± 10	50	102–137	40–70
6	Son-Narmada-Tapti (SONATA) zone	300	40–120	120–150	50–98
7	Damodar valley	–	45	–	–
8	Godavari valley	80 ± 20	40	175–215	50–60
9	South Indian cratonic areas	–	30–38	–	–

Initiation of He- exploration in India

Preliminary investigations in seventies by Variable Energy Cyclotron Centre (VECC) and Atomic Minerals Directorate for Exploration and Research (AMD) at Bakreswar, District Birbhum, West Bengal revealed the presence of helium in the area. Two groups of thermal springs at Bakreswar, West Bengal and Tantloi, Jharkhand recorded substantial quantities of helium as bubbling emanations. This region reflects a very high geothermal gradient (~90°C/km) and high heat flow rate (~200mW/m^2) and hosts almost 60 hot springs within 2,500 sq km area. The volume of gas that escapes from the hot spring vents and the wells drilled in the above sites is 130 L/h and the flow rate of thermal water is 21,000 L/h. The temperatures of the thermal waters vary from 70-75ºC. The geothermal gradient and heat flow rate values of the Bakreswar-Tantloi geothermal area are 80ºC/km and 200 mW/m^2 respectively.

Considering the growing strategic need for helium, AMD has re-initiated helium investigations in parts of Bakreshwar, Tantloi, Phulsari, Rautara, and Rajnagar areas in Birbhum and Dumka districts, West Bengal and Jharkhand since 2019. Initially, reconnaissance survey by means of

hot spring water and soil-gas sampling in specially fabricated tedlar bag (Poly Vinyl Fluoride material) using indigenously developed gas sampling technique was taken up. Analytical support for analysis of helium and associated gases (H_2, O_2, N_2, Ar etc) using Gas Chromatography–Mass Spectrometer (GC-MS) was provided by Analytical Chemistry Division, BARC and Heavy Water Plant, Vadodara. These samples indicated significant presence of helium in spring water and in soil-gas. This was followed by radon surveys in selected tracts to delineate radon anomaly vis-à-vis the structural trends. This has helped in narrowing down target area for follow up exploratory drilling.

Simultaneously, AMD is collaborating with ONGC Energy Centre (OEC) for helium exploration. OEC has established presence of substantial helium in Rohtas Limestone of Vindhyan basin in Sagar and Hatta areas, Madhya Pradesh. The boreholes drilled by OEC in these areas have recorded encouraging concentration of helium. Rohtas Limestone has the established potential to generate helium as reported by OEC. AMD is further carrying out soil gas sampling (reconnaissance stage) to evaluate the role of deep-seated faults related to Son-Narmada-Tapti Lineament for upward migration of helium in these areas.

More recently, AMD has initiated exploratory core drilling, depth-wise gas sampling, thermal logging of the boreholes in parts of Bakreswar – Tantloi areas. The present stage of exploration is focussed on narrowing down the potential target areas for helium. In the subsequent stages of exploration, further drilling will be deployed to explore the continuity and trend of the fractures which are the conduits of helium emanation. Besides, geophysical surveys (IP/resistivity and gravity-magnetic) have also been taken up for sub-surface mapping of faults/fractures and guiding the drilling programme and delimiting the potential helium productive zones in the area.

Conclusion

Helium has wide range applications in several fields of fundamental science, cutting edge technologies, medical appliances and other industries besides defence space and atomic research related strategic requirements. India has no known helium resources and most of its present requirement is met through imports. Helium is usually produced as a by-product of natural gas from the oil & natural gas fields in countries like USA, Algeria, Poland, Qatar, and Russia where He concentrations range 3–7 vol%. Natural gas and oil fields in India are poor in He (~ 0.05 vol%). However, the hot springs in the known geothermal provinces of India are enriched with

He (upto 3.30 vol%). SONATA geothermal provinces is considered as the first order target for He exploration in a large scale considering the high heat flow (~300 mW/m^2) and geothermal gradient (40-120°C/km) in the area.

AMD, VECC and OEC have initiated survey and exploration for helium in different parts of the SONATA geothermal provinces mainly in Bakreswar, West Bengal, Tantloi, Jharkhand, Sagar-Hatta-Banda areas in Madhya Pradesh and parts of Tattapani geothermal area in Chhattisgarh. Major breakthrough in the recent exploration efforts by AMD and OEC will lay the foundation for building the framework for self-sufficiency in helium resources and production capability in India.

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Biosketch of Dr. D.K.Sinha

Dr. Deepak Kumar Sinha the Director, Atomic Minerals Directorate for Exploration and Research (AMD) has vast experience in exploration of atomic minerals spanning over 38 years in different geological domains of the country. He was instrumental in discovery, development and establishing of a unique polymetallic uranium deposit at Kudada, near Turamdih Uranium

Mine, Jharkhand. Dr. D.K. Sinha received the "DAE Group Achievement Award – 2019" for the discovery and development of the deposit as group leader.

He has effectively guided and monitored the Airborne and Heliborne survey operations, Geospatial Database Management System (EGDMS) project of AMD. His strong geological acumen to collaborate with Universities has highly been appreciated. An adjunct professor in Homi Bhabha National Institute (HBNI), Mumbai, an institute of national Importance, he is a recognized Ph.D supervisor for RTM Nagpur University, Nagpur and Osmania University, Hyderabad.

His several strategic assignments for Department of Atomic Energy (DAE) and his contributions have been recognised by the Department in 2012 and was conferred upon "Special Contribution Award-2011" for valuable services in the field of Nuclear Science & Technology and to the programme of the DAE..

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Nanotechnology: Genesis, Growth and Future Prospects

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Abstract:

The current surge of interest in nanotechnology is partly driven by the miniaturization of devices and new technologies. The history of nanotechnology goes back to many centuries. Advanced experimental tools have opened up new possibilities for studying nanostructures down to the atomic level. Among different nanoparticles, magnetic nanoparticles and their dispersions (ferrofluids) are intensively studied owing to their applications in diverse fields such as magnetic refrigeration, catalysis, cell labeling, contrast agents for magnetic resonance imaging (MRI), cell separation, selective removal of cancer cells and drug delivery. Dispersion of magnetic nanoparticles exhibit several fascinating applications in heat transfer, cation sensing, defect sensors, optical limiters, and biomedicine. Besides they are wonderful model systems to probe molecular interactions and structural transitions under external stimulus.

1. Introduction

The seeds of nanotechnology was planted by the physicist and Nobel laureate Richard Feynman in his 1959'[1]. Nanotechnology deals with control and manipulation of matter at the level of about 1 to 100 nm. By now it is well established that nanotechnology can produce smaller, cheaper, faster, better information and devices/systems. The history of nanotechnology goes back to many centuries. For example, gold nanoparticles were used in coloring glasses in medieval times and during the days of ancient Romans and Michael Faraday made gold nanoparticles in1850. So though nanoscience is very new, the technology is very old. The current surge of interest in nanotechnology is partly driven by miniaturization of devices and new technologies. Advanced experimental tools have opened up new possibilities for studying nanostructures down to atomic level. In 2000, national nanotechnology initiative was launched in

US with an approved budget of $500 million. Subsequently, other countries launched similar initiatives to promote the Nanotechnology program. The top five organizations with maximum number of patents on nanotechnology (1970 – 2011) are Samsung Electronics, Nippon Steel, IBM, Toshiba and Cannon. Nanomaterials exhibit peculiar size dependent optical, electrical, magnetic and chemical properties due to (i) the large fraction of surface atoms; (ii) spatial confinement (iii) high surface energy; and (iv) reduced imperfections [2]. Some of the novel properties of nanomaterials over their bulk counterparts are:

- Significantly lower melting point or phase transition temperature due to large fraction of surface atoms.
- Better mechanical properties such as yield strength and hardness.
- Unusual optical properties, magnetic, electronic properties and thermal properties
- High chemical reactivity.

Nanomaterials or structures are classified as 0D, 1D and 2D based on the number of dimensions that are confined to the nanoscale. OD materials are nanosized particles that have their diameters within the nanometer range (e.g., nanoparticles), 1D materials have a nanometric diameter but have a length that is much larger than nanoscale, 2D materials have a thickness in nanoscale but have larger in the other two dimensional planes (thin films). 3D materials have length scale larger than nanoscale in all three dimensions. Among different nanoparticles, magnetic nanoparticles and their dispersions (ferrofluids) are intensively studied owing to their applications in diverse fields such as magnetic refrigeration, catalysis, cell labeling, contrast agents for magnetic resonance imaging (MRI), cell separation, selective removal of cancer cells and drug delivery.[3] Another class of materials which is becoming popular in these days is smart materials or stimuli responsive materials. These are material with an ability to change their properties under a stimulus like, heat, temperature, sunlight, pH, stress, strain , magnetic or electric field etc.

Nanostructures have been present in nature for millions of years (e.g., moth's eye, coccolith, alpine flower, butterfly, gecko, lotus leaf). Now scientists and engineers are trying to create such nanostructure by learning from nature. The unusual properties of nanomaterials have been employed in a variety of applications such as solar cell designs, biomedical applications, light emitting diodes, lasers, photography, catalysis, biological labeling,

photonics, optoelectronics, information storage, catalysis, nanoelectronics, electric batteries, field emitters, radiation sources, spintronics, sensors, field emission displays, gas sensors, quantum computing, energy storage, energy conversion devices, and hydrogen storage media. What we see today is the evolutionary application where we improve the existing processes, materials and applications by exploiting the unique size dependent properties of materials at the nanoscale. A good example for this is the computer/electronics devices where nanolithography made interconnects with smaller nanostructure that enabled to shrink the size of electronic devices and computers.

2. Work Done at IGCAR

Dispersion of magnetic nanoparticles exhibit several fascinating applications. Besides they are wonderful model systems to probe molecular interactions, structural transitions under external stimulus etc. In this section, I discuss a few applications developed in our laboratory using magnetic nanofluids.

2.1 Nanofluid with tunable thermal properties

In 2008, we experimentally demonstrated the tunable thermal property of a magnetically polarizable nanofluids for the first time.[4] By controlling the linear aggregation length, the thermal conductivity (TC) was enhanced up to 300 % with a small fraction of particles. **Figure 1** shows the thermal conducitivity ratio and the enhancement as a function applied magnetic field in the magnetic nanofluid containing 4.5 vol.% of Fe_3O_4 nanoparticles.

This discovery enabled new possibilities to use magnetic nanofluids as a new class of coolants for nanoelectromechanical system and microelectromechanical system based devices. .[5]

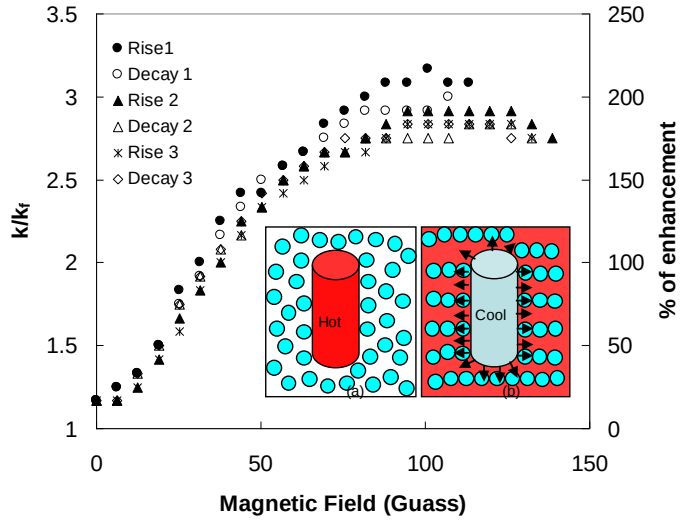

Figure 1. The thermal conductivity ratio and the enhancement as a function applied magnetic field. The inset shows the mechanism of heat transport from a cylindrical device immersed in magnetic nanofluid without and with magnetic field.(Reproduced from J. Philip et al. Appl. Phys. Lett. 92, 043108, 2008).

2.2 Nanofluid based optical sensor for defects detection.

We have developed a simple sensor for detecting internal defects in materials using a magnetically polarizable nanoemulsion. This new technique enabled visual inspection of buried defects in ferromagnetic components and has many advantages over the conventional magnetic flux leakage testing probes. **Fig. 2 a-i** show the schematics and the corresponding photographic images of the nanofluid sensor response.

The centre line on the colour pattern was straight for the rectangular slot and semicircular pattern for the cylindrical slot. The defects are clearly discernible from the images, though color contrasts were not very clear.[6]

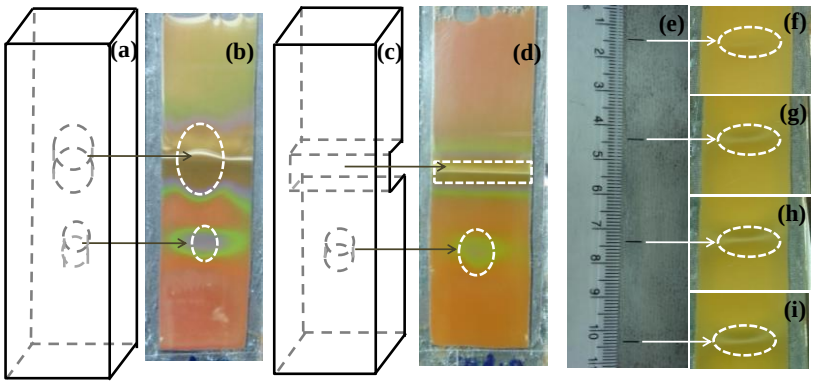

Figure 2. Schematics of the specimens S1–S3a–d (a, c and e) and the corresponding photographic images of nanofluid sensor (b, d and f–i), respectively. (f–i) are S3a, S3b, S3c, S3d, respectively. [Reproduced from V. Mahendran and J. Philip, NDT&E Int. **60**, 100, 2013)].

2.3 Magnetic nanofluid based sensor for ultrasensitive detection of Analytes:

We have also developed a magnetic nanofluid based sensor for ultrasensitive detection of biologically important metal ions such as Na^{+}, K^{+}, Ca^{2+}, Cu^{2+} and Fe^{3+} ions using an oil-in-water nanoemulsions. The sensor was tested for Na^{+}, K^{+}, Ca^{2+}, Cu^{2+} and Fe^{3+} ions. This approach is also extended for detection of glucose, ammonia and methanol. **Figure 3** shows the effect of methanol on the Bragg peak.[7]

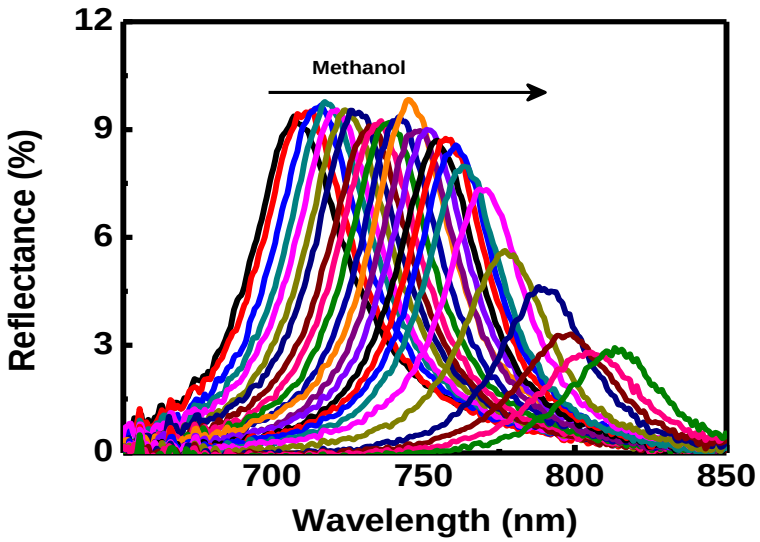

Figure 3. Effect of methanol on the Bragg peak. The arrow indicates the increase in methanol concentration starting from 0 to 5000 ppm. [Reproduced from V Mahendran and J. Philip, Langmuir **29**, 4252 (2013)].

2.4 Magnetic nanofluid based non-enzymatic sensor for urea detection

Using magnetic nanoemulsion, we have developed an optical probe for the detection of urea. In the presence of urea, the probe showed a large wavelength shift in the visible wavelength range, due to complexation of urea with the functional moieties. The fast response time of the sensor and the wide urea detection capability are the unique features of the new sensor.[8]

2.5 Efficient removal of dye using Fe_3O_4 nanofluids:

We have synthesized cellulose capped magnetite nanoparticles for efficient removal of cationic dye. Fig 4. Shows the photograph of methylene blue mixed with magnetic

nanoparticles before and after dye removal. (Bottom figure shows the schematic showing MB captured by magnetic nanoparticles. This new approach enabled a new platform for efficient magnetic separation technology.[9]

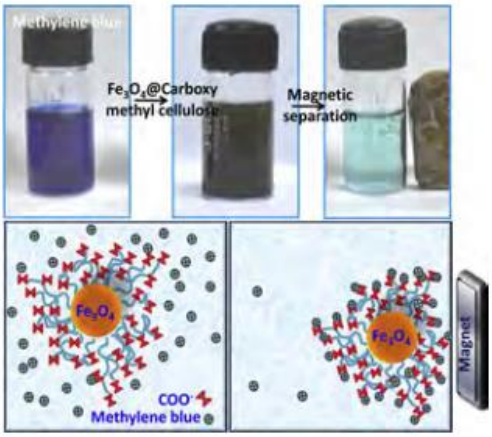

Fig 4. (Top) Photograph of methylene blue, MB mixed with magnetic nanoparticles before and after dye removal. (Bottom) schematic showing MB captured by magnetic nanoparticles.[reproduced from C. Anushree, J. Philip, Colloids and Surfaces A 567 (2019) 193–204)]

2.6 Efficient cancer therapy using magnetic nanofluids:

Magnetic fluid hyperthermia is an emerging cancer therapy where superparamagnetic Fe3O4 magnetic nanoparticles are used to selectively ablate the cancer cells. The advantages of using magnetic nanoparticles include biocompatibility, the distal guidance, superior in vivo efficiency and low side effects. We have developed magnetic nanomaterials with superior heating

efficiency by controlling the size and distribution, morphology and insitu orientation of magnetic nanoparticles during the radiofrequency induced heating. Recently we have demonstrated a 62% enhancement in heating efficiency in a magnetic fluid containing SPM particles.[10]

3. Conclusions

Materials with superior properties are necessary for miniaturization, reduction in manufacturing cost and power saving. Among various new materials, nanomaterials have been at the forefront because of their superior properties and interesting technological applications in diverse fields. Nanotechnology has made tremendous progress in various fields over the last two decades. Nanotechnology has become a part of daily life with many nanotechnology products available in market now. Truly revolutionary nanotechnology envisages nanorobots and nanomedicine performing diagnosis, surgery and drug delivery, which are yet to emerge. We have developed several fascinating applications using magnetic fluids in heat transfer, cation sensing, defect sensors, optical limiters and biomedical applications.

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Biosketch of Dr. John Philip

Dr.John Philip obtained a Ph.D from the Indian Institute of Technology, Madras. He did postdoctoral research at CNRS, France and at University of Hull, UK. In 1995, he joined the Metallurgy and Materials Group of Indira Gandhi Centre for Atomic Research, Kalpakkam. Presently, he is the Associate Director of the Materials Characterization Group and Head of Smarts materials section at the metallurgy and materials group. He is also a Professor at Homi Bhabha National Institute. He is an elected Fellow of the National Academy of Sciences.

He has six patents in his credit and over 300 publications in leading refereed international journals. His H-index is 57 with over 15000 citations. He has delivered more than 180 invited lectures in India and abroad. His name is listed in World's top 2% scientists data published by Elsevier and Stanford University, USA in the years 2019, 2020 and 2022.

He is the recipient of several awards, which include Science and Technology excellence award, INS medal, NDT man of the year award, MRSI medal and Ron Halmshaw award of British Institute of NDT and Distinguished Faculty award of HBNI in 2015 and Homi Bhabha Science and Technology award in 2016. He was the founding editor-in-chief of the Journal of Nanofluids of American Scientific Publishers and served as EIC for 8 years. He is an editorial board member of journals and reviewer of many international journals and national and international funding agencies. He is a research council member of ARCI, DST, Hyderabad, Member, Scientific Advisory Committee of DST, academic council member of Hindustan university, and medical Biotechnology and nano-technology sectional committee of Bureau of Indian standards. 21 Ph.D students have completed their Ph.D under his guidance.

Environmental Release and Management of Unintentionally Produced Persistent Organic Pollutants in India

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Abstract :

The environmental release of unintentionally produced persistent organic pollutants (UpPOPs) dioxins and furans have been assessed at the country level as a part of the preparation of National Implementation Plan (NIP). During the NIP preparation the ground level situation of environmental release of intentional POPs and UpPOPs have been assessed through proper inventorisation , sample collection , analysis and interpretation. In the present paper the environmental release of UpPOPs , polychlorinated dibenzo-p-dioxins/ dibenzofurans have been elaborated.

Introduction :

Persistent organic pollutants (POPs) are drawing the attention of environmentalists over the last two decades because of their very high toxicity to human beings. Pesticides, polychlorinated-bi-phenyls (PCBs), dioxins and furans (D&F) and few of the industrial chemicals are some such POPs restricted by the Stockholm Convention (SC). Convention has established the measures for 28 POPs, which are used either as pesticides or in commercial manufacturing processes or unintentionally produced in the industries or high temperature-based processes. Government of India (GoI) Ministry of Environment and Forest (MoEF) has submitted the National Implementation Plan (NIP) to SC for 12 POPs in March 2011. The submission of India's NIP on POPs has fulfilled the commitments set out by the convention and also indirectly helped in India's own chemical management.

During the NIP preparations the environmental releases of intentional and unintentionally produced POPs (UpPOPs) have been evaluated by proper inventorisation, sampling, analysis and interpretation.

Work :

The National Inventory on environmental release of UpPOPs with chemicals identified as polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) have been discussed below.

The intensive agriculture, polluting industry and unplanned urbanisation have caused enormous disturbance to the environment of the specific country and as well as across the globe, Emerging technologies have been responsible for releasing many unknown pollutants and causing great public concern all over the world. Extensive community and regulatory agencies are on to maintain a healthy environment and to provide better life to the people of the world. The Stockholm and Rotterdam Conventions have targeted some of the emerging pollutants viz. persistent organic pollutants (POPs) and UpPOPs, pesticides and other hazardous chemicals.

These man made organic contaminants can be broadly classified into the following four very broad categories.

- Hydrocarbons
- Pesticides
- Herbicides
- Industrial Solvents

<u>Persistent organic pollutants (POPs)</u>

There are 28 POPs covered by the Stockholm Convention so far. POPs can always be transported across different countries through ocean, atmosphere and migratory species. They have a tendency to bioaccumulate in human bodies and other animals. Some of the POPs are banned, but some countries still produce and use such chemicals. For example DDT is used in vector management for disease control. Stockpile of unwanted POPs exists in many parts of the world, including India. All these could be mitigated and controlled by multilateral approach and adequate addressing of the problem.

The Stockholm Convention

This convention (SC) held in Stockholm on 22 May 2001 on POPs was signed by 90 countries at a diplomatic conference. The Convention entered into force on 17 May 2004. The first meeting of the Conference of the Parties was held in Punta del Este, Uruguay during 2-6 May 2005. The meeting was held in Geneva, Switzerland on 8 May 2008 in which 152 countries, including India, had signed the Convention and 128 countries had ratified it.

In June 2017 the Stockholm Convention declared the control measures for 28 POPs. These are either used as pesticides or in commercial manufacture processes or are unintentionally produced in industries. These chemicals are listed in three Annexures A, B and C in the category of: To be eliminated, restricted use and UpPOPs to the Convention.

All these chemicals have been classified for international action based on their persistence, bioaccumulation, dispersion and toxicity. Three broad areas covered are:

- Pesticides: intentional chemicals
- Dioxins, furans, dioxin-like PCBs: UpPOPs
- POPs in stockpiles and waste, e.g. pesticides, PCBs

Regulations on Chemicals

In India comprehensive legislation is available for various chemicals at different stages of life cycles. However, due to the cross-sectoral nature of chemical management it has been addressed in several parts of legislation, regulations or standards in the country. In India the industries production, chemical waste and all related industrial aspects including POP chemicals are regulated and managed under various Acts /Rules/ Notifications maintained by GOI time by time since 1962.

Environmental Contaminants in India

The country's commitment towards SC has been facilitated by MoEF, GOI in (2007-08) through the participation of various Indian institutions for the action on identified POPs. Initiatives were based on primary and secondary data collection from different activities associated to prepare the

national inventory on POPs issue. In respect to UpPOPs data have been collected from all the North, Central, East, West and South zones of the country and compiled and evaluated. This has been achieved by accessing the ground level status of UpPOPs through inventorisation, sample collection, analysis and interpretation of such releases from unintentional and intentional production and use in various sectors.

Release of Unintentional POPs (UpPOPs)

The annual releases of UpPOPs, PCDD and PCDF estimates have been calculated using UNEP Toolkit. It was estimated as 8565.55g TEQ (Toxic Equivalent Quotient). The waste incineration and ferrous and non-ferrous metal production categories have the major contribution in UpPOPs emission followed by heat and power generation (*Table 1*).

In annual releases the waste incineration has the major share of 66.75%. At the time of data collection (2009-10) nearly 4.4 mt/year of hazardous waste generation in India was reported. The second major share of 20.22% was from ferrous and non-ferrous metal production. Waste incineration and ferrous and non-ferrous metal production sectors were identified for special attention and control. To achieve the requirement under Stockholm Convention the implementation of best available technique (BAT) and best environmental practice (BEP) were suggested to undertake for the minimisation or elimination of the formation of UpPOPs release. The reported data (2009-10) on dioxin release activities in the country have not reflected the complete status because of the various reasons associated. The present inventory was considered as preliminary inventory of the period referred. The major quantity of dioxin has been released to residues and then to air. The potential categories were waste incineration and ferrous and nonferrous metal production (*Table 1*).

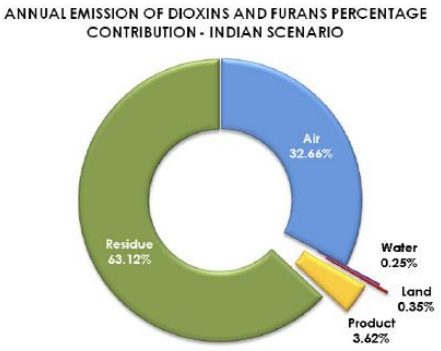
Table 1 : Environmental releases of Unintentional Persistent Organic Pollutants in India

Source	Annual Release of PCDD/Fs (gTEQ/a)						
	Air	Water	Land	Products	Residues	Total	%
Waste incineration	1812.14				3965.83	5777.97	66.75
Ferrous and non-ferrous metal production	539.68				1210.36	1750.04	20.22
Heat and power generation	308.65				195.50	504.15	5.82
Production of mineral products	141.33					141.33	1.63
Transportation	9.57					9.57	0.11
Uncontrolled combustion processes	15.19		30.29			45.48	0.53
Production and use of chemicals and consumes goods	0.174	20.27		243.51	88.51	352.46	4.07
Miscellaneous	0.566				0.16	0.73	0.01
Disposal/Landfill		1.22		70.16	3.44	74.82	0.86
TOTAL	2827.30	21.49	30.29	313.67	5463.80	8656.55	100.00
Release To Matrix (%)	32.66	0.25	0.35	3.62	63.12		100.00

* *Toxic equivalent quotient per annum*

The highest amount of PCDD and PCDF were released into residues 63.12% (5463.80gTEQ), followed by air emissions 32.66% (Fig 1) of the total releases. Waste incineration and ferrous and non-ferrous industries discharge contributed a large amount into residues. Fine fly ashes and dusts contain byproducts of PCDD and PCDF in concentrated form, hence not emitted in air.

The potential of residue to cause environmental contamination with PCDD & PCDF exposure mainly depends on how the residue is treated and disposed off. In case of not properly doing the incineration and effectively destroying the PCDD and PCDF contaminated waste from the chemical industry may result into creation of a reservoir source. Residues from one process may become raw material in another



process and if not processed for control measures, would release PCDD and PCDF in air, water or product. This needs to be given some importance because generally air releases are mostly considered by regulatory agencies. In the case of PCDD and PCDF there is a necessity that current regulatory mechanisms need to be updated to address these pollutant releases in a holistic manner.

Conclusion :

The status of environmental releases of PCDD and PCDF (2009-10) has been discussed at the country level. The annual releases calculated using UNEP Toolkit were estimated as 8656.55g TEQ. The major contribution was found from waste incineration and ferrous and non-ferrous metal productions followed by heat and Power generation sectors. Waste incineration had contributed 66.75% of the total annual releases. The copper recycling was the most leading activity under second highest source of ferrous and non-ferrous metal production for PCDD and PCDF releases. These sectors were reported to be the most important sector for controlling the environmental releases. Residue released 63.12% the highest amount of PCDD and PCDF followed by air emission with 32.66% of the total releases. The present data on environmental releases of PCDD and PCDF have been used to work out the strategies for elimination/ reductions of these UpPOPs for the chemical management of the Nation's resources in order to attend to the ultimate goal of sustainable development.

Acknowledgement :

Author wants to convey her sincere thanks to Director CSIR - National Environmental Engineering Research Institute, Nagpur (India) for his support and continuous encouragement in conducting these studies. Entire team is grateful to UNIDO, Vienna and MoEF, GoI for financial support.

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Brief Biosketch of Dr. Neeta Thacker

Dr. Neeta Thacker is an Environmental Scientist and Researcher. She worked as Chief Scientist and Head at Analytical Instruments Division and Academy of Scientific and Innovative Research of CSIR-National Environmental Engineering Research Institute, Nagpur, Maharashtra, India (1977 - 2014). She has published books , papers in National and International journals and patents for the technologies on Improved Water Filter for removal of pesticides and trihalomethanes. Recipient of Hiyoshi Think of Ecology Award, Hiyoshi Corporation,Japan 2014, Best Paper Award, Hindi Science Academy Council 1997, fellow, Japanese Association of University Women, 1982, and WHO 1987, Maharashtra Academy of Sciences 2003 and Member of many learned National and International Societies. Personal Email: neetathacker9@gmail.com

CORONA Vs POLLUTION: A LOVE-HATE RELATIONSHIP

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Abstract

Environmental pollution, destruction of biodiversity, global warming, climate change, population explosion and associated poverty, malnutrition and lack of hygiene etc. are known to exacerbate the elimination of existing species and creation of new species. This will accelerate the emergence and re-emergence of infectious diseases and their transmission. At the same time, the fear and the spread of diseases may lead to more caution, better hygiene, less polluting activities etc. resulting in decreased exploitation of natural resources, slower spread of the disease-causing vectors and thus bringing the disease under control eventually. This scenario is all the more true in the case of the current pandemic of Covid which has brought the entire world to a standstill. When the countries, one after another went under lockdown, the pollution has decreased significantly and environment has become cleaner, the multiplication and spread of the virus slowed down and the pandemic became manageable. This kind of direct and inverse relationship between the environmental degradation and the emergence of diseases can be equated to the simultaneous or alternating 'Love-Hate' relationship in life.

In nature, all species have some predators or other; often multiple predators. The existence and extinction of the species, which is the basis of sustained life on the planet, depend on the complex relation between the species and the predators. The greedy selfish human has declared himself as the super-predator, at the top end of the food chain with presumable license to kill or exploit anything and everything in nature. This arrogance and contempt for other species is the root cause of most problems in the world today. Even among the humans, the richer and the more powerful consider themselves as super predators and so are the nations. Smaller and less affluent nations should remain as passive subservient satellites of the rich and the powerful. Here comes the corona virus, natural or synthesised, as if from nowhere and the whole world has

changed. A miniscule virus, invisible to the naked eye of man, could expose how helpless, weak and incapable the super predator is. In history, there are many instances of such events happening when the arrogance of man becomes uncontrollable and detrimental to other species. Now the arrogant homosapien realized the hard way that the nano-sized corona virus is the real super predator, scaring the all-powerful man to run from pillar to post for cover. The stupid human thought that, just because he could tame the biggest and most fierce animals on earth and reach every remote corner of the earth, and conquer other planets, he is the super power. He thought that his deadly weapons of mass destruction will keep him invincible for ever. Painfully and shockingly he woke up to the reality that his rockets, bombs, missiles and other deadly military hardware are no match to the tiny virus. Man is getting apt response for his arrogance in the same coin. Soon he will realize that there are more such predators of human waiting to strike unless he behaves himself. Covid is indeed an eye opener.

Life on this beautiful planet has changed forever, for good or bad, with the industrial revolution in the 18^{th} century and thereafter. Science and technology replaced man with machines, thereby improving production, productivity and quality at lower cost. Demand for raw materials and other resources grew resulting in over-exploitation of all kinds of scarce natural resources; forest, land, rivers, oceans etc. etc. Pollution increased in geometric proportion, GHG emission is unprecedented, global temperature is increasing, climate is changing radically and the earth is getting defaced beyond recognition. To a great extent the nature has its own corrective mechanism. But now, the rate of exploitation and destruction are beyond what nature can self-repair. Man has to slow down, stop or reverse whatever and wherever needed to protect the earth, its life and prevent the emergence of newer and newer deadly pathogens. Sea level is rising at the level of 3-4mm per year. At this rate 15-20 island nations are likely to disappear from the planet in just 100 years.

More than 16% of all deaths worldwide (~9 million) is attributed to pollution related causes. 25% of these deaths (~2.3 million) is reported to be in India. Unfortunately, the brunt of pollution-related disasters are to be borne by the poor undernourished nations who contributed very little or nothing towards the global pollution. Around 17% of the world population from these vulnerable countries account for more than 28% of all pollution-related deaths.

The indirect effects of pollution and environmental degradation are beyond imagination and will take many years to manifest fully. Effects like decrease in the productivity of soil, availability of water and consequent drastic decrease in food production and the diminishing nutrition value of available food will make future generations less and less healthy and vulnerable to more and more diseases.

Pollution can destroy biodiversity in short term as well as long term. Biodiversity is responsible for the creation and maintenance of life on earth. Loss of biodiversity means loss of life. The international Union for Conservation of Nature (IUCN) Red List recently included 30,178 species threatened with extinction. One-quarter of all assessed species of mammals are in danger. The number of species becoming extinct every year is between 200 and 2,000. The estimated current extinction rate is 1,000-10,000 times higher than the natural extinction rate. For every species becoming extinct at least 5 species which are directly related and 20 species that are indirectly linked will also become extinct eventually. Even more severe is the loss of local species caused by invasive species. Import of foreign plant or animal species will naturally bring disease vectors which are alien to the region. Added to these, in today's world of global village and unpredictable climate change many strange species may be formed and many will be destroyed by the interplay of a number of random events (genetic drift), change in the genetic composition due to various types of mutagens (genetic mutation), natural adaptation and survival of the organisms on the basis of evolution and adaptation (natural selection), region-based isolation of certain organisms that prevents breeding between these animals (geographical isolation), development of different types of reproductive structures which prevents breeding of different species (reproductive isolation), other environmental factors etc. etc. It is possible that the corona virus is the natural result of one or more of the above factors or a product of laboratory development as a biological warfare agent. Many scientists believe that the corona virus is a man-made genetically modified species. This matter needs detailed investigation/analysis, which is beyond the scope of this short paper and is hence not discussed here.

According to some scientists, the emergence and re-emergence of hitherto unknown disease vectors may be primarily attributed to the pollution effect on evolution. One of the major direct consequences of pollution on the evolution can be seen in the changing habitats and lifestyles of

animals. The best example is the polar bear, one of the most ferocious yet very cute, beautiful and friendly-looking animals. They feed on seals. But with pollution, global warming and melting of the Arctic ice, their habitat became smaller, hunting time became longer and longer and the food available was shrinking day by day. The disastrous consequence was that they became cannibals. Cannibalism is spreading among many other species too. Will this spine-chilling phenomenon ultimately reach the humans too?

Natural selection is an important component of evolution. The evolution of more green colored bugs to camouflage with nature and escape predator birds, the near extinction of peacock males without large bright tails (because female peacocks preferred to mate with males with large beautiful tails) etc. are examples.

Sustainable development is the slogan of all governments, politicians, industries, technocrats and environmentalists today. Is the development model competitively promoted by different governments and planners really sustainable? Yesterday's 'development' is coming back to us under the guise of global warming, climate change, emerging diseases, social and economic inequalities, crimes, psychological problems and various societal ills. Net result is the rich becoming richer, healthy becoming healthier and poor becoming poorer and poorer. No development will be sustainable if it will not guarantee environmental protection, preservation of biodiversity and balanced use of natural resources. In the context of the pandemic covid 19, the preservation of the biodiversity with billions of flora and fauna, including the natural predators of millions of species within becomes important. All species on the planet, estimated to be between 13-20 billion, are interrelated in many ways for their existence and extinction and natural population control of respective species. Who knows? The natural predator of corona virus may have become extinct or a new deadly species may have been formed as a result of the destruction of biodiversity.

Around 60% of all known human diseases (rabies virus, ringworm and salmonella etc.) originate from animals. Normally the animal pathogens do not harm the humans. But if the man crosses their path too frequently and choke them, they will react in unpredictable ways. Spill-over events (in which a **virus overcomes several barriers to become active in another species**) are less in intact/protected ecosystems. Most spill-over events follow the same mechanism. The virus should not be too effective in its primary host species, to prevent ruining the species viability,

and this species acts as a reservoir for the virus. With shrinking habitats, changes in land use, deforestation, mining, animal-husbandry, commercial cultivation, changing biodiversity etc., the numbers and population densities of several species are severely altered. This creates the opportunity for a virus to spill-over, mutate and multiply. The bigger the number of spill-overs, the faster the virus will multiply and mutate. According to the theory of 'natural selection', the virus will be more virulent in the spill-over and can even lead to the formation of more toxic and contagious phenotypes. Finally, these infectious strains jump to humans and aid the spread of the disease. In short, when we break the integrity of natural ecosystems we create conditions that invite pandemics upon us.

Animal infections can cause human pandemics one after another, unless we act upon right away, preferably today itself, because tomorrow will be too late. The same virus can become more virulent and mutate into more harmful forms with time. This is well manifested in the case of the corona virus. Earlier we were advised to keep physical distancing by few meters to protect ourselves from the virus because its lifetime in the air was short. But now it is reported that the mutated form can be virulent in the air for longer time.

Old Friends Hypothesis

Certain organisms are recognised by the innate immune system as harmless or, in the case of some helminths (intestinal worms), treated as 'friends' because of our long evolutionary association with them. Both internal as well as external environment of the body are important to develop immunity. While the importance of cleanliness cannot be underestimated, extreme cleanliness and instant treatments changes the environment inside our bodies and those friends can turn foes. Our immune system has co-evolved with these inner environs for hundreds of years, and changing it overnight makes our body vulnerable to diseases. As long as these bacteria and viruses co-evolve with us, they do not become a nuisance. This is what scientists call the 'old friends hypothesis'. But if we change the internal or external environment of our body, they will react differently and unpredictably leading to vulnerability to disease and poor health.

Biodiversity Hypothesis

Research studies show that allergies causing cold, asthma, skin diseases, etc. are severely aggravated with the alteration and destruction of the biodiversity around. This is broadly the basis of 'biodiversity hypothesis'.

Air Pollution is known to exacerbate respiratory diseases. Covid 19 is also a respiratory system disease that weakens lungs and result in obstructive chronic pulmonary diseases, lung cancer, asthma and pneumonia. Small particles can reach the blood stream and affect cardiovascular system and other organs. Covid 19 will be even more harmful to patients with other pollution related diseases.

Silver Lining

Amidst the devastating Covid-19 pandemic, an 'out of the blue' positive sign has been the significant global decrease in air pollution levels, in particular of nitrogen dioxide (NO_2) and other pollutants such as particulate matter, carbon monoxide, sulfur dioxide, ground-level ozone, and lead. NO_2 measurements accurately reflect emissions sources, because unlike other gases that can travel a significant distance from where they're emitted, NO_2 has a short lifespan and dies before it can move very far. The drop in NO_2 emissions during this lockdown has been significant. This is encouraging because exposure to high levels of NO_2 has substantial detrimental effects on human health. Short-term exposure to high levels of NO_2 can result in worsened coughing, aggravation of existing respiratory diseases (asthma), and hospitalisation while longer-term exposure can lead to the development of asthma and increase one's susceptibility to respiratory diseases. Increased Covid-19 death rates in vulnerable sections of the population can be at least partially attributed to long-term exposure to high levels of air pollution. Many researchers point out that the current drop in air pollution levels may be saving significant number of lives i) by reducing individuals' susceptibility to Covid-19 and ii) by preventing some of the world's 9 million annual deaths due to air pollution exposure. Still, the dangerously high levels of NO_2 in many urban areas before Covid-19 has likely resulted in far more deaths compared to the lives lost in Covid itself.

The fact remains that pollution is still the biggest killer directly and indirectly. Pollution induced exacerbation of covid has been the second biggest killer in recent times. Covid as such is only

the third biggest killer. No effort on containing covid or other emerging diseases can be complete and meaningful unless the issue of pollution, environmental degradation, damage to biodiversity and climate change are addressed.

The pandemic, its aggravation due to pollution, the lockdown and quarantine dictated by the fast spread of the disease and the subsequent decrease in air pollution levels have opened up intense studies and discussions on the love-hate relation between high levels of air pollution, the pandemic and modern day 'development'.

Man will certainly win the war against covid in the short term with the multipronged approaches of using face mask and sanitizers, keeping physical distance, use of vaccine, medicine etc. However, in the long run we have to go back to nature, bring back the biodiversity and ecological integrity, and return the space, ambience and resources that legitimately belong to other species in order to arrest or slow down the emergence and re-emergence of diseases. In short, "Render unto Caesar the things which are Caesar's; and unto God the things that are God's."

Biosketch of E.P.Yesodharan

Dr.E.P.Yesodharan is the Chief Executive Officer of the Sree Narayana Gurukulam College of Engineering at Kadayiruppu, Ernakulam District, Kerala. He was formerly Professor in the School of Environmental Studies, Cochin University of Science and Technology, Executive Vice President, Kerala State Council for Science, Technology and Environment and Principal Secretary S&T, Government of Kerala. He was also former Chief Inspector of Chemical Disarmament OPCW/UNO

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Role of Radiopharmaceuticals in diagnosis and therapy

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Abstract: Radiopharmaceutical products are inorganic, organic and biological compounds labelled with radionuclides which are used for diagnostic and therapeutic purposes. The lecture covers some basic principles of radiopharmaceuticals and its applications in health care. Use of Positron Emission Tomography, static and dynamic imaging , in-vivo and in-vitro methods for detection of thyroiditis are discussed in brief followed by use of radiopharmaceuticals in radiation therapy. The role of radiopharmaceuticals in covid treatment is also highlighted. Brief description of the work carried out by our research group in detection of thyroiditis in pregnant women and children, and synthesis of I-125 brachytherapy source for the treatment of retinoblastoma is followed by the precautions to be taken while using the radiopharmaceuticals in diagnosis and therapy.

Introduction: When the word "radioactivity" is heard, most of the people are afraid of it as they remember Hiroshima, Nagasaki, and other nuclear accidents; a destructive side of it! On the other hand, its positive side depicts large number of peaceful applications, most of them being in the field of medicine. The present article gives an overview of radiopharmaceuticals and their applications in diagnosis and therapy.

Historical Background: The golden age of nuclear and radiation chemistry started with the discovery of X-rays on 8th July 1895 by William Rontgen. Just 114 days after that Becquerel invented the phenomenon of radioactivity, the name "Radioactivity" being coined by Marie and Pierre Curie who discovered Po and Ra in 1898. All of them were conferred with Nobel prize. Discovery of Artificial radioactivity by Irene and Frederic Joliot curie in 1934 made it possible to synthesize large number of radioisotopes which has found applications in almost every branch

of science. Few more discoveries in this field were that of cyclotron (Lawrence), Nuclear fission (Hahn and Strassman), Nuclear Reactor (Fermi and co-workers), radioisotope tagging(Hevesy).

Nuclear Medicine: Nuclear medicine is a special branch of medicine, the origin of which lies in the discovery of X-ray and artificial radioactivity. In 1946, radioiodine was used to treat the thyroid cancer. In the decade of 1950s, use of nuclear medicines was started at a larger scale. In 1960s, nuclear medicine was recognized as a special branch while in the decade of 1970s, use of nuclear medicines to study other organs was started and, in the decade of 1980s, first time nuclear medicines were used to study heart diseases.

Progress of Nuclear medicine in India: Dr. Homi Bhabha played very important role in starting nuclear medicine branch in India. In 1960, a research grant was made available at Department of Atomic Energy and in 1963, radiation medicine Centre was started at Tata memorial hospital. Dr. Ernest Lawrence, N.L. provided many equipments. Bhabha Atomic Research Centre and Board of Research in Isotope Technology played a major role in the progress of nuclear medicine branch in India.There are AERB approved (as on 2.12.20) 349 nuclear medicine centers in India out of which 49 are in Maharashtra and 9 in Pune.

Radiopharmaceuticals: The inorganic/organic compound containing radiotracer when used for diagnosis and therapy, it is known as a radiopharmaceutical which gives anatomical as well as physiological information of the organ under study. It can be designed by considering its preferred localization and biological function in the organ. The radiopharmaceutical dose can be planned depending on its physical and biological half-life as well as benefit/risk ratio. Its effective half life should not exceed 1.5 times the test duration. Depending on its use, type of radiations are selected. Usually gamma emitting isotopes with an energy of 0.1-.25 MeV

are preferred. Now a days targeted therapy is used to avoid radiation dose to surrounding tissues.

Some of the commonly used radiotracers, their chemical form and uses are: **Tc-99m** (Sodium pertechnetate): Brain, blood pool imaging, **I-131**(Sodium iodide):Thyroid diagnosis and therapy, **Xe-133** (gas):Pulmonary inhalation imaging, cerebral blood flow studies,**Tl-201** (thallous chloride) :myocardial imaging, **Ga-67** (Gallium citrate): Tumor imaging.

Various units used for measuring the radiation dose[1] are Curie (Ci), Rad (r), Rontgen(R), Relative Biological Effectiveness (RBE), Rontgen Equivalent Mammal (REM) and Sievert (Sv).

Radionuclide generators:

These are used to extract relatively short lived radioisotope from its parent nuclide. Most of the nuclear medicine centres use technetium generator. There is a transient equilibrium between ^{99}Mo ($t_{1/2}$ = 2.7 d) and ^{99m}Tc ($t_{1/2}$ = 6 h). Hence one can extract ^{99m}Tc from loaded ^{99}Mo in the generator when it reaches a maximum activity. Growth and decay of ^{99m}Tc is a continuous process and one can extract it repeatedly after certain interval of time, just like milking a cow after certain time period. The generator essentially consists of alumina column adsorbed with ^{99}Mo wherein its decay results in ^{99m}Tc . ^{99m}Tc can be extracted from this column using sterilized saline solution (Fig.1).

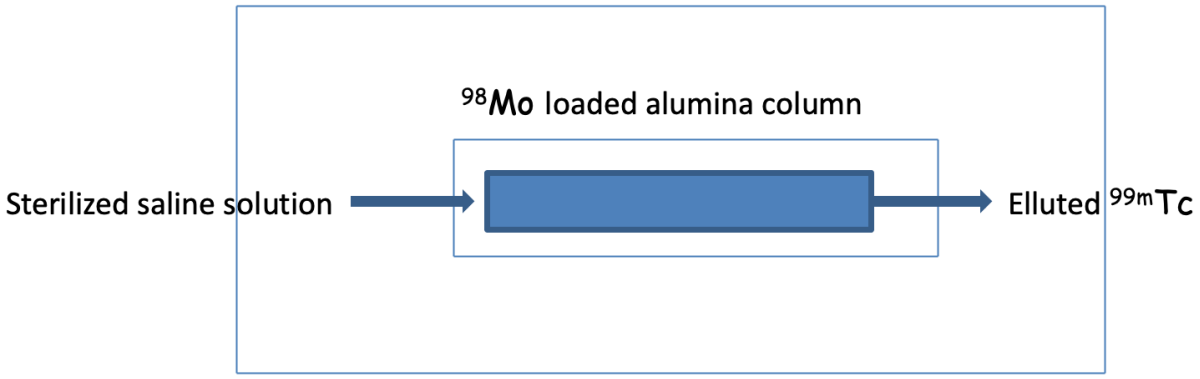

Fig.1 A schematic diagram of Technetium Generator

Radiopharmaceuticals for Diagnosis: In vivo diagnosis: For diagnosing a patient by in-vivo method, radiopharmaceutical is either injected into the patient or given orally/ by inhalation depending on the purpose. NaI(Tl) detector is used as gamma camera for monitoring gamma rays emitted which can be further analysed to get the required information about the diseased organ. Uptake of radiopharmaceutical will be different for normal and diseased tissues. Increased uptake (eg. ^{99m} Tc in bone cancer) is referred to as 'hot spot' while decreased uptake (eg.^{204}Tl in heart scan) is referred as 'cold spot'

The half-life of radioisotope used in nuclear imaging must be sufficiently long to monitor the function of organ but it should not be too long to avoid further damage to the tissue. Its gamma energy must be sufficient for penetrating the tissue.

Positron emission tomography[2] (PET)

PET is one of the most powerful technique used for imaging the organs. It is mainly used for detection of cancer and to study spread of cancer and to review the effectiveness of radiation therapy. Positron emitting radioisotope (e.g. F-18 in the form of FDG) is injected into the patient. Emitted positron loses its kinetic energy during interaction with surrounding atoms and combines with the surrounding electron. This leads into an annihilation process resulting into two gamma photons (each of 511 keV energy) exactly in opposite directions (180^{o} to each other). Thus, three dimensional image of the organ under study can be obtained. F-18 fluro deoxy glucose(FDG) acts as a scanning agent during imaging process. It acts like glucose and gets transported into the cells. Malignant tumours have increased glycolysis (hence increased uptake of FDG) resulting into hot spot in the image.

Some of the radioisotopes used for PET are: Ga-88($t_{1/2}$ = 68 min), N-13 ($t_{1/2}$ = 10 min), C-11

($t_{1/2}$ = 20.4 min) and F-18 (1 $t_{1/2}$ = 10 min). Out of these F-18 is most widely used.

Static and dynamic imaging: The imaging techniques are classified as static and dynamic.

Static imaging: In static imaging, radiopharmaceutical is first injected, and further imaging is carried out once the radiation is taken up by the organ. PET is the example of static imaging and usually used for brain, bone, and lung studies.

Dynamic imaging: In dynamic imaging, uptake of radiopharmaceutical in the organ is measured as a function of time after its injection and usually used for heart and kidney functioning.

Renogram: In order to study the function of a diseased kidney, renograms (dynamic images of kidney) are carried out. The tracer [MAG-3(Tc-99m)] is injected into the patient which will be taken up by the kidney from the blood stream and gets concentrated in it. Continuous uptake and decay of radiotracer is studied as a function of time for about 20 min., for every few seconds, using gamma camera. Normal renogram shows initial uptake followed by decay of tracer. However, diseased one shows different profile showing ups and downs in the curve depending on the extent of damage.

Thyroiditis: Thyroid is the critical organ for iodine and it plays very important role in our growth and metabolism. Iodine consumed by us gets accumulated in this gland. The adequate intake of iodine is in the range of 50-200 μg d^{-1}, and The Recommended Dietary Allowance (RDA) of India is 150 μg d^{-1}. Excess or less iodine uptake by the body results into hyper or hypothyroidism respectively, the condition can be diagnosed using I-131 radiotracer. In a recent survey it has been reported that, in India, out of 324 districts surveyed, 264 have been found to be endemic for iodine deficiency disorders (IDD).

In-vivo diagnosis of thyroiditis [1]: I-131(10 μCi) is added to the juice and orally administered to the patient. I-131 reaches the thyroid gland, gets accumulated and decays.

Gamma activity of the radiotracer is measured at interval of 1h at about 20 cm away from the patient. One can diagnose hyper/hypo throidism from the following Fig.(Fig 2). Once diagnosed, I-131 (200 μCi)can be used for therapy of hyper thyroiditis.

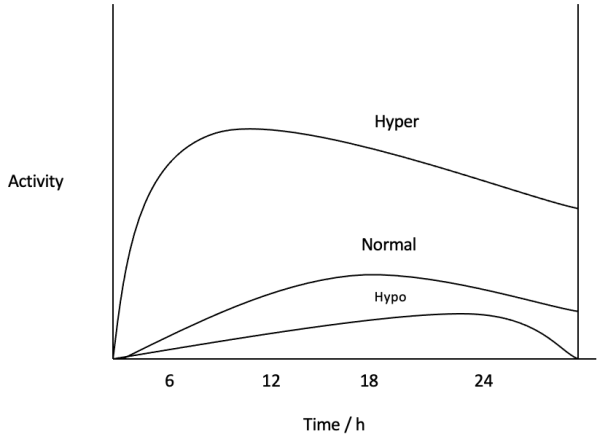

Fig.2 Thyroid condition

In vitro diagnosis of thyroiditis: The technique of Radio Immuno Assay (RIA) is used for the in-vitro diagnosis of thyroiditis. Antigen-Antibody reaction in this assay can be shown as follows:

(Antigen) + (Labelled antigen) + (Antibody)

→ (Antigen-Antibody complex) + (labelled Antigen-Antibody complex) + Free labelled antigen + Antibody

Antigen (Thyroid hormone) can be measured by measuring radioactivity of bound antigen antibody complex. The technique is highly sensitive and one can measure ng concentration also.

Work carried out by our research group[3]

Children and pregnant women are more prone to thyroiditis. Hence, we selected pregnant women and children from Pune city and nearby area for the studies. Serum samples were analyzed for thyroid hormones. Research grant was provided by BCUD, SPPU and UGC UPE phase II.

RIA kits from BRIT, Mumbai were used to estimate thyroid hormone concentrations. The thyroid hormone, RIA kit used and normal concentration range of these hormones are listed in following Table (Table 1).

Table 1 RIA of thyroid hormones

Thyroid hormone	RIA kit	Normal range of thyroid hormone
T3	**MAG 3**	0.7 to 2.1 ng/mL
T4	**BRIA MAG 4**	55-135 ng/mL
hTSH	**IRMAK-9**	0.17 to 4.05 ng/mL

Our results showed that out of 243 Pregnant women, 128 Were prone to hypothyroidism and out of 172 children, 65 Were prone to hypothyroidism.

Radiation therapy: In order to treat the cancer patients tiny sealed gamma source is used which delivers the desired dose to the patient through collimator. When the source is kept at certain distance from the patient, it is termed as teletherapy and when the source is kept close to affected

organ, it is called as brachytherapy. Most commonly used gamma sources for radiation therapy are: Co-60 ($t_{1/2}$ =5.27y), Cs-137 ($t_{1/2}$ =30 y) I -125 ($t_{1/2}$ = 60 d)

Requirements of Sources for their Use in Radiotherapy[4]:

(1) Solid and Non-leachable (Insoluble) Matrix (2) Stability against Heat and Radiation

(3) Higher Specific Activity (4) Smaller Source Size

(5) Inertness towards Encapsulating Material (6) Low Leachability

(7) Uniformity of Activity within Source Core (8) Activity Variations within ± 10%.

(9) Ease of Source Preparation (10) Economic Viability

Work carried out by our research group[5,6]

We had prepared I-125 brachytherapy source in association with radiopharmaceuticals division, BARC. Initially, 100 MBq of I-125 was allowed to adsorb on Pd - Ag rod . It was then encapsulated in a tiny titanium capsule(0.8 mm diameter and 4.75 mm length). Brachytherapy sources thus prepared were then used for the cancer treatment (retinoblastoma and prostate cancer) [4-6] at different nuclear medicine centres.

Use of radiopharmaceuticals in diagnosis of Covid 19: During pandemic period of Covid19, Computational Tomography (CT) technique was used for examining the chest for the detection and monitoring of pneumonia induced by Covid 19. The technique gives three-dimensional image which can track the location of the organ affected and progression of the disease.

Another technique which was used to examine covid 19 patient was PET. The technique was used for few patients before the formal outbreak of covid-19 using F-18 radiotracer which indicated the lymph node involvement. The technique was used at different nuclear medicine centers during pandemic period. Asymptomatic patients also showed Covid 19 induced pneumonia during PET examination. PET technique played an important role in identifying the prevalence of COVID-19 among high-risk, asymptomatic patients.

Covid -19 therapy using radiopharmaceuticals: One of the first study was carried out by researchers at Emory University Hospital. Few patients with Covid 19 having severe pneumonia were treated with 1.5 Gy gamma radiation dose applied to both the lungs[7]. Most of them showed rapid recovery and there was no adverse effect of radiations. Similar results were observed at the AIIMS facility in New Delhi, two severely ill patients were given 0.7 Gy to the lungs and they were recovered. More patients were then treated. Now a days many countries are using this therapy for treating the covid 19 patients

Probable effects observed after radiation therapy: Generally, effects are seen after second or third cycle of radiation therapy. Fatigue, vomiting, hair loss are some of the common effects. Probable effects after radiation therapy on some of the organs are:

- Brain: Fatigue, vomiting, hair loss, dry skin, headache, eyesight is affected
- Breast: fatigue, hair loss, swelling, skin gets affected
- Chest: Fatigue, hair loss dry skin, throat ache, breathing problem

Precautions to be taken while using the radiopharmaceuticals: As an example, precautions while I-131 is used for diagnosis and therapy of thyroid are described

- Do not consume food which contains iodine before few weeks of the treatment
- Consumption of radioiodine decreases WBC hence the person should not come in contact with the patient having infectious disease
- Drink more water after taking the radioiodine dose
- Person taking the treatment should avoid the contact with others. His clothes and other belongings are to be kept separate
- Flush twice after using the toilet
- Patient must be hospitalized unless his radiation dose becomes less than 5 mrem/h
- Floor of the Patient's room must be covered with plastic or absorbing material. Similarly other objects also to be covered
- RSO should see that radioactivity should decrease to less than 200dpm/100 square cm before room is allotted to another patient

Conclusion:

Radiopharmaceuticals play very important role in health care as they are effectively used in diagnosis and therapy of various diseases

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Brief Bio-sketch of Dr. Nilima S. Rajurkar

Dr. (Mrs.) Nilima Rajurkar is Former Professor and Head of the Department of Chemistry and Former Head, Department of Environmental Science at Savitribai Phule Pune University with a teaching experience of more than 40 years. She is a Fellow of Maharashtra Academy of Sciences and has been working in multidisciplinary areas such as Nuclear and Radiation Chemistry,

Electrochemistry, neutron activation analysis, Environmental pollution, wastewater treatment, medicinal plant chemistry, synthesis of ayurvedic bhasma, radiopharmaceuticals, public health etc. Through her career, she has guided 16 students for M. Phil and 30 students for Ph.D. degree from various parts of India and Abroad. She has more than 200 research publications in National and International journals. She acted as the Editor of International journal "Clean-Soil Air and Water" of Wiley Blackwell and also as

peer team member of NAAC. International Biographical Research Centre at Cambridge, UK has listed her among the "Leading Scientists in Nuclear Chemistry" in 2009 and Indian Council of Chemists conferred her with "Prof. Kaza Somshekhara Rao Award "for Best Women Scientist in Chemistry" in 2014.She has written a book "Nuclear chemistry through problems" with Prof. H .J. Arnikar and she is also a co-author of a book on "Science and Technology" for competitive exam students. She was involved in preparing video films on 'Radioactivity' and lectures on 'Environmental Science' for UGC countrywide classroom in association with EMRC, Pune. She visited various countries for invited talks and conferences and also organized number of National and International conferences, workshops and seminars. She was the Vice President of "Indian Association of Nuclear Chemists and Allied Scientists", EC Member of Indian Science Congress", "Convener, "Indian Women Scientists' Association, Pune branch" and Vice President of "Marathi Vidnyan Parishad, Pune Vibhag". Presently, she is Chairperson of "Indian Society of Analytical Scientists, Pune Chapter" and Editor of the "Journal of ISAS". She is a member of number of scientific societies through which she is actively involved in science popularization program

Analytical Regimen of Chemical Weapons Convention

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Director, Defence Research and Development Establishment (DRDE) Gwalior

1. Introduction

Chemical weapons are considered to be loathsome amongst weapons of mass destruction. To save mankind from horrifying menace of chemical weapons, an international treaty, known as Chemical Weapons Convention (CWC) has come into existence since April 1997. CWC prohibits proliferation of chemical weapons, signatory states are obliged to abide provisions of the CWC i.e. not to develop, produce, store or use chemical weapons other than the provisions not prohibited in the convention. Signatory states to this convention are also obliged to destroy their chemical arsenal within the stipulated period of time.

India is also one of the 193 signatories of CWC, hence, obliged to implement the provisions of CWC. One of the most important aspects of CWC is its verification program which ensures implementation of the treaty by virtue of inspections of chemical industries and sites of chemical weapons storage, destruction and storage facilities. These inspections are conducted by the inspectors appointed by the OPCW, an organization known as Organization for Prohibition of Chemical Weapons, The Netherlands. The OPCW is administrative organization of CWC and maintains a global network of designated laboratories to undertake the off-site analysis of samples collected by its inspectors during systematic, routine or challenge inspections. In case of unresolved, during on-site analysis, the samples are submitted to at least two off-site designated laboratories. Thus role of ‘designated laboratories’ become crucial in deciding the compliance and/or non-compliance of CWC.

India, by virtue of its large chemical industry, is one of the fastest growing economies including defence sector; hence, required at least one ‘designated laboratory’ within its territory to play a critical role in case of any eventuality of chemical emergency and / or unresolved ambiguities during inspections by the OPCW.

DRDO is not only committed to meet the scientific and technological requirements of national defence, but also committed to play an international role as and when entrusted by the nation. In the context of CWC, a laboratory under the DRDO, namely Defence R & D Establishment (DRDE) located in the city of Gwalior (M. P.), was entrusted to obtain the status of designation from OPCW. Achievements of DRDE in establishing the the analytical technology of verification analysis of CWAs are delineated below.

2. Process of Designation:

Process to attain and maintain the status of designated laboratories is an uphill task, as it requires excellence in synthesis, analysis and identification of CWAs and their degradation products (so called markers). To examine the scientific capabilities of a laboratory, OPCW conducts international official proficiency tests (OPTs) twice in a year. And a laboratory aspiring to become and stay designated has to participate in these OPTs and perform as per the following stringent criteria.

i) Laboratory must have in place an internationally recognised quality system e.g. ISO17025: 2017 or equivalent.

ii) Laboratory must participate at least once in a year in the OPTs conducted by the OPCW.

iii) Laboratory must secure at least two ‘A’ and one ‘B’ grade in three consecutive OPTs.

Official proficiency tests are conducted by the OPCW with the help of two already laboratories. One laboratory prepares the samples for analysis and second laboratory evaluates the reports submitted by the participating laboratories. There are several intricacies of these OPTs and a laboratory has to prove its competence in following ways.

1. The time frame for OPTs is only fifteen days i.e. the laboratory has to analyse the samples and submit the report within the 15 days.

2. Samples may include soil, water, polymer or organic liquids containing traces of CWAs and / or their degradation products with high background chemicals to challenge the analysis.

3. Laboratory has to identify the structures of spiked chemicals with the help of GC-MS, LC-MS, FT-NMR and GC-FTIR analyses. Sample preparation laboratory may select the spiking chemicals from three schedules of chemicals as laid down in the CWC or their degradation products.

4. The spectral data of spiked chemicals may not be available in any of the commercially available data base or in the data base supplied by the OPCW. Thus laboratory must have high skills of interpretation of spectral data of unknown chemicals to elucidate their structures.

5. Laboratory must have efficient sample preparation methods / protocols to eliminate the background chemicals and extract and enrich the analytes of interest from samples.

6. Total numbers of CWC related chemicals are several hundreds of thousands, out of which types and numbers of spiked chemicals are not known to the participating laboratory.

7. Identified chemicals must be substantiated by submitting the spectral data of synthesized reference chemicals. Thus laboratory must have the capability to synthesize new chemicals with in the 15 days.

8. Laboratory must report only those chemicals which are relevant to the CWC. Reporting a chemical (though present in the sample) not relevant to CWC, is considered as an irrelevant chemical and constitutes failure in the test.

9. A reported chemical must be identified by at least two spectroscopic techniques.

10. All the reported spectral data must fulfil the requirements of reporting criteria as formulated by the OPCW. Not meeting any one of these criteria is considered as incomplete information and data for that particular chemical are rejected.

Thus a laboratory willing to participate in OPTs must have team of skilled scientists and required infrastructure.

2.0 Status of DRDE:

DRDE Gwalior was tasked to participate in OPTs with an objective to achieve and sustain the status of 'designated laboratory'. DRDE started participating in OPTs and a division known as VERTOX (verification of toxic chemicals) laboratory was created and equipped with required infrastructure. A team of scientists was dedicated to accomplish this task. The Vertox laboratory launched its own R & D program on synthesis and analysis of CWC related chemicals and developed novel synthetic/analytical techniques which were published in reputed peer reviewed international journals. The new techniques which were developed in the Vertox laboratory include (i) SDME, (ii) INDEX, (iii) OMDEX, (iv) HF-LPME and many more. Simultaneously, the Vertox laboratory also participated in OPTs conducted by the OPCW. Like any scientific endeavour, with initial quirks, Vertox laboratory achieved 'A' grade in three consecutive OPTs and was first awarded the status of 'designated laboratory' in the year 2006. Continuing the regular participation in OPTs with securing the required grades, DRDE has so far (i.e. 2022) maintained the status of designation from OPCW. Thus, the Vertox Laboratory, DRDE remains the only laboratory of India designated by the OPCW.

3.0 Analytical Methods Developed:

The R & D program of Vertox laboratory has resulted in development of several analytical techniques including synthesis, spectroscopic characterization, sample preparation and mass-spectrometric analysis of CWAs and their markers. Entire program has culminated to approximately couple of dozens of publications in high IF international journals, twelve Ph.Ds and publications of many analytical methods in the form of recommended operating procedures' for the international community of scientists involved in the analytical verification work of the CWC. Some of the important analytical works are enumerated below.

3.1 On-matrix derivatization extraction (OMDEX) of basic and acidic degradation products of CWAs from soil and water:

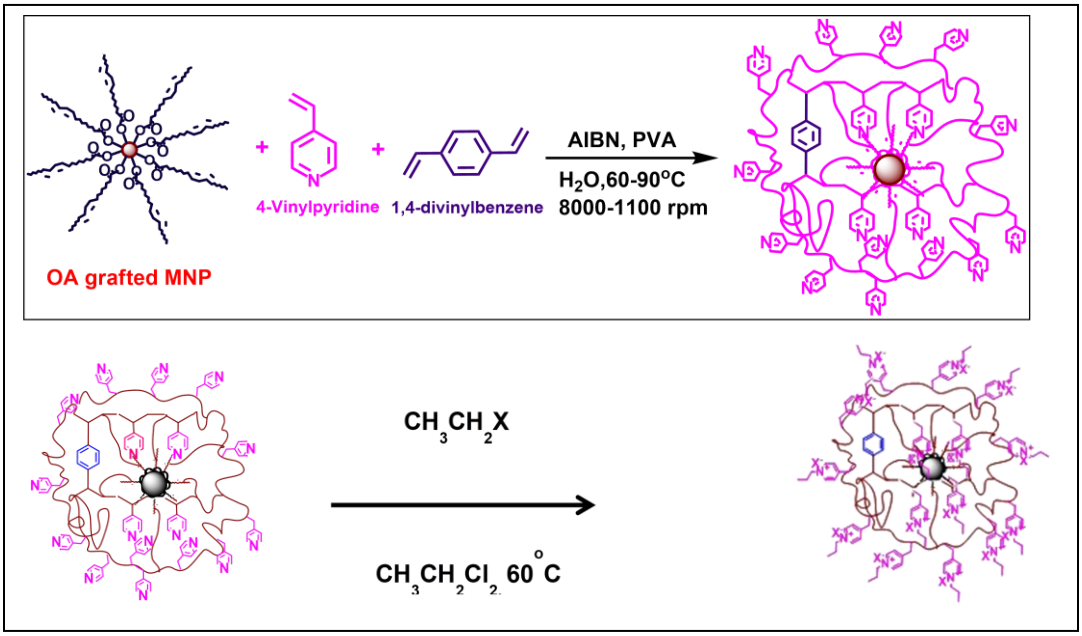
Derivatization in conjunction with extraction of aminoalcohols and phosphonic acids was developed. In this method, hexamethyldisilazane (HMDS) was combined with tert butyldimethylsilylation to derivatize and extract analytes from soil and diatomaceous earth. This procedure offered better recoveries than the one recommended by the OPCW in the form of

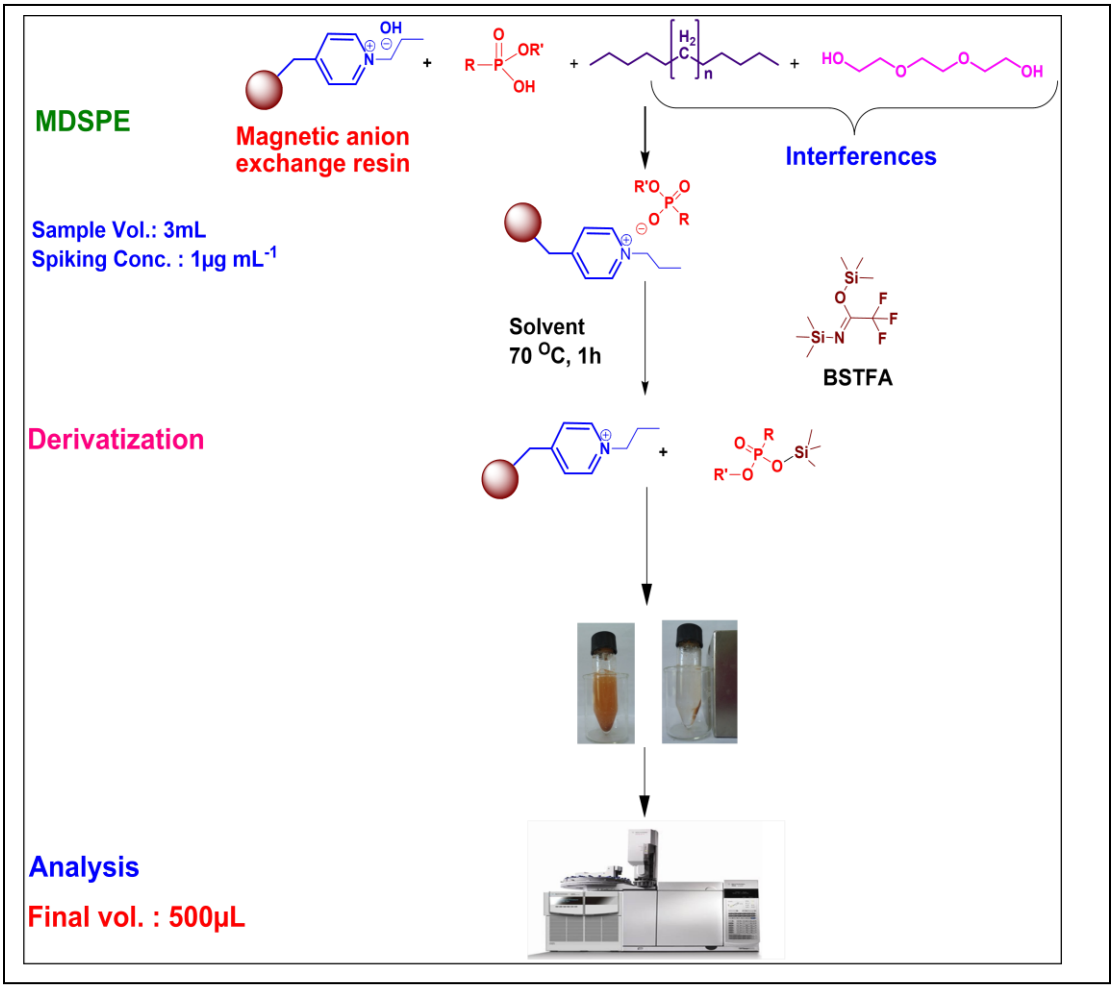
recommended operating procedures. The analytical technique used was gas chromatography–mass spectrometry. Recoveries of analytes ranged from 45-103% and the limits of detection (LOD) and limit of quantification (LOQ) ranged from 8-277 and 21-665 ng mL^{-1} respectively.

3.2 Design, synthesis, evaluation and validation of magnetic micro- / nano-spheres for extraction, enrichment, derivatization and identification of CWAs and their markers:

Extraction, enrichment and identification of CWAs and their markers from environmental samples was achieved by the development of novel materials based on magnetic nano-spheres. Magnetic nano-spheres were custom functionalized with hydrophilic-lipophilic balance (HLB) polymers, cation- and anion-exchange functionalities. Magnetic particles possessed super-paramagnetic character with high surface area. These properties endowed high mass transfer of analytes from matrix and simple retrieval of magnetic particles with external magnate. Factors influencing the extraction and enrichment of analytes such as solvent, time, amount of sorbent, washing solvent, derivatization conditions, reusability of material, temperature and interfering materials were optimized. Developed methods were compared with the reported and hitherto used methods. Magnetic spheres based methods surpassed the performance in terms of recoveries of analytes, removal of interfering materials, linearity, limits of detection, limits of quantification, time and ease of performance. Analytical figures of merit were much better than those required by the verification analysis. For example, for aminoalcols, linearity range was 5-200 ng mL^{-1}, LOD and LOQ were 2-6 ng mL^{-1} and 5-19 ng mL^{-1} respectively. Developed materials as well as methods were validated with real environmental samples and application was tested with the blind samples supplied by the OPCW during international proficiency tests. Synthesis of functional magnetic nano-particles (MNPs) and their application as extractant of markers of CWAs are exemplified with cation-exchange MNps using phosphonic acids as target analytes.

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts



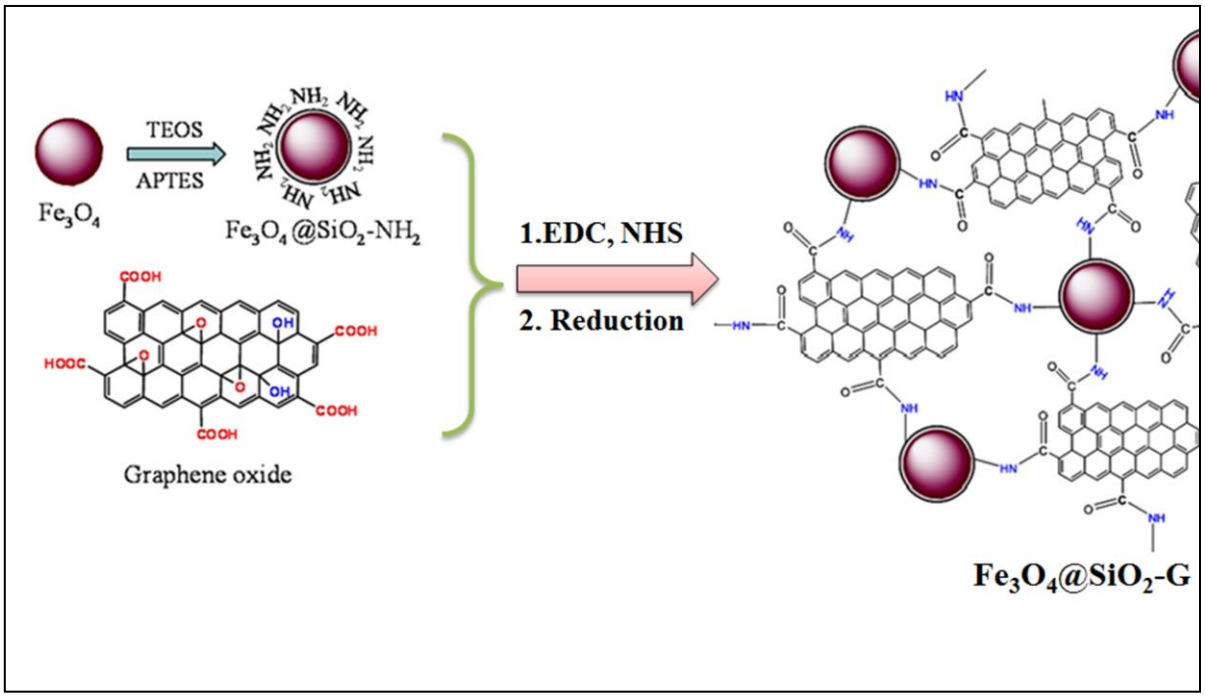


i) 05 publications in J. Chromatogr A (IF 4.18).

ii) Developed methods are used as validated methods for the identifications of CWAs and their environmental degradation products in blind samples

3.3 Design, synthesis, evaluation and validation of magnetic graphene composites for extraction, enrichment, derivatization and identification of CWAs and their markers:

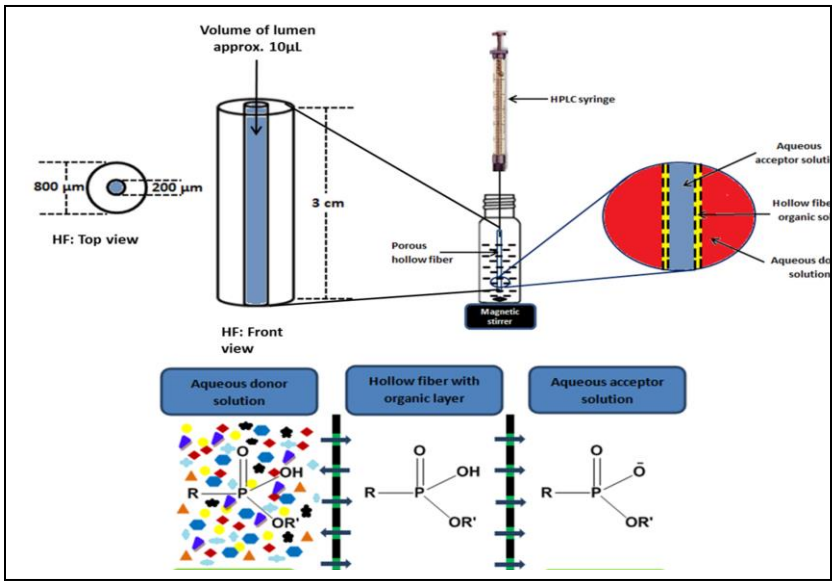
Graphene was selected due to its unique characters such as large surface area (theoretically 2630 m^2/g), extremely high surface to volume ratio, light weight nano-sheet structure and delocalized π – π electron system makes it an excellent sorbent material for analytical applications. Composites of graphene were prepared with magnetic nano particles, cationic and anionic polymers and were exploited for the extraction of real warfare agents and their acidic and alkaline degradation products respectively. The important findings of these studies are representatively illustrated with magnetic graphene. Nanocomposite, iron oxide-silica-graphene was prepared by anchoring silica and iron oxide onto the grapheme. Extraction parameters for chemical warfare agents were determined. Sample pH and ionic strength governed the extraction efficiency. Fo example, nerve agent Sarin showed maximum recovery at pH 5, while VX recovered best at pH 9. Salts raised recoveries to as high as 94% for SM. LODnfor sulphur mustard and VX were 0.11 ng $mL^{-1}$and 0.19 ng mL^{-1} respectively.



i) 03 publications in J. Chromatogr A (IF 4.18).

3.4 LC-MS/MS and appropriate sample preparation methods for CWAs:

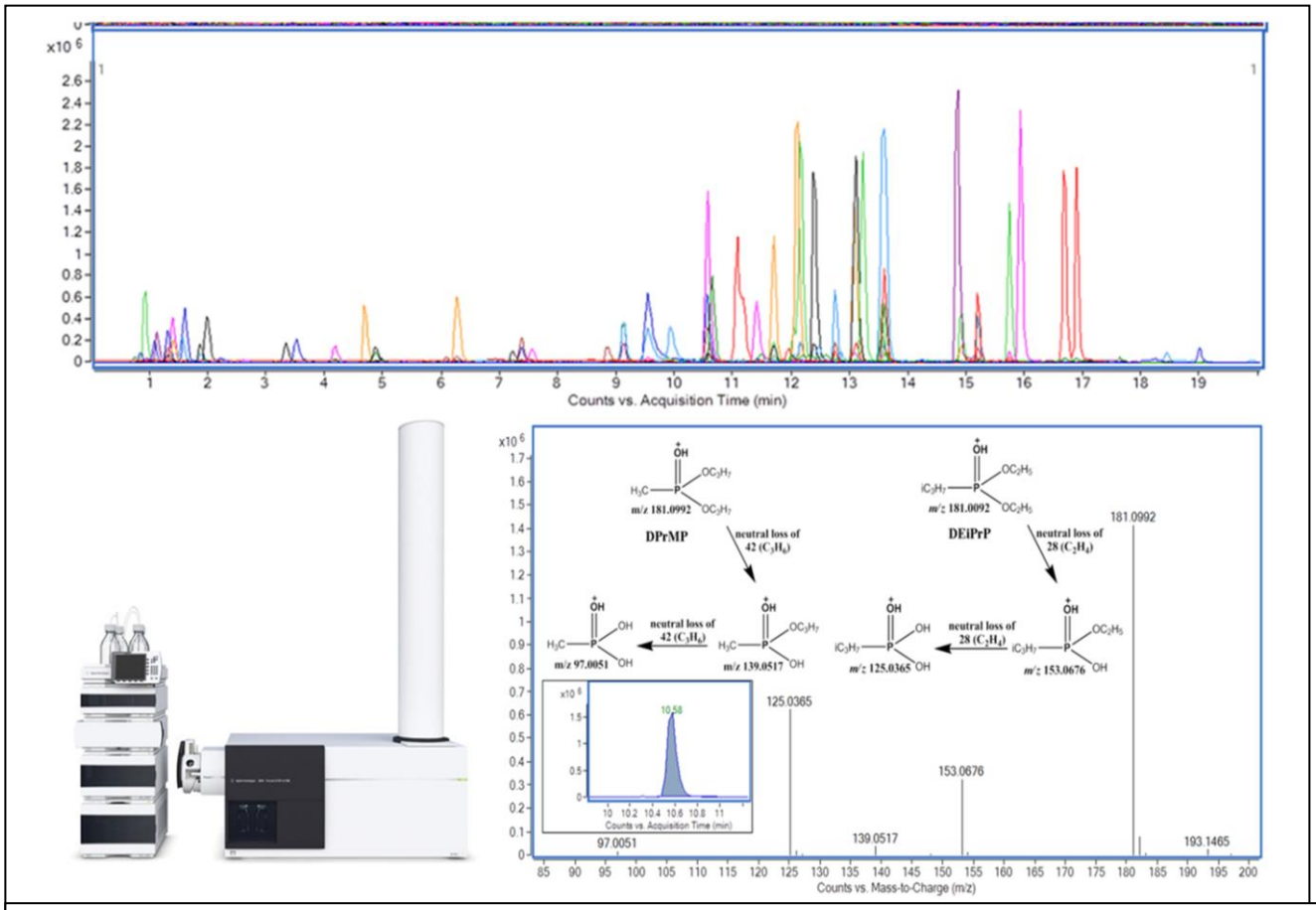
Liquid-liquid-liquid microextraction aided by hollow fibre (HFLLLME) was developed for extraction of phosphonic acids AAPAs from water samples. These were extracted from aqueous phase to organic phase through pores of hollow fibre and then concentrated to acceptor aqueous phase in it's lumen. Experimental conditions arrived were: 1-octanol in pores, pH in lumen 14; time, 60 min; pH of sample 1; and salt 10% (w/v). Lower limits of detection ranged from 0.1 to 100 ng mL^{-1}. After validation, the method was used for detection of AAPAs in the samples provided by the OPCW in subsequent proficiency tests.



Passive diffusion the analytes across the pores of hollow fibre was a limiting factor of this method, it was overcome by development of a simple and fast method through microfluidic electromembrane extraction (µ-EME). The edge provided by this method was efficiency (3 min) and sample size (10 micro liter).

Sensitivity of the method was enhanced by the post column addition of tricationic reagent which led to the formation of stable adducts with phosphonic acids. These adduct carrying positive charges were detected in positive ESI. 1,3-imidazolium-bis-(1-hexyl-benzyl-imidazolium)-trifluoride (IBHBI) was used as cationic reagent. Various parameters including solvent composition, concentration of IBHBI, effect of pH and interferences were optimized. Limit of detection (0.1 ng) achieved were better than those previously reported in literature.

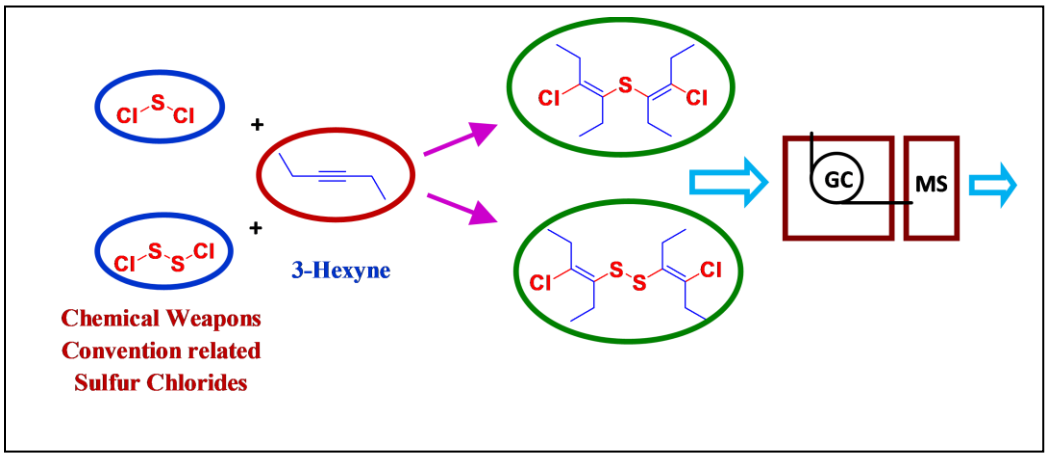
Structural diversity of CWAs and their associates is major challenge for analytical scientists. Operational parameters govern the spectral features in LC-MS; it makes more difficult to universalize the LC-MS method for CWAs. A generic LC-MS method was developed employing ultra-high performance liquid chromatography in combination with quadrupole time-of-flight mass spectrometer (UHPLC-QTOF). Accurate mass measurement with characteristic fragment ions of pseudo-molecular ions and retention time were resorted to identify the target analytes. Even the isomeric and isobaric compounds were distinguished by this method.



i) 03 publications in J. Chromatogr A (IF 4.18); 3 publications in Rapid Commun Mass Spectrom

3.5 Analysis of sulfur chlorides *via* electrophilic additionderivatization:

Sulfur monochloride (S_2Cl_2) and sulfur dichloride (SCl_2) are used as raw materials to manufacture the mustards. An electrophilic addition to 3-hexyne by these compounds was resorted to develop a novel analytical method. Various analytical conditions, including reaction conditions (time, temperature, stoichiometry), and the detection parameters were optimized. Analytical figures of merit of derivatives in GC-MS analysis were sufficient for the forensic analysis and the verification of these analytes if used in the manufacturing the sulphur mustards.



Published in Analytical Chemistry

4.0 Future Endeavours:

DRDE is committed to work as the nodal laboratory for the verification of CWAs, and fulfil the national obligation by sustaining the status of the 'Designated Laboratory'. The scientific developments on the synthesis and analysis of markers of CWAs involving computational chemistry, microfluidics, automation, material development including nano-technology, magnetic materials and miniaturisation shall continue. The laboratory is looking forward to develop the analytical methods to detect and identify the new threats emerging on horizon**.**

Acknowledgement:

Entire work is outcome of my dedicated, hard –working and wisdom full team of scientists and students. I profusely thank one and all of them for their un-tiring efforts, patience

and perseverance to bring this glory to the nation in general and DRDO in particular. Thank you Dr - A.K. Gupta, -Vijay, -Deepak, -Ajay, -Raghvendra, -Pankaj, -Varoon, -Sridhar, and – Kanchan for being in the team and your invaluable contribution.

I also thank DRDE and DRDO for providing me the opportunity to take this challenge and lead the team. I sincerely thank seniors, mentors and preceding Directors for their support. I would like to specifically show my gratitude to Secretary and Chairman Defence R & D, DRDO, Dr G. Sateesh Reddy, for providing all support, resources and motivation.

Biosketch of Dr. D.K. Dubey

Dr. D. K. Dubey is Director for Defence Research Development Establishment (DRDE), Gwalior being the nodal laboratory for the development of Chem-Bio defence technologies. Dr. Dubey is associated with this laboratory for more than 42 years and has made significant contributions in the development of efficient and up-scalable synthetic procedures, enzyme based nerve agent detection devices, decontamination formulations, state-of-the-art analytical procedures and materials for forensic and verification analysis of warfare agents. He is the founder of `Vertox Laboratory' which is the internationally recognized national centre for the off-site analysis of chemical warfare agents from environmental as well as biomedical samples. He is the recipient of many awards including the prestigious `DRDO Scientist' of the year and `Agni Award' for excellence in self-reliance.

Aluminium - the strategic metal; Emerging technologies & its importance to India

Dr. Anupam Agnihotri

Importance of Aluminium

Aluminium is the 3rd most abundant element in the earth's crust accounting for 8% of its mass. It is also the most abundant metal which is followed by iron. Aluminium has grown 9.45 times since 1960 becoming the largest growing metal followed by copper, steel, lead, tin etc. It is the 2nd most widely used metal after steel and the most widely used non-ferrous metal. Aluminium is widely accepted as the metal of the future, strategic metal and green metal. It is the metal of the future as it is replacing many metals in various applications with its lightweight, good conductivity, corrosion resistance etc. Because of its importance in sectors like defence, aerospace, electrical, renewable energy, infrastructure, transportation, military, etc., it is also called a strategic metal. Though most of the metals are recyclable, aluminium garners special importance as green metal as its recycling requires a fraction of energy used for primary metal production.

Aluminium production

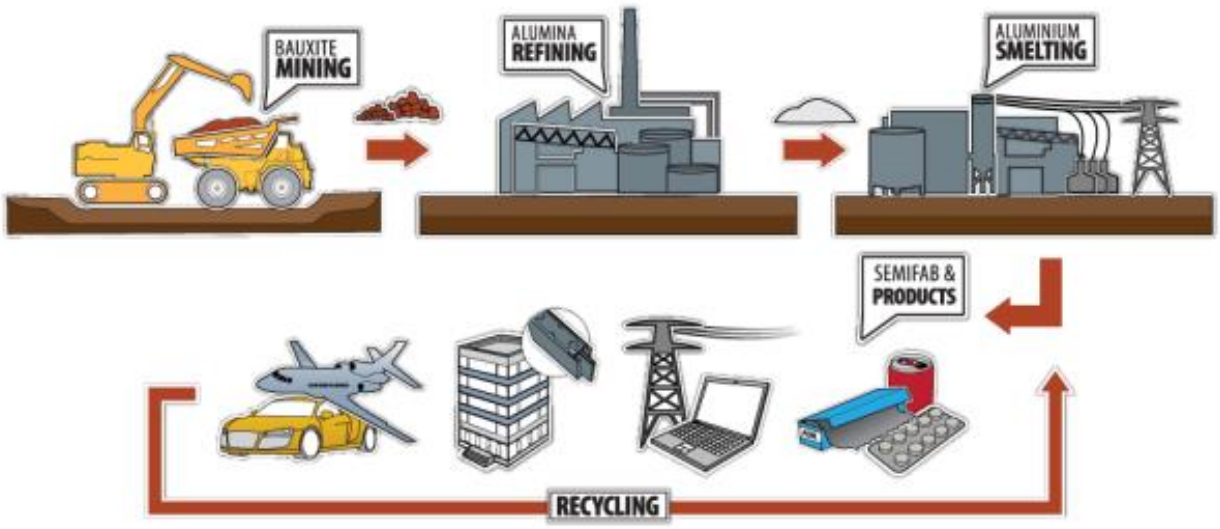


Figure 1 Aluminium production flow chart

Primary aluminium production (Figure 1) starts with the mining of its ore, bauxite, followed by refining of bauxite, where impurities in the bauxite were removed and pure alumina is obtained. Bayer's process is widely used for refining bauxite and 4 kgs of bauxite when refined, produces approximately 2 kgs of alumina and 2 kgs of red mud which contains impurities like SiO_2, TiO_2, Fe_2O_3 etc. which were present in the ore. Pure alumina obtained from the refining process is subjected to electrolysis, called the Hall-Heroult process. Electrolysis requires approximately 2 kgs of aluminium oxide, 400 grams of carbon, 20 grams of aluminium fluoride, 2 grams of cryolite and most importantly 13-14 kWh of electrical energy to produce 1 kg of aluminium. Aluminium produced will be further subjected to various downstream processes viz. rolling, extrusion, forging, drawing, etc. for making it suitable for its applications in various sectors like auto, electrical, construction & building, consumer durables, and others. At the end of life, products containing aluminium will be collected, segregated, and recycled. Apart from end-of-life products, waste generated during the machining and forming operations were also recycled.

Challenges for the industry

Globally challenges for the aluminium industry for its growth and development are E^3 viz. (i) economy (reducing the cost of production), (ii) energy (reducing the energy consumption) and (iii) environment (reducing the carbon footprint). But at the national level, apart from these E^3 challenges, Education or awareness about aluminium among the public is an additional challenge for increasing its per capita consumption in the country. Hence challenges for the domestic aluminium industry are symbolically E^4.

Wastes generated by the aluminium industry

Major wastes generated by the industry are red mud, dross, spent pot lining (SPL), fly ash and carbon dioxide. Red mud is produced during the refining of bauxite. Whereas SPL, fly ash, dross and CO_2 are produced from electrolysis. CO_2 emissions are from direct and indirect sources, where consumption of carbon anodes during the electrolysis contributes to the direct emission of CO_2. While aluminium electrolysis is an energy-intensive process and most of the electricity produced is from thermal power plants in the country, electricity consumption contributes to indirect emissions. Globally and nationally several efforts and research are being carried out for bulk utilization of wastes generated, reduction of emissions and energy consumption.

Aluminium demand and impact on various sectors

In India, aluminium and its alloys have a high impact on sectors viz. automotive, aviation, construction, defence manufacturing, electrical and electronics, food processing, oil & gas, ports, space and thermal. It has low to medium impact in sectors viz. tourism, textiles & garments, renewable energy, railways, pharmaceuticals, leather, IT, chemicals and biotechnology.

Abundant availability of coal & good quality bauxite and infrastructure operatives played a crucial role in the country to become 2nd largest producer of aluminium in the world. The current per-capita consumption of aluminium in India is very low at just 2.5 kgs compared to the global average of 11 kgs, country has robust growth prospects for aluminium in the future. If India's per-capita consumption reaches half the world average, it would imply that aluminium consumption will become more than 5 mT per annum. Economic growth acts as a fundamental driver of aluminium consumption in the country. The weight of aluminium utilized in automobiles is very less in the country when compared to the global average and it is increasing steadily for light-weighting and reducing carbon footprint.

History of Indian Aluminium Industry

After the discovery of the Hall-Heroult process for bulk production of aluminium, domestic aluminium production started with establishing the Indian Aluminium Company in 1943 with an installed capacity of 2500 tons per annum (TPA). Later HINDALCO in 1962, MALCO and BALCO in 1965 were started in the country and BALCO is now owned by Vedanta. A public sector unit, NALCO was established in 1987 with an installed capacity of 2,18,000 tpa. Today installed capacity for aluminium production in the country is 4.1 mt and India stood as 2nd highest aluminium producer in 2020 globally, with a production of 3.75 mt. India's aluminium production during the 1950s is a few thousand tons per annum and increased many folds to its current level of a few million tons per annum.

India's position

Indian bauxite deposits are the 5th largest in the world and account for 5.1% of the world's deposits. India has a reserve of 3.8 billion tons of good quality bauxite deposits. India has 6 refineries that produced approximately 6.4 mT of alumina from bauxite in 2018 making it the 4th largest alumina producer in the world. During 2018, India was the 2nd largest producer of

aluminium in the world with 7 smelters contributing to a production of 3.7 mT which accounted for around 5% of the world's aluminium production. Since aluminium production is energy-intensive and most of the electricity produced in the country is through thermal power plants, being the 3rd largest coal producer in the world, helped the country and the aluminium industry to achieve several milestones.

Production & Consumption of aluminium in India

Vedanta, HINDALCO and NALCO are the primary aluminium producers in the country with a total installed capacity of 4.1 mT. Production of aluminium in the country has seen a 3-fold increase since 2007 during which aluminium production was around 1.2 mT. Sectors in India are characterized by companies ranging from fully integrated to product specialists. The downstream segment comprises more than 150 large and mid-sized companies and a much larger base of smaller and unorganized players in the country.

Bauxite resources in the country

Most bauxite ores are situated in the states Of Odisha, Andhra Pradesh, Gujarat, Jharkhand, Madhya Pradesh, Chhattisgarh and Maharashtra. Odisha accounts for more than 50% of the bauxite ores followed by Andhra Pradesh with 16% and Gujarat with 8%. The distribution of bauxite resources amongst central India, eastern & western ghats is shown in Figure 2 (a) and locations of bauxite ores is shown in Figure 2 (b).

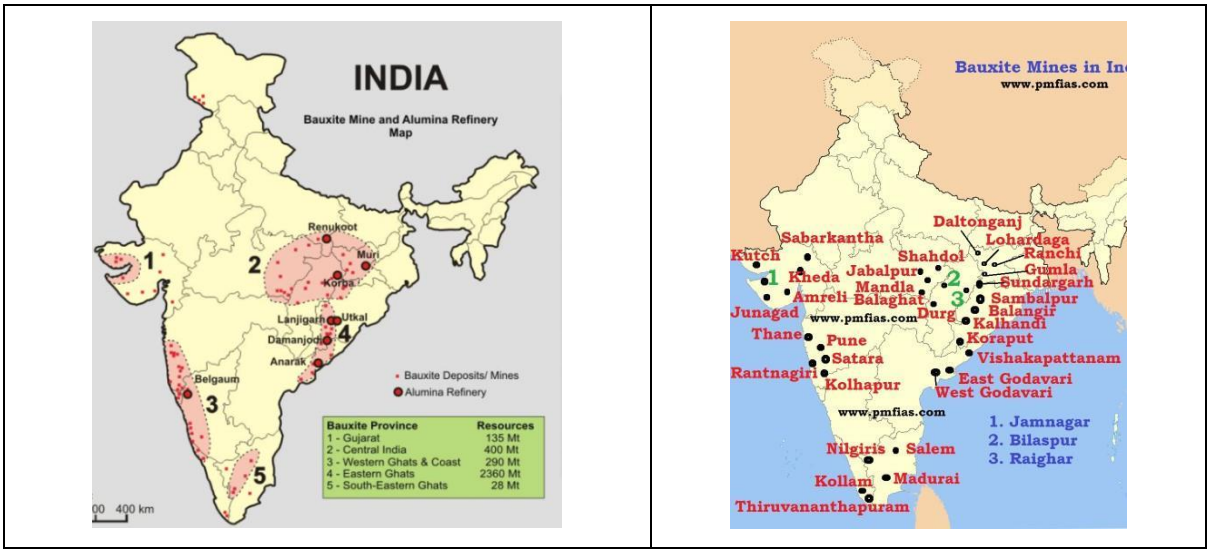


Figure 2 (a) Bauxite mines and alumina refinery map; (b) bauxite ore locations

A shift in aluminium production base:

The aluminium production base is shifting from West to East due to rising power, labour, environmental costs, logistics and aluminium prices in the West. The abundant availability of alumina in India, gas in the middle east and cheap sources of energy in south-east Asia result in huge opportunities for the creation of joint ventures among the countries in the East.

Aluminium consumption by applications in the country

The government's thrust on the power sector is the dominant consumer of aluminium in India, which augurs well for the aluminium industry. The electric sector accounts for 45% of the aluminium consumption in the country followed by transport (18%), construction (15%), machinery (9%), consumer durables (8%) and packaging (5%). The consumption pattern for aluminium in the country is different from the world's consumption where construction and auto are leading consumers of aluminium. This is also one of the reasons for lower per-capita aluminium consumption in the country which is currently at 2.5 kgs. Aluminium is a key metal that will be needed during the further industrialization phase of India and hence its demand is expected to become 8 mT by 2025 which will be boosted by urbanization, rising PCI, government schemes like Make-in-India & Smart Cities.

The growth rate of aluminium in the country

The per cent growth rate of aluminium production, consumption, exports and scrap imports is shown in Figure 3. Though India is the 2nd largest producer of aluminium, it is a net importer of aluminium. India exports primary ingots and imports alloys and finished goods of aluminium which calls for indigenous technology development for alloy production and value addition of aluminium semis.

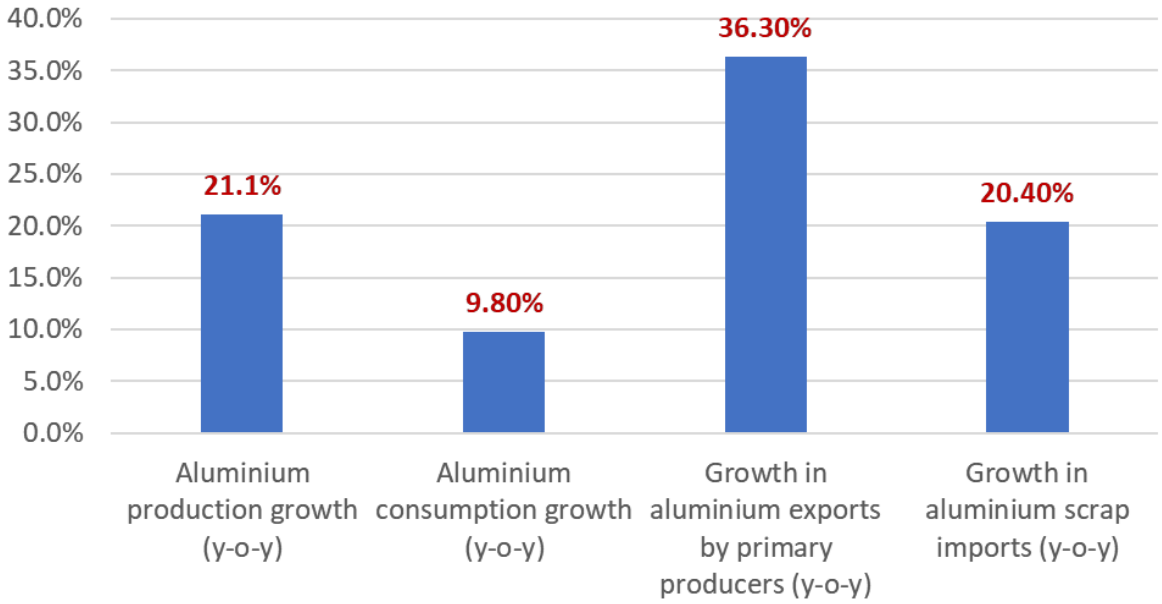


Figure 3 Percent growth rate of aluminium in India during FY18

More than 60% of the aluminium is likely to be produced and consumed in China, but growing markets in Brazil and India, increasing accessibility of resources, including energy in Russia, Africa and South-East Asia could change the pattern of aluminium production and consumption once more, this time southwards, as well as eastwards.

Contribution of recycling to the growth of aluminium

Apart from primary metals, India has witnessed strong growth from the recycling industry. The growing emphasis on environment conservation and sustainable development has increased the focus on metals recycling. With time, the share of recycling in the total metal production has increased significantly and is almost in part with the global level. In India, recycled aluminium production is around 30% of the total aluminium produced which is on par with the global share of recycled aluminium production.

The secondary production of metals through recycling significantly lower resources as compared to the requirement for primary production and contributes significantly to meeting the total demand for non-ferrous metals in India. Out of all metals, aluminium recycling requires the lowest energy when compared to the energy that was required to produce primary aluminium. Percentage of primary metal energy saved by recycling for various metals viz. aluminium, nickel, copper, zinc, lead and steel are 95%, 90%, 85%, 75%, 65% and 60% respectively.

Aluminium as a strategic metal

The notion of 'strategic minerals' or 'critical minerals' is relatively new to policymakers in India as compared to other major economies of the world. As per Council on Energy, Environment and Water's (CEEW) report on non-fuel minerals, 2016, aluminium was classified under Zone III with low economic importance & low supply risk (least critical). In the 1950s itself, India has recognized aluminium as the most vital metal in war.

As per the US, The National Strategic and Critical Minerals Production Act of 2013, the term strategic and critical minerals mean necessary minerals

- For national defence and national security requirements;
- for the Nation's energy infrastructure, including pipelines, refining capacity, electrical power transmission and generation, and renewable energy production;
- to support domestic manufacturing, agriculture, housing, telecommunications, healthcare, and transportation infrastructure;
- for the Nation's economic security and balance of trade

Futuristic & Innovative technologies

Currently, sensors are being used for determining the real-time measurement of alumina content, superheat, temperature and bath ratio of the electrolysis bath during the Hall-Heroult process.

Figure 4 shows various areas of research identified in various processes, applications and recycling of aluminium viz. utilization of red mud produced during refining, spent pot lining produced during smelting, light-weighting of transport, collection & sorting of EoL products, recycling of packaging, contamination in recycling etc.

But there is scope for mature and small improvements in cell designs, feeding systems, bath composition and control systems in the Hall-Heroult process. A reduction in energy consumption by 0.2 – 0.5% per year, improvement of current efficiency to over 95% to reduce overvoltage are such small improvements envisaged in the aluminium electrolysis process. Technological and engineering improvements in the electrolysis process includes point feeder improvements with the incorporation of accurate cell controllers and advanced process controllers to reduce the frequency of AE & control operational variables.

Technologies that are still in the concept and research stage are wetted, drained cathode technology, alternate cell concepts which combine wetted & drained cathodes with inert anodes, commercial-scale carbothermic reduction, etc.

As per International Aluminium Institute's Mission 2020, the following were the targets for the aluminium industry:

- 5% reduction in the energy intensity
- Reduction of electrical energy consumption to 11 kWh/kg of aluminium produced during smelting
- 25% reduction in the cost of metal production
- 25% reduction in energy usage for melting
- Increase of current efficiency to 97% at a low energy input
- Reduction of electrical energy consumption to 13 kWh/kg of aluminium for retrofitted smelters

This shows that the aluminium industry is continuously striving to overcome the 3E challenges.

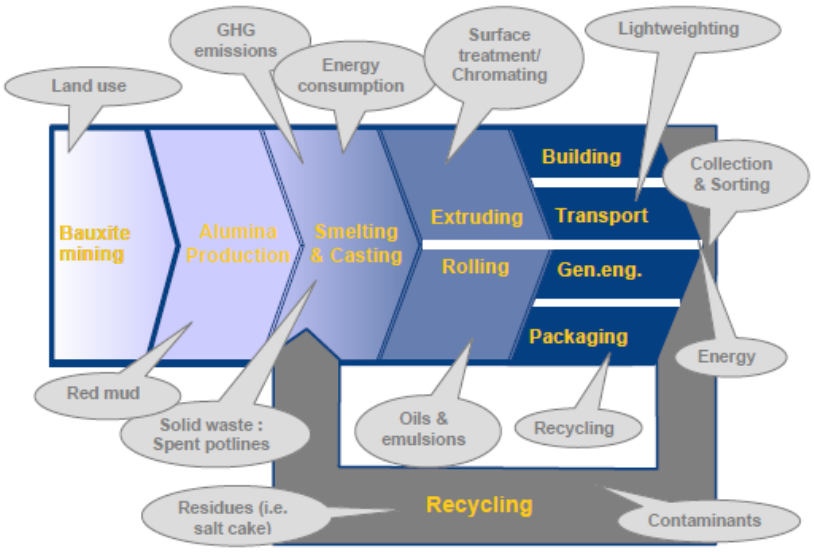


Figure 4 Research areas related to aluminium production, usage and recycling

Net Energy Advantage

Aluminium products generate a net energy advantage (NEA) over their life cycle. NEA is possible when aluminium products save more energy during their useful life than was required to produce those products.

Internationally, there are several projects worth over 100 million dollars related to aluminium production are being carried out in cost-shared funding. Some of the projects are selective adsorption, intelligent pot room operations, revolutionary cell technologies, isothermal melting process, reduction of oxidative melt loss, prevention of molten aluminium-water explosions, texture in aluminium alloys, etc.

Some of the current challenges of the Indian aluminium industry are reducing ACD, current density to achieve maximum energy savings, reduction of power consumption from around 16 kWh/kg to 12 kWh/kg to achieve 11 kWh/kg, reduction of voltage from 4.1 volts to 3.8 – 3.4 volts and reducing heat losses. The following cell technologies help the Indian aluminium industry reduce energy consumption, cost and carbon footprint:

- Inert sidewall
- Increasing conductivity of anodes
- Decreasing corrosion rates
- Decreasing ACD from 1 inch to 0.5 inch
- Optimization of electrolyte chemistry
- Operating temperature
- Elimination of electrode penetrations
- Eliminate anode carbon, CO/CO_2 emissions, perfluorocarbons (PFCs)
- Production of oxygen as a by-product which is possible with inert anodes

Incorporating inert anode with the wetted cathode in aluminium electrolysis cell leads to a 10% reduction in operating costs, 5% increase in cell productivity and 41% reduction in greenhouse gas (GHG) emissions. But drawbacks of the same include the higher cost of inert anode material, contamination of metal and higher anode wear rate.

The best non-Chinese technology, the DX+ has the following advantages

- Highest productivity per unit cell area of all smelters

- Anode current density – 0.9 A/cm^2
- Lowest energy of high-amperage cell – 13 kWh/kg of aluminium
- 96.2% current efficiency
- Lowest PFC emissions
- Uses capabilities of modern control instrumentation and knowledge
- Uses modified work practices through applying knowledge from advanced process sensing.

Chinese aluminium producer, Chinalco made a significant breakthrough in Electrolytic Aluminium Technology by installing 600 kA super-large cells which were developed by SAMI in seven years. These cells were designed to solve technical difficulties like magnetic fluid stability as well as operational stability. After being tested for 1.5 years the energy consumption of these cells was as low as 12.14 kWh/kg of Al.

Future trends

Amperage increase has been the trend for many years now. This has implied lower cell voltage to maintain a proper heat balance in the cell. It may seem to create an opportunity now for gains in cell voltage, which probably will be below 4.0V in the future. Lower energy consumption will be required, as the aluminium industry will be expected to save energy in the years to come.

Aluminium may become an even greener metal than today. For the aluminium industry to be a winner, it must be among the very best in technology and operations. Technically, the aluminium production process can be most energy-efficient, close to zero GHG emissions and lowest carbon footprint. But on the way to achieving zero GHG emissions, the aluminium industry may face the following challenges:

- Focus more on lower specific energy consumption & eliminate AE
- Recovery of energy from main heat loss sources, like cathode linings and gas exhaust systems
- Collecting and cleaning CO_2 from the electrolysis process itself may be a technically possible future scenario

The status of emerging technologies in the aluminium sector is given in Table1.

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Table 1 Status of various emerging technologies in the aluminium sector

Area	Technology	Status
Electrode technology	Inert Anode	Demonstration
	Wetted cathode	Demonstration
	Multipolar cells	Demonstration
	The novel physical design of anodes	Commercial with low adoption
Reduction technology	Carbothermic reduction	Pilot stage
	Kaolinite reduction	Research stage
Low-temperature technology	Ionic liquids	Development stage
Recycling technologies	Novel physical recycling techniques	Demonstration
	Aluminium mini mills	Pilot

Inert anode technology

Inert anodes can significantly improve the Hall-Heroult process for producing aluminium by eliminating the need for regular replacement of the carbon anodes currently used in Hall-Heroult cells. Ideal inert anodes are chemically nonreactive and are not consumed by the electrolysis reaction, and thus could ideally have the same lifetime as the smelting cell.

Materials that have been considered for inert anodes include metals, ceramics, and cermet, which are a mix of these two. In addition to eliminating the energy and material needs for frequently replaced carbon anodes, inert anodes can reduce the ACD in a Hall-Heroult cell, is a major

determinant of electricity used by the cell. Figure 5 shows the reaction, input and output of the aluminium electrolysis cell with inert anodes.

$$\frac{1}{2}Al_2O_3 \rightarrow Al + \frac{3}{4}O_2$$

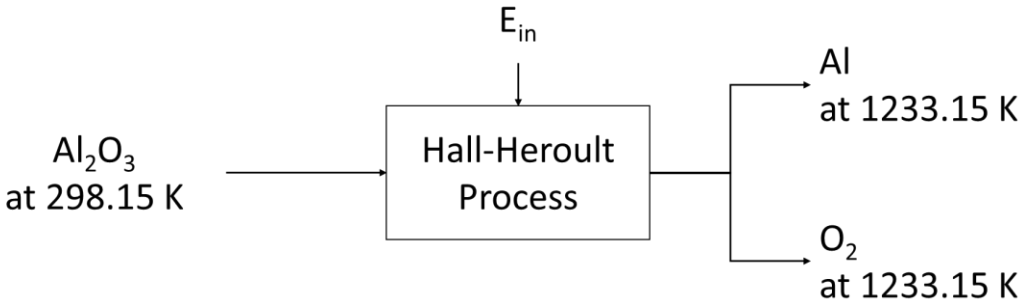

Figure 5 Inert anode technology

Benefits of inert anodes include:

- Energy savings of 3-4% within a modified Hall-Heroult cell (U.S. DOE 2007)
- Capital costs for inert anodes could be 10-30% lower than that for conventional anodes
- Eliminating greenhouse gases produced by electrolysis with carbon anodes (CO_2, carbon monoxide, and PFCs)
- Improving occupational health by eliminating the need to regularly replace carbon anodes in the smelting cells
- Improving plant operating efficiency by eliminating anode effects
- Reducing cell energy losses by 60% or more

Wetted cathode technology

The cathode in a Hall-Heroult cell is technically the negatively charged surface of the molten aluminium that is being formed by electrolysis, but usually ‘cathode’ refers to the solid carbon material upon which the molten aluminium collects. The molten aluminium is somewhat stable under normal operating conditions but bringing the anode closer to it causes large waves due to MHD forces. ‘Wetting’ refers to improved electrical contact between the molten aluminium and the carbon cathode material.

A completely wetted cell lining that was also inert to the cell bath would allow molten aluminium to be drained out of the anode-cathode spacing. This design could withstand a smaller ACD, leading to significant energy savings. Titanium diboride (TiB_2) is a durable, wetted cathode material that can withstand corrosive and high-temperature conditions within a cell.

Wetted cathodes face several design challenges, namely compensating for complications that arise with a smaller ACD and lower voltage operation. These include lost heat energy and impeded circulation and mixing of the molten bath. Finally, TiB2 and related composites can be very expensive. Several possible concepts for wetted cathode and draining cells is shown in Figure 6.

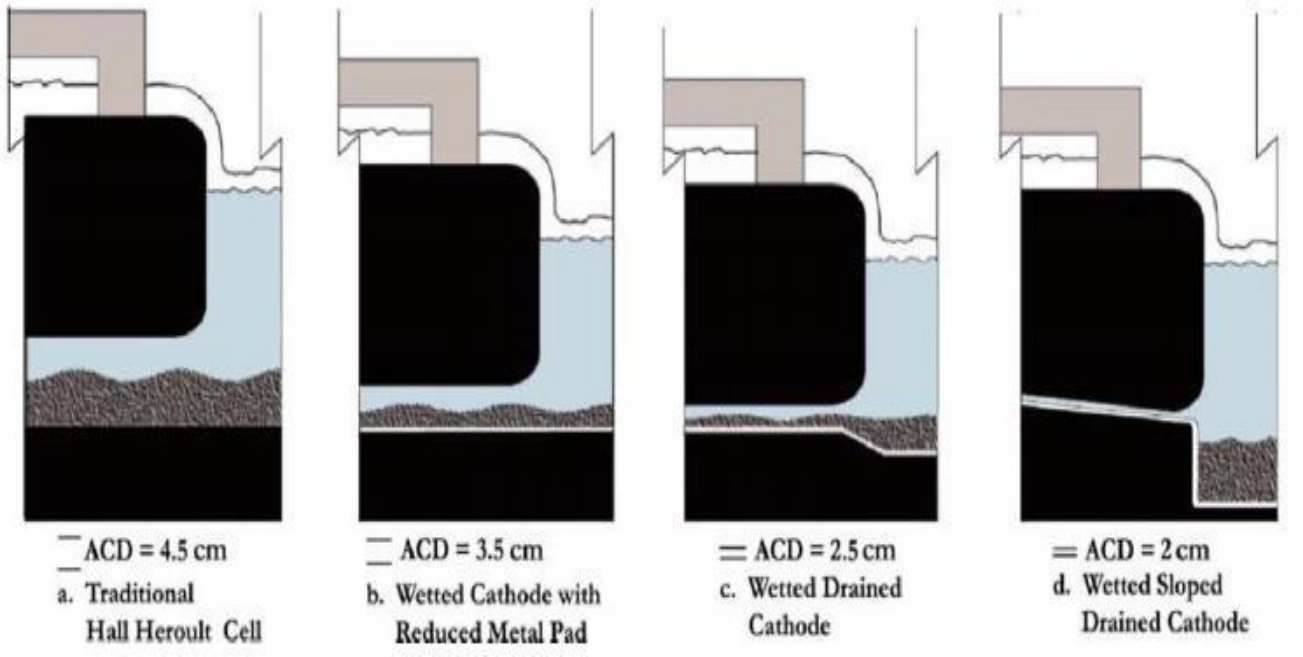

Figure 6 Possible combinations for wetted cathode and draining cells

shows that carbothermic is the best technology in terms of energy and alumina consumption, whereas inert anode technology is the best with the lowest carbon footprint amongst all the technologies.

Table 2 Comparison of emerging technologies for aluminium smelting

Technology	Energy use (kWh/ kg of Al)	Alumina (kg/kg of Al)	Carbon anode [carbon] (kg/kg of Al)	CO2 [CO] (kg / kg of Al)
Hall-Heroult	15.37	1.93	0.45	1.66
Wetted cathode	11.83	1.93	0.45	1.66
Inert cathode	16.82	1.93	0	0
Carbothermic	10.15	1.89	[0.67]	[1.56]
Best technology	Carbothermic	Carbothermic	Inert anode	Inert anode

Conclusion

To conclude, India's vision for aluminium's growth includes the following:

- Updating the status of aluminium as a core industry
- Bringing reforms in coal and bauxite mining
- Strengthening aluminium scrap recycling
- Energy policy for energy-intensive sectors
- Export policy for the downstream industry

Bioskecth od Dr. Anupam Agnihotri

Dr. Anupam Agnihotri is working as Director, Jawaharlal Nehru Aluminium Research Development and Design Centre, Nagpur.Under UNDP, he has served as a visiting faculty to the

University of Quebec in Canada as well as the Hungarian Research Institute under United Nations Development Program (UNDP). Dr Agnihotri is deeply involved in research activities on aluminium technology related to energy audit, environmental monitoring, modernization programs, low cost material alternatives etc. He is a Member of Aluminium Mission Plan (2012-2022), Ministry of Mines, Sector Expert (Aluminium) for National Mission on Enhanced Energy Efficiency (NMEEE), Ministry of Power, Board Member, Aluminium Association of India, Member of Indian Institute of Metals and Indian Society for Non Destructive Testing (INST)

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

A Perspective on Separation Science and Technology

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Abstract

Separation science plays a critical role in our society. Chemical separations are essential in providing the foods and services that are needed to maintain our standard of living and quality of life. Without separations, access to such necessities as medicines, clean water, safe food, and energy sources would not be possible. A focus on separation science is also needed to reduce the adverse effects of industrial activities, and to develop a sustainable chemical enterprise that can drive the economy. The goal of a separation process can vary from dividing a complex mixture into several fractions to extracting a single chemical from a highly dilute solution. The scale of a separation process can vary from less than a microgram to mega tons of material. The constant pressure to produce higher-purity products (> 99.999%) creates a demand for new separation processes / technologies. An attempt has been made in this article to highlight the challenges and directions of future developmental activities. The importance of separation science in contemporary scientific pursuits like desalination, production of oxygen and Super Critical Fluid Extraction are highlighted. Some examples from the author's work related to gas chromatography and separation of radionuclides using designer ligands are also discussed.

Introduction: The critical essential elements impacting the rapid growth of our country are Health, Energy, Environment, Water and Security. Cross functional discipline of Separation Science and Technology plays a pivotal role in meeting the mammoth challenges in these areas.

In the coming decades, health and hygiene is going to be vital for India with growing urbanization. Bulk drugs and proprietary pharmaceuticals would require modern separation science to provide breakthrough and make these drugs available at affordable price. The enzymatic based separation process, ion exchange resins integrated into nano synthesis of the bulk drugs and drug delivery system will change the fundamentals of health services in future.

Providing affordable energy in abundance which does not pose environmental hazards will be the major challenge facing India with a population of more than 1.3 billion. The future of energy and environment

in India depends on a) energy conservation and conversion of waste to energy; b) clean coal technology along with nuclear technology and c) renewable energy technologies like solar-biomass-wind-geothermal. All these technologies use advanced separation science and technology.

Namami Gange and Jal Shakti Abhyan aims at providing clean, potable water to every citizen in the country. Developments in membrane science, nano-bio technology, nano coated impregnated resins are critical to ensure water availability in desired quality and quantity in the coming years.

Finally, security is assuming a major challenge for India due to changing global geo politics. High technology and sophisticated surveillance systems are essential features of future security systems. Need for high purity electronics / nuclear materials will form essential part of future security/ strategic systems. Many processes in the electronics, solar energy and nuclear industry have much higher purity requirements than in past decades. Uranium concentration in seawater is extremely low (parts per billion), but resource is large (more than 4 billion tons) and required purity level > 99.99%. Radionuclides like Sr-90, Cs-137, Mo-99 are present at trace concentrations in competition with bulk ions at 100,00-fold higher concentrations in matrices like High Level Nuclear Waste / Special Target Dissolver Solutions and need to be recovered at >5 N purity. Rare earths recovery and purity at >5 N level is essential for the development of high technology materials with desired optical, magnetic and nuclear properties.

Given the importance of separation science, the U.S. Department of Energy, the National Science Foundation, and the National Institute of Standards and Technology asked the National Academies of Sciences, Engineering, and Medicine to develop a research agenda for fundamental research in separations to transform the field and provide opportunities for a paradigm shift. Important findings of the committee are summarized in the report published in 2019 [1]. Highlights of this report are

1) Important advances have occurred in the last 30 years in molecular modeling and simulation, machine learning and data analytics, analytical techniques, and characterization. These advances tantalize us with the prospect of a greatly improved theoretical and mechanistic understanding of separation processes, improved modeling and prediction of chemical behaviors, and the exploration and development of new chemicals, materials, and approaches.
2) Thus, separation science is poised for a paradigm shift in which the brightest minds in chemistry, chemical engineering, materials science, and other fields will be vying to achieve the breakthroughs in the next generation of separation science, and conventional separation technology will be replaced with high-throughput, energy-efficient, and exquisitely selective separation systems.

Membrane-based separations for Desalination: **Fig.1** shows that various chemical separation processes have vastly different energy requirements. Sea is perhaps an infinite source of an essential life sustaining constituent like water. However, prohibitive cost involved in distillation was responsible for little headway in exploiting fruits of desalination to reach general public. Reverse-osmosis Membrane technology, though developed in mid 20th century has been employed on large scale only in last two decades. It has major advantage of substantially lower energy requirement (only twice the thermodynamic minimum energy) as compared to evaporation. Thousands of facilities now use this technology worldwide. Additional improvements in the technology will need to focus on such issues as the longevity of membranes particularly with respect to fouling, pretreatment, and post-treatment conditions

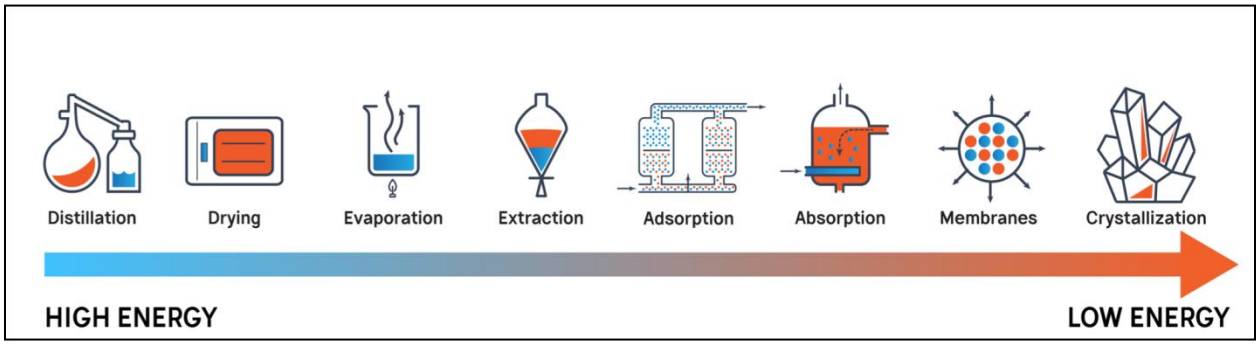

Fig.1: Energy Requirements of Different Separation Processes

Production of Oxygen: Recent COVID epidemic brought to focus the need to produce and distribute medical oxygen in large scale at competitive cost. It is produced industrially by three processes viz. Cryogenic Distillation, Membrane Separation, Pressure Swing Adsorption

- **Cryogenic Distillation (Fig.2)** : It is a leading leading process for producing >99% oxygen in bulk. It Involves liquifying air and distilling the liquid air to separate the Oxygen, Nitrogen, and Argon. It Can be sold in a liquid form. 1 L of liquid Oxygen = 860 L of gaseous Oxygen. Major drawbacks of this process are, use of large bulky equipment, substantial energy requirement and the possibility of liquid oxygen evaporating back into the atmosphere over time

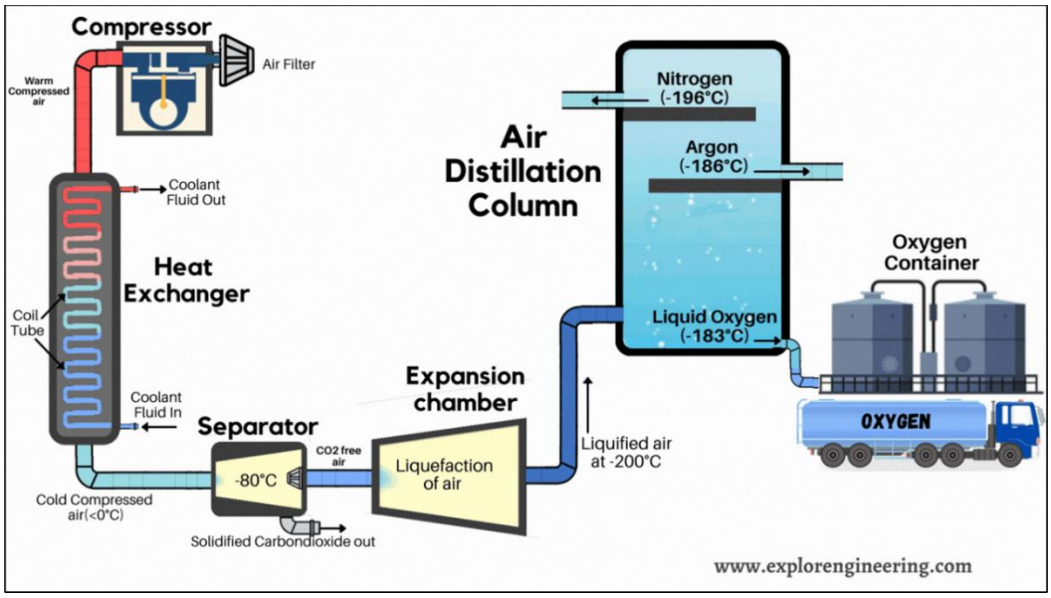

Fig.2: Schematic of Cryogenic Distillation Process for production of Oxygen

- **Membrane Separations**: In view of the energy intensive Cryogenic Distillation process, membrane based separations are preferred. Permeable materials are used to selectively separate Oxygen, Nitrogen, and Argon. Pressurized air is passed through the membrane and is separated by permeability characteristics of each component in relation to the membrane porosity. Membranes require a large surface area to achieve high product flow rates. Large pressure is however a safety hazard.

- **Pressure Swing Adsorption:** Pressure swing adsorption (PSA) is a technique used to separate some gas species from a mixture of gases (typically air) under pressure according to the species' molecular characteristics and affinity for an adsorbent material. It operates at near-ambient temperature and significantly differs from the cryogenic distillation commonly used to separate gases. Selective adsorbent materials (e.g., zeolites, (molecular sieves), activated carbon, etc.) are used as trapping material, preferentially adsorbing the target gas species at high pressure. The process then swings to low pressure to desorb the adsorbed gas as shown in **Fig.3**.

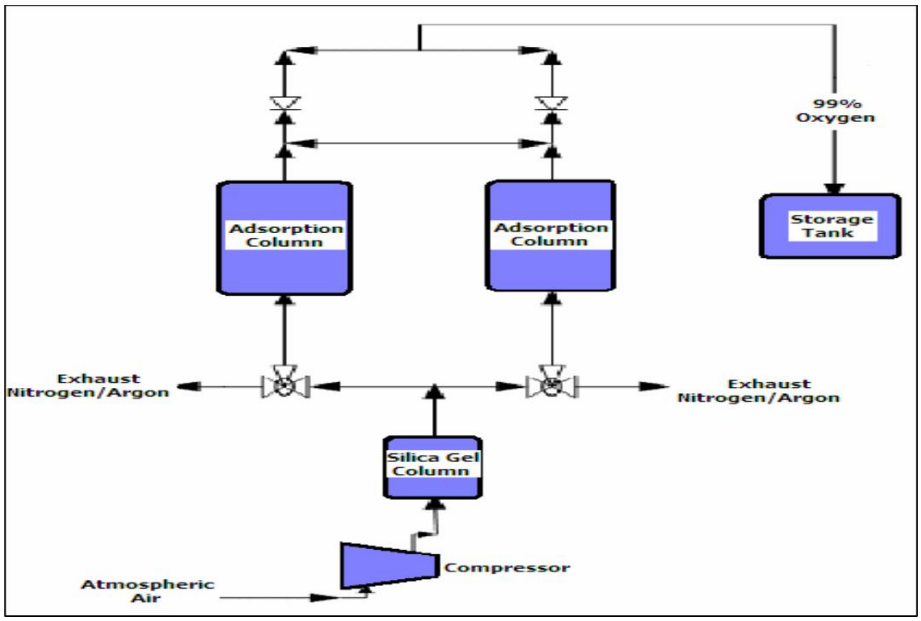

Fig.3: Schematic of Pressure Swing Method for the production of Oxygen

Supercritical Fluid Extraction (SFE): A supercritical fluid is any substance above its critical temperature and pressure. It can diffuse through solids like a gas and dissolve materials like a liquid **(Fig.4).** Additionally close to the critical point, small changes in pressure and temperature result in large changes in density, allowing many properties to be tuned. It can replace hazardous organic solvents in industrial processes. Non flammable and non toxic Carbon dioxide is the most common SCE due to its favorable properties like its low critical temperature (31.9^0C) and moderate critical pressure (73 bar). It has lower viscosity but larger diffusivity than liquid solvents. Carbon dioxide (CO_2) is sometimes modified by co-solvents such as ethanol or methanol.

- Supercritical fluid extraction (SFE) is the process of separating one component (the extract) from another (the matrix) using supercritical fluids as the extracting solvent. Extraction is usually from a solid matrix, but can also be from liquids. SFE can be used as a sample preparation step for analytical purposes, or on a larger scale to either strip unwanted material from a product (e.g. decaffeination) or collect a desired product (e.g. essential oils).
- Applications of SFE are increasing in the areas like Decaffeination of tea, Extraction of flavors from herbs , Extraction of fats and oils (Eucalyptus/Soyabean/Ginger), Dealcoholisation of alcoholic beverages, Extraction of aromas from different flowers / juices , Extraction of antioxidants such as vitamin E and C, Extraction of bioactive components with added value for human health, such as catechin, α-tocopherol, resveratrol, and various natural pigments.

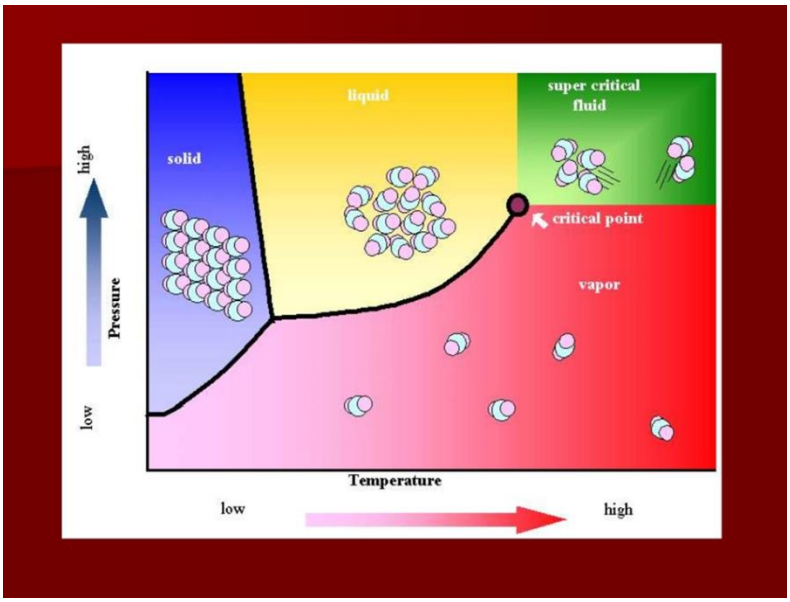

Fig.4: Molecular Characteristics of Supercritical Fluid

Tailoring of molecules for challenging separations in the backend of Nuclear Fuel Cycle: Important advances in separation technologies have occurred in applications in which the exquisite selectivity and the ability to manage extremely complex feeds with high radiation fields and highly corrosive conditions are critical. It is characterized by designer solvents that use highly specific properties tailored to catch target component and reject almost all competing ions and deliver a nearly pure product.

Separation of U-233 from irradiated Th : Pure Thorium does not undergo fission with thermal neutrons, in practice, seeds are needed to start energy production. Any fissile material (^{233}U, ^{235}U or ^{239}Pu) can be used as seed. It is necessary to produce sufficient amount of Pu-239 / U-233 prior to the exhaustion of naturally occurring fissile U-235. In Th fuel Cycle, focus is on production of U-233 and its subsequent separation from the source material, Th-232 and activation / fission products. Branched extractant molecules like Tri-sec-butyl phosphate / Tri-ethyl hexyl phosphate/ N,N di (2-ethylhexyl) isobutyramide offer interesting possibility to enhance the S.F. values of U(VI) over Th(IV). This is explained as due to the fact that inner coordination sphere of Th(IV) accommodates four bidentate nitrate ions vis-vis two bidentate in case of U(VI), there is more steric constraint to accommodate solvating extractant molecules in the former case. Data in Table 1 shows that N,N di (2-ethylhexyl)isobutyramide is a Promising Amides as alternate to TBP in THOREX process recommended for the recovery of U-233 from irradiated Th-232 [2]

Table 1: Role of the structure of Alkyl group in Dialkyl Amides on the Separation Factor of U(VI) over Th(IV)

Amide	R1	R2=R3	D_U	D_{Th}	S. F.
D2EHIBA	$(CH_3)_2CH$	$CH_2CH(C_2H_5)(CH_2)_3CH_3$	3.7	$1.0x10^{-2}$	370
D2EHPVA	$(CH_3)_3C$	$CH_2CH(C_2H_5)(CH_2)_3CH_3$	2.9	$8.0x10^{-3}$	362
DIB2EHA	$CH_3(CH_2)_3CH(C_2H_5)$	$CH_2CH(CH_3)_2$	4.7	$1.3x10^{-2}$	361
DOIBA	$(CH_3)_2CH$	C_8H_{17}	5.8	$1.4x10^{-2}$	414
DO2EHA	$CH_3(CH_2)_3CH(C_2H_5)$	C_8H_{17}	6.6	$1.9x10^{-2}$	347
D2EHPRA	C_2H_5	$CH_2CH(C_2H_5)(CH_2)_3CH_3$	9.7	0.1	97
D2EHBA	C_3H_7	$CH_2CH(C_2H_5)(CH_2)_3CH_3$	8.4	$6.0x10^{-2}$	140
D2EHAA	CH_3	$CH_2CH(C_2H_5)(CH_2)_3CH_3$	19.1	1.1	17
DHOA	C_7H_{16}	C_6H_{13}	12.4	0.6	21
DHDA	C_9H_{19}	C_6H_{13}	11.6	0.5	23
DBDA	C_9H_{19}	C_4H_9	11.5	1.0	12
DHHA	C_5H_{11}	C_6H_{13}	12.8	0.8	16
TBP	-	-	*40*	*4*	*10*

Role of Actinide Partitioning in reducing radio-toxicity: Long lived minor actinides like Am-241, Am-243, Cm-244 are responsible for the radiotoxicity of high level liquid waste generated post fuel reprocessing aimed at quantitative recovery of U and Pu. Fig. 5 shows that the removal of long lived actinides reduces the radiotoxicity of the high level waste in about 300 years (instead of waiting for million years) to the background level of natural uranium ore. Designer ligand like TODGA are capable of separating minor actinides from short lived fission products and inactive structural elements [3].

Wealth from Waste:

- Recovery of Sr-90, Cs-137 and PGMs (Platinum Group Metals) from HLW is essential not only for the ease of surveillance of the vitrified blocks, but also for their many possible applications. The extraction of Sr-90and Cs-137 from simulated HLW solution was achieved using crown ether (DTBCH18C6), Chlorinated dicarbollide (CCD)and Calixcrown. Ru-106 is recovered from HLW using solvent extraction / ion exchange and oxidation / electrochemical methods.
- Till date, more than 3 lakh curies of ^{137}Cs of desired quality has been recovered from HLLW and about 250 numbers of Cesium glass pencils have been produced successfully for deploying them for blood irradiation and grain irradiation with enhanced safety and security [4].

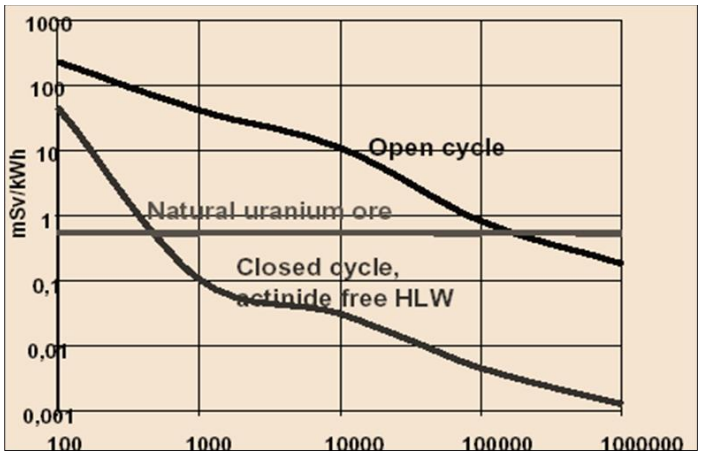

Fig.5: Radiotoxicity Profile of the Spent fuel over million years with and without actinide partitioning

Eleven numbers of indigenously developed Ru-106 eye plaques of different geometry configurations (six numbers of round geometry plaques and five numbers of notch configuration plaques) have been supplied to various hospitals of country including AIIMS-New Delhi, Centre for Sight – Hyderabad, Shankara Eye Hospital – Bengaluru.

Chromatography: A powerful Analytical technique with diverse Applications

Chromatography is an important part of science encompassing physical chemistry, chemical engineering, biochemistry, and is cutting through different fields. While it is primarily considered a laboratory method, the amounts handled by chromatography cover many orders of magnitude. It was gas chromatography which initiated the development of microsyringes, with capacities of less than one microliter (10^{-3} g) and today, we routinely determine amounts in the picogram (10^{-12} g), and even to the femtogram (10^{-15} g) level. On the other hand, industrial plants were constructed in the former Soviet Union in the 1970s, using gas chromatography columns of 15– 200 cm diameter, for the production of 200–1200 metric tons/year of pure compounds.

Today, chromatography is an essential analytical tool that is used extensively by chemists, biologists, forensic scientists and environmental scientists all over the world. It comes in wide ranging forms like Paper Chromatography (PC), Thin Layer Chromatography (TLC), Gas Solid Chromatography (GSC),Gas Liquid Chromatography (GLC), High Performance Liquid Chromatography (HPLC), Ion Chromatography (IC), Extraction Chromatography (EC), Size Exclusion Chromatography (SEC), Capillary Electrophoresis (CE) and Supercritical Fluid Extraction Chromatography (SFEC), all designed to meet specific requirements. Nobel Prize for Chemistry was awarded in 1952 to **Archer J. P. Martin and Richard L.M.Synge** for their pioneering work in Partition Chromatography.

Analysis of bonding/cover gas in fuel pin:

Apart from the composition of fuel, the composition of the bonding material (filling or cover gas) influences the thermal behaviour of the fuel pin. Inert gases like Ar and He are used as cover gas for the fuel pin. Helium is preferred as bonding gas for the advantage of its having high thermal conductivity and thus the efficiency in heat transfer from the fuel to the cladding. Helium is used for filling the fuel pins of both Pressurized Heavy Water Reactor (PHWR) and Fast Reactors. The helium gas cylinders are subjected to quality check for the impurities such as oxygen, argon and nitrogen which would reduce the thermal conductivity of the gas. The quality of the helium gas is checked by Gas Chromatographic technique prior to its filling in the fuel pins. The accepted purity is better than 99.99%. Special attention is given to the tubing used to connect the source and the gas chromatograph to eliminate any contamination of the carrier gas .

The pins containing mixed oxide or mixed carbide are thus filled with qualified helium gas and the end plugs are sealed. The dimensions of the fuel pin vary depending upon the nature of reactor and fuel. The fuel pin is checked for the purity of the gas as a part of quality assurance for its certification for loading in to the reactor. The fuel pin is punctured under vacuum and the gas is collected in a calibrated volume container. The pressure as read on the manometer after puncturing the fuel pin helps in deriving the volume of the bonding space. The initial pressure usually is maintained at 1.2-1.5 atm considering its subsequent dilution to 10-15 times with the release of fission gases inside the reactor. However, the purity of the helium at 95% for oxide fuel and 99% for carbide fuel (excluding hydrogen), is an important specification. The purity affects the thermal conductivity of the fuel and thus the performance of the fuel particularly during the initial stages of operation of the reactor.

Considering the pressure and volume of the gas available in the fuel pin of FBTR, a sub ambient atmospheric technique is needed to be employed in the analysis. The volume of the gas in the fuel pin in carbide fuel pins with stainless steel cladding is around 2 ml and the pressure of the gas comes down to 8-10 cm when released in to the sample loop of the gas chromatography. Whenever a low pressure sample travels through the column , equilibrium concentrations of major impurities like oxygen and nitrogen in the solid adsorbent (molecular sieves 5A) and in the carrier gas undergo change. This results in a bias in the concentrations of these constituents as observed in the chromatogram. The bias is inversely proportional to the pressure of the sample. Hence a correction is required to be applied during analysis of sub atmospheric sample. Therefore a blank run is necessarily to be made at the same pressure for determining the correction to be applied to the actual sample for these impurities. This technique,

sometimes referred to as Vacancy Chromatography was successfully used in the standardization of the gas chromatographic procedure for the quality control of FBTR fuel pins [5].

Summary:

Although chemical separations are integral to overwhelmingly large number of industrial processes, they are not always considered during product development. That inattention results in industrial processes that are inefficient, cost prohibitive and have adverse environmental effects. A focus on separation science is needed to overcome such issues and ultimately to improve human health, and to develop a sustainable chemical enterprise that can drive the economy. Energy-intensive separations are reported to account for 80% of industrial separations. Some separation processes generate large waste streams with heavy metals and other contaminants that are expensive to manage. There is need to curtail the use of Volatile Organic Compounds (VOCs) and replace them with more sustainable environmentally friendly solvents.

Designing Separation Systems with High Selectivity, Capacity, and Throughput are necessary to meet the challenges. Advances in materials science, systems-engineering approaches, external stimuli (Electric Fields, Magnetic Fields, Field-Flow Fractionation, Photoregulation), instrumentation and characterization (Spectroscopic Techniques, Imaging Techniques, Scattering Techniques) and in data science and analytics have contributed to the development of novel separation processes. An important role has been played by the development of new materials like Room Temperature Ionic liquids, Metal-organic frameworks (MOFs): Selective adsorbents , Two-dimensional materials such as zeolites, graphene, graphene oxide and polymeric brushes (Promising Membrane Materials), composites containing selective extractants (Magnetic Assisted Chemical Separations), Supercritical Fluid Extraction and Tailoring of ion specific molecules / extractants.

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Biosketch of Prof. V.K. Manchanda

Prof. Manchanda's work in the area of complex / separation chemistry, CQC nuclear materials and novel materials as radiation sensors is recognized internationally. He has about 1100 publications (about 400 in International peer reviewed journals of repute). He has appeared in the list of top 2% scientists published by Stanford University in 2020. He is serving on the Advisory Board of `Radiochimica Acta' (Degruyter, Munchen, Germany) and has served as Associate Editor of `Frontiers in Energy Research : Nuclear Energy' as well as on the Editorial Board of `Solv. Ext. Ion Exch.' (Taylor and Francis Group), well known International Journals in the areas of Radiochemistry, Energy Research and Separation Science respectively. He was awarded Fulbright Fellowship to pursue post-Doctoral studies in Texas, USA. As a Ph.D. / M. Phil. Guide of University of Mumbai, HBNI, Mumbai and SKKU, South Korea, he has guided 20 students. He was responsible for initiating BRNS supported symposium series on Separation Science and Technology. He is the Founder President of Separation Scientists and Technologists (ASSET) and is the past President of Indian Association of Nuclear Chemists and Allied Scientists (IANCAS). He has worked as Scientific Officer at Radiochemistry Division, BARC, Mumbai, India for 42 years (including as HOD from 2003 to 2011). He was invited to join Dept. of Energy Science, SKKU, Suwon in South Korea as WCU Professor where he taught and guided Ph. D. students till 2014. He is the recipient of OUTSTANDING RADIOCHEMIST AWARD for 2017. He is currently Vice President of Indian Nuclear Society.

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Future of Food-Feeding 10bn people by 2050

Agam Khare

Founder, CEO at Absolute foods

Our World Needs Help!

About 800mn people go to bed hungry each night. Approximately 700mn people fall ill every year because of eating tainted food. And about 2bn people suffer from micronutrient deficiency. This is a world of 7.8bn people. By 2050, there may be 10bn of us. We radically need to transform our food production system - grow more & grow better without costing our planet.

Humans learned the science of agriculture about 10,000 years ago. Fast forward to today, we are using 60% of all arable land on Earth for agriculture. While this provided the baseline necessity for human existence, all this happened at the cost of sacrificing nature's ecology. Growing concerns about climate change and increasing carbon footprint are further forcing governments, organizations, consumers & institutions worldwide to focus on food systems which accounts for roughly 25% of global greenhouse gas emissions. Reversing this footprint will play a key role in shaping the future of humanity. We understand the need for the co-existence of a fine balance between vibrant biodiversity & agriculture-food ecosystem, today, more than ever. As a civilization, we need to leverage science & technology to solve some of the grandest challenges that humanity faces today & may face in decades to come - clean air, clean food, clean water; building a home where both people & planet win as one.

Over the last seven decades, we have made significant advancements in our understanding of plants—how they live, share resources, peers they like to grow with, and more. This, combined with leaps made in sensor technology, biotechnology and chemistry, has paved the way for some necessary additions to our millennium-long agriculture practices. For instance, at Absolute, we began by mapping variety wise crop behaviors in four segments collecting hundreds of data points across them on daily basis.

Plants are living, just like us. If we can understand the triggers that causes a plant to build it's biomass, flavor profile & texture; we may as well enable it to function better, naturally. That was the core idea behind the crop recipes.

1. **Plant Nutrition:** Plant Specific diet plan, sufficing their micro and macronutrient requirements like NPK for faster growth and development with minimal use of synthetic inputs.

2. Light: Plant-specific spectrum choice and photonic flux requirement. Light recipe also determines the sleep cycle, and everyday requirements of light (Daylight Integral).

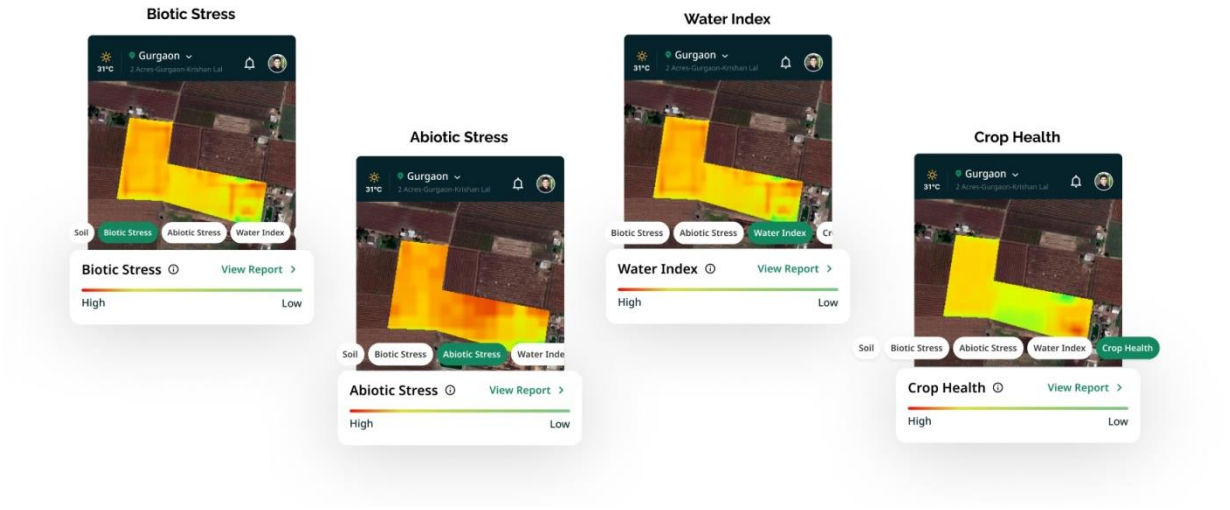
3. Environment: The ideal living environment for the plant, specific to its variety. There are over 400 environment-specific data points like pH, EC, TDS, OD, humidity, water pressure, crop stress, wind pressure, etc that can be optimized for better crop growth & development.

4. **Interaction:** Interaction related datapoints like CO2, Chlorophyll Concentration,, etc. helps with better understanding of what crops to be grown together,

Technological advancements have helped us build an agriculture system that is resilient and sustainable. Today, farmers, as well as large-scale agricultural businesses, have access to precise data through advanced technologies such as satellite imaging, sensor suites, drone technology, and biomarking, which can help increase crop productivity, quality, nutritional value and flavour profile.

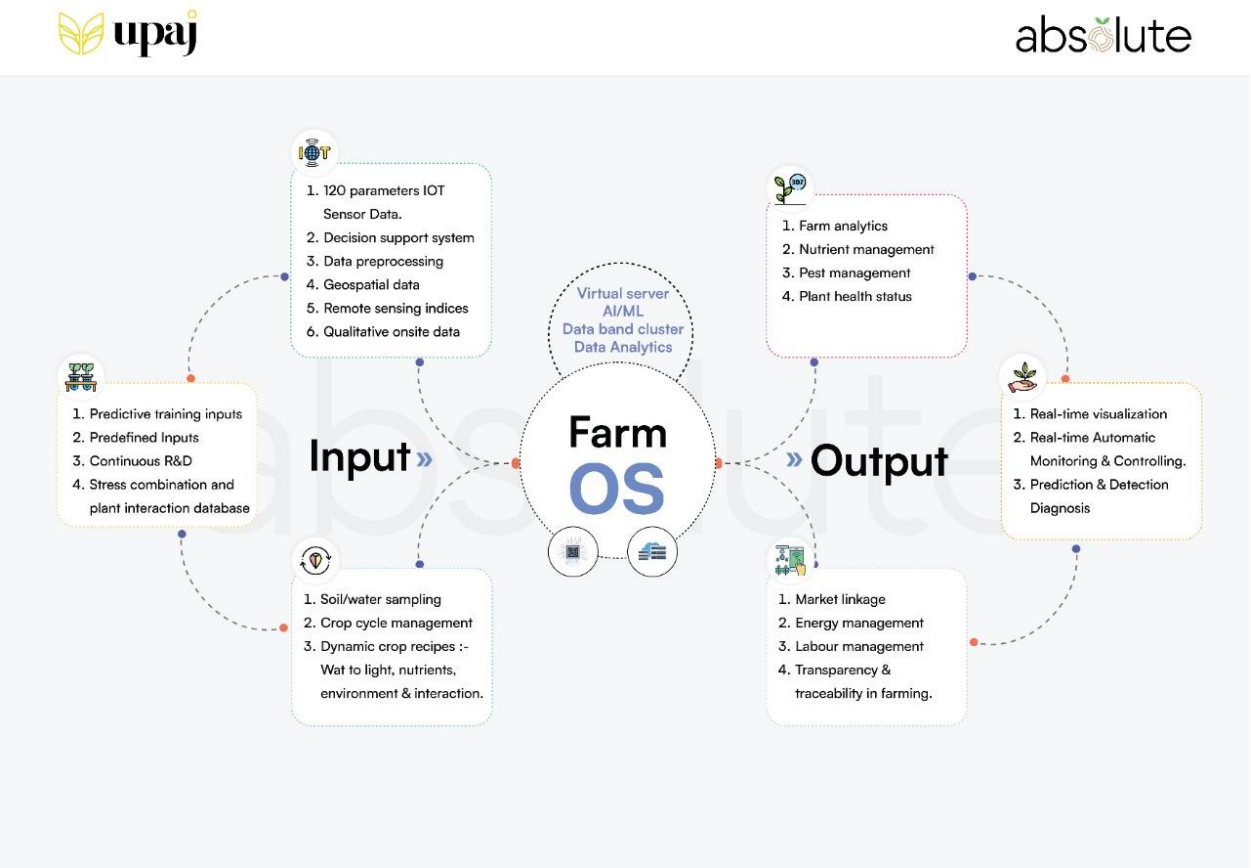
It is vital that these technological advances be merged with emerging trends in biological sciences. Advances in Omics, for example, play a key role in providing better insights into the abiotic and biotic stress tolerance and resistance in plants. Similarly, new explorations in systems biology shed light on how to improve consistency and predictability in plant breeding with faster production of higher quality food crops.

Absolute's Universal Farm OS is the powerhouse of data streams captured through satellites, IoT, Drones, and proprietary sensor suites provided to the grower. This real-time data enables growers to auto-analyze 100+ parameters personalized to their farm, crop, and geography. Through the lens of biology; weather, microclimate, and soil data are also the essential variables to determine and reflect the biotic, abiotic, and irrigation stress - which happen to be the grower's most fundamental problems during the growth cycle.



Absolute for instance is merging plant science with epigenetics and molecular biology to further leverage data and generate meaningful insight into what is precisely happening on the grower's

crop at each step in the process. Such personalized zero ambiguity insights enable growers to take better decisions for their crops - in fact, making the growing process completely autonomous while promoting carbon sustainable methods of farming.



Microbial applications further are critical in solving major agricultural and environmental issues. There have been significant biological breakthroughs leveraging microbial innovations for sustainable agriculture. Combine this with a deeper understanding of plant biology, epigenetics and molecular biology, and we have a way to improve farmer livelihoods, soil health, and productivity.

Merging all of these insights with digital technologies is the best way to ensure the viability of those technologies in real-life applications on farms. This means access to such data is

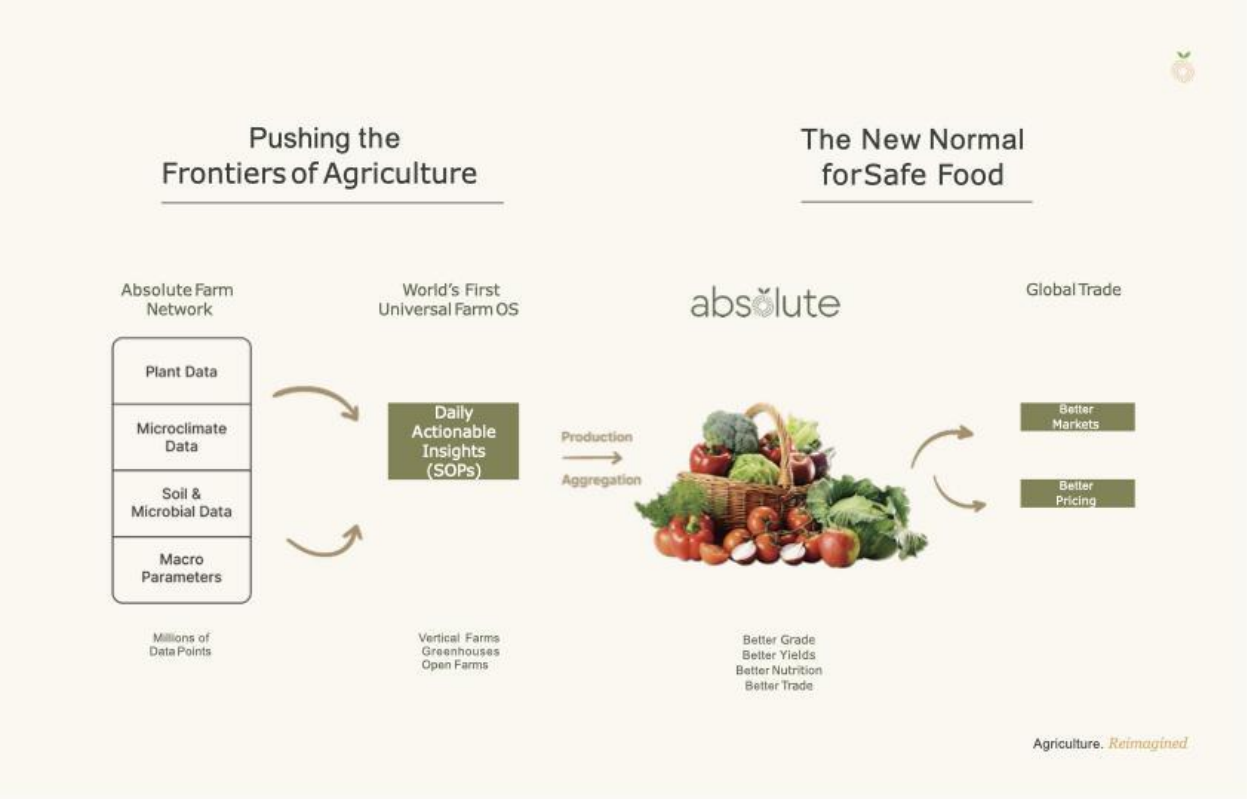
paramount. We're trying to do our bit at Absolute, building the world's largest plant bioscience platform to curate the most concise bio ag data library, which will further equip new technologies with pathbreaking bio intelligence.

We are one step closer to our collective goal to grow more and grow better, thanks to the introduction of vertical farms and greenhouses—methods that are proving to be especially effective for countries with adverse growing environments. . The problem of insufficient light can be resolved with the use of grow lights, which have become almost a necessity in these kinds of setups. At Absolute, we built one of the world's most economical grow lights, reducing the CapEx and OpEx by over 50% of the global average.

These semi-indoor and indoor farms use less land to grow exponentially more food per hectare. It is therefore extremely important to optimize their cost, productivity, and profit margins to scale them further. Scaling these solutions globally could be a game changer in fighting climate change, land use change, and increasing carbon footprints.

In the world we live in today, we're faced with the unique predicament of the paradox of hunger. We talk about working to eliminate hunger and starvation resulting from crop failure or low crop productivity. But at the same time, there coexists the contradictory concept of obesity. More than one-third of the global adult population is obese and a third of all the food that is produced is either lost or wasted.

We need to build an optimal trade ecosystem that addresses the issues of food losses and food security. And while ensuring equal access to farmers' produce around the world can be a transformative step, we also need to create livelihood opportunities for the farmers and help them increase their incomes. This is the only way communities at the bottom of the pyramid will be able to feed themselves safe, nutritious and healthy food. While we do that, it is imperative & almost morally obligatory to provide consumers worldwide with access to safe and healthy food. At Absolute, we are working to solve just that thorough a model that strikes right at the core of the above problems.



Earlier, we talked about the fine balance between strengthening the food ecosystem and preserving our biodiversity. Standing on the edge of this precipice can be daunting, to say the very least. But if we look at it from a different perspective, we have the opportunity—and the capability—to transform our world back to how nature intended it to be.

Today, we have a generation-defining opportunity before us. If countries can become self-reliant and come together to transform agriculture globally; it would be our biggest chance to build a shared future, one where people & planet can thrive in harmony. Where there is abundant clean air, clean water, and safe food for all of us today and for generations to come.

As a race, we must realize we are not alone. Our lives depend on the coexistence of the entire food & life chain in harmony. For 1700 yrs, India was on the richest civilizations in the world & we produced some of the most advanced practices by the standards of those days in agriculture. It's time for an exponential shift to revive that pursuit from India, for the world.

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Brief Biosketch of Agam Khare

Agam is the Founder, CEO at Absolute - a pathbreaking Plant BioScience & Precision Ag company. Prior, Agam ran India's leading Industrial Robotics & Factory Automation company working across various sectors - Food & Beverage, Pharma, Auto, Oil & Gas, Steel & Cement.

Between 2010 & 2012, Agam worked very closely with the 11th President of India & World Renowned Scientist- Late Dr. APJ Abdul Kalam on building moonshot innovations to solve some of the grandest global challenges faced by humanity.

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Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Radiation Technology: A versatile tool for multifaceted applications

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Abstract

Ionizing radiation (gamma rays, electron beams, plasma, etc.) have been widely used as environment friendly, efficient and versatile tools for bulk as well as surface modifications of polymers and nanomaterials. The article covers the fundamentals of radiation processing of materials including polymers and nanomaterials, and their use for development of novel functional materials for a range of target applications to showcase the versatility of Radiation Technology. The novelty of the radiation processing technology lies in being operated under ambient reaction conditions, not requiring any harmful initiators, chemical reductants and organic solvent systems (green process), better process control, reliability, etc. Therefore, radiation technology has been efficiently used for tailoring high-end value-added functional materials. Some of our recent developments in environmental and healthcare fields, namely, functional adsorbent for water purifications, sewage sludge hygienization, biocatalytic systems, and antibacterial fabrics will be presented here.

1. Introduction

Polymers have found to be one of the versatile materials being used in our day-to-day life and other various important fields, including environment, industry, healthcare, sensors, agriculture, etc. [1-4]. Most of the polymers possess desired thermo-mechanical properties, however, certain modifications in their surface and bulk properties are to be done for ~~the~~ certain target applications. Radiation processing of polymers and nanomaterials, being efficient and green process, has been widely used for incorporating new functionalities and unique characteristics with the help of using ionizing radiations as a tool.

Fundamentals of radiation processing of materials is depicted in figure 1. Briefly, whenever a molecule is exposed to a high energy ionizing radiation, two primary processes take place simultaneously: i) Ionization and ii) Excitation. These primary processes lead to

further secondary processes, such as, recombination, molecular dissociation, etc., giving rise to highly reactive species, e.g., free radicals and solvated ions. These reactive species initiate subsequent chemical reaction in the materials, leading to the desired changes in the properties of the materials required for different applications (Figure 1a).

Depending on the modifications required for target applications, four processes are mainly used for polymer processing (figure 1b): i) Radiation induced graft polymerization (RIGP), ii) Radiation induced curing, iii) Radiation induced degradation and iv) Radiation induced crosslinking. Radiation induced crosslinking and degradation are bulk modification processes, whereas radiation induced grafting and curing are the surface modification processes. In RIGP process, new polymer chains of desired functional monomers are grown over the existing polymer backbone chains using ionizing radiation as a source of initiation [1,2]. Radiolytic synthesis of metal nanoparticles is another important process used for synthesis of range of nanomaterials-based products, e.g., Noble metal nanoparticle for catalytic and sensor applications.

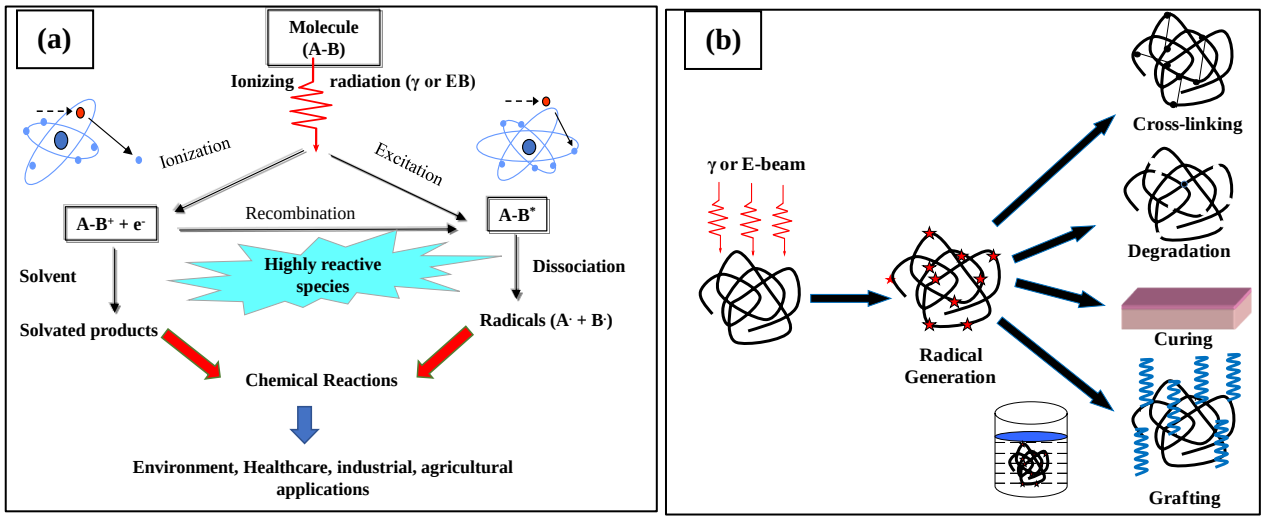

Figure 1. (a) Fundamentals of radiation processing of materials and (b) processes used in radiation processing of polymers

Some of our recent developments in the field of environmental and healthcare fields are being presented in this article. This includes different types of radiation grafted functional adsorbents for the purification of drinking water and industrial wastewater, enzymes immobilized robust and recyclable bio-catalytic systems fabricated by using radiation assisted surface engineered material supports, radiation hygienization of sewage sludge, gamma

radiolytically synthesized nanomaterials-based sensor, radiation processed antimicrobial fabrics, etc.

2. Environmental applications

2.1. Radiation grafted adsorbents for treatment of textile dye wastewater

Steep population and industrial growth have led to huge amount of coloured dye wastewater generated from textile, leather and printing industries. Disposal of untreated industrial wastewater not only affects the aesthetic quality of water bodies adversely but also causes environmental pollution, leading to serious health risks to human as well as aquatic lives [3]. During recent years, due to increased public awareness and strict regulation from government agencies, including pollution control boards, have put restrictions to the industries not to discharge untreated wastewater to the environment. Therefore, it is the need of the hour to develop simple, efficient and economically viable processes to treat the dye effluents. There are various processes reported for dye effluent treatment, such as adsorption, coagulation, membrane filtration, degradation (chemical, biological, electrochemical, ionizing radiation, etc.) [4]. However, adsorption process using suitable functional adsorbents has been reported to be a comparatively simple, efficient and up-scalable water cleaning method, wherein the pollutant moieties are literally removed from the water, therefore, eliminating the possibility of generating toxic secondary degradation by-products in the treated water.

A variety of functional adsorbents have been synthesized in our laboratory via RIGP process and employed for removal of ionic dyes from textile waste waters. For example, Quaternary ammonium, sulphonic and carboxylate groups containing green adsorbents were fabricated using RIGP process with cotton cellulose fabric (a low-cost abundant biopolymer) as a base polymer matrix [5-7]. These adsorbents have been successfully employed for removal of textile dyes from simulated and real dye wastewater in both batch as well as continuous flow mode operation. Dye adsorption data were fitted to different adsorption isotherms and kinetic models, using linear and nonlinear regression methods, to obtain the best fit models. Schematic of a lab scale fixed bed column setup for continuous mode operation studies and the breakthrough curve are presented in Figure 2.

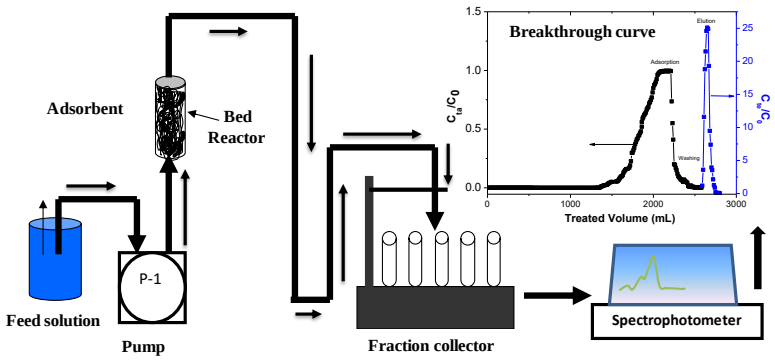

Figure 2. Fixed bed packed column setup and breakthrough curve established in continuous flow mode adsorption and desorption studies

Based on the radiation grafted cellulose adsorbent, portable treatment setup and pilot scale prototype setups have been conceptualized, designed and fabricated for the treatment of textile dye effluent in relevant and operational environments. The prototype pilot treatment setups are under field trails at industrial sites (Figure 3).

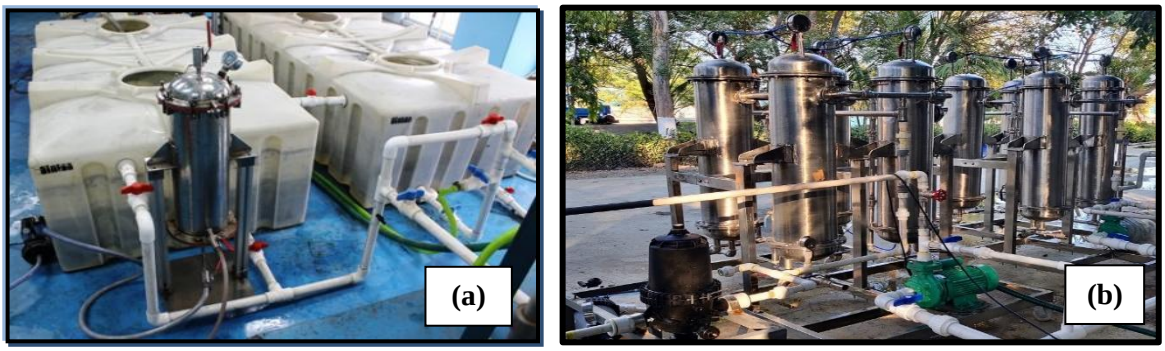

Figure 3. Radiation grafted cellulose adsorbent-based dye wastewater treatment setups (a) portable treatment setup and (b) prototype pilot treatment setup

2.2. Enzyme–immobilized-polymer supports based biocatalytic system for wastewater treatment

Enzymes are well known biocatalyst systems with high selectivity and specificity that allows them to perform range of complex chemical reactions under the mild experimental conditions. However, the free solution phase enzyme system suffers from issues such as reusability, storage stability, sensitivity to pH, temperature, denaturants, etc., as well as practical applications in continuous mode operation [8]. Therefore, enzyme immobilization on solid matrix support systems is simple and viable solution for these limitations of free

enzyme systems. Immobilization of enzymes offers advantages, such as it enhances storage and thermal stability, broadens the pH range of enzyme activity and enables recovery of product with greater purity. In addition, reusability of the expensive or scarcely produced enzymes and using it in continuous flow mode makes it practical and economical viable [9]. Covalent immobilization of enzymes on functional polymer supports has taken precedence over other immobilization strategies including physical adsorption, entrapment, crosslinking [10]. RIGP process has been widely used to introduce desired chemical functional groups onto existing polymer surfaces, which were subsequently used as template support for covalent immobilization of enzymes [11-14].

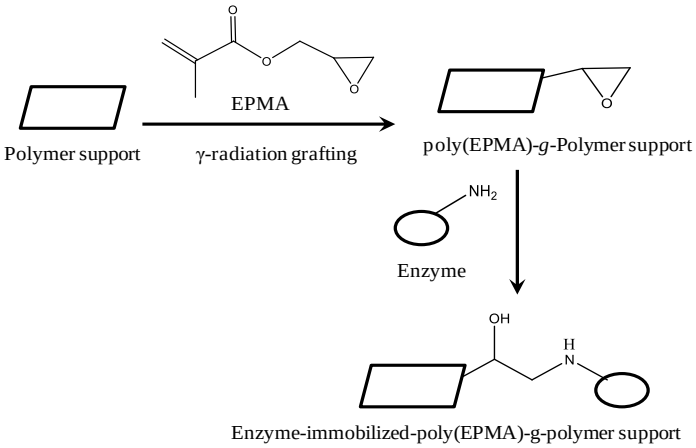

Figure 4: Synthesis of poly(EPMA)-*g*-polymer support via Radiation induced grafting process and covalent immobilization of enzyme on to it.

In this regard, a range of epoxy functionalized polymer supports (PE/PP, PES, cellulose) in different forms (film, non-woven sheet, beads, etc.) have been synthesized in our laboratory through radiation grafting of 2,3-epoxypropyl methacrylate (EPMA). Horseradish peroxidase (HRP) Laccase and Catalase enzymes, with great relevance to industrial and environmental applications, were immobilized covalently on to the functional polymer supports with an objective to develop robust and recyclable bio-catalytic systems. A single step-room temperature coupling reaction was used, wherein amine group of enzyme reacts with the epoxy group of grafted poly(EPMA) chains, as depicted in Figure 4 [12,13]. The Laccase-immobilized-poly(EPMA)-*g*-PES beads system showed improved storage stability as compared to free laccase system. Moreover, it could be reused up to 10 cycles over a period

of 5 days, without significant loss of catalytic activity. This biocatalytic system has been found to effectively degrade textile dye acid Red 1 in aqueous solution. In another study, HRP-immobilized-poly(EPMA)-g-PE/PP nonwoven matrix was found to show enhanced thermal stability as compared to the free enzyme system. Similarly, a recyclable Catalase-immobilised-poly(EPMA)-g-Cellulose based biocatalytic system was synthesized using RIGP process, which was employed for enzymatic degradation of H_2O_2 over 5 cycles within 10 days without substantial loss in activity [14]. The immobilized enzymes based biocatalytic systems developed via RIGP process, showing improved operational stability and reusability, can be used for potential wastewater treatment applications.

2.3. Radiation hygienization of sewage sludge to produce enriched manure

Sewage is another type of wastewater, generated mainly from domestic (house hold) human activities, which contains 99.9% water, <1% solid (organic and inorganic matter), nutrients (N,P,K, etc.) and pathogens. During the treatment of the sewage, large amount of sewage sludge is generated in sewage water treatment plants (STP) on daily basis. Proper disposal of the sewage sludge is matter of concern for urban authorities, because the sewage sludge contains high load of infectious microorganisms (bacteria, viruses, protozoa, helminthes, etc), which can be a potential threat to public health. However, sludge being an important source of macro and micro nutrients (C, N, P, K and Zn, Fe, Cu, etc.), may be used as a manure (circular economy) and soil conditioner/rejuvenator after proper hygienization treatment.

^{60}Co-gamma radiation has been well known for its unique ability of inactivating/killing microorganisms present in the sewage sludge in a most efficient and reliable manner. Basically, ionizing radiation interacts with DNA, proteins and water molecules present in the cell, resulting in the inactivation/killing of microorganisms. Moreover, the gamma radiation not only kills pathogens but also degrades other unwanted constituents, like chemicals, weeds, etc., and, thereby, makes sewage sludge safer for land applications. As per USEPA norms, radiation dose ~10 kGy is sufficient to hygienize sewage sludge. The schematic of the radiation hygienization process for dry sewage sludge is shown in Figure 5. Salient features of the radiation hygienization process are as following.

- Simple, effective, economic and scalable process

- Easy to integrate with the existing sewage treatment facility
- Indigenous and fully automatic process
- The hygienized sludge is enriched with beneficial soil bacteria
- Hygienized sludge is a potentially useful enriched organic manure, which can be used as a good substrate to produce bio-fertilizer of the required standards.

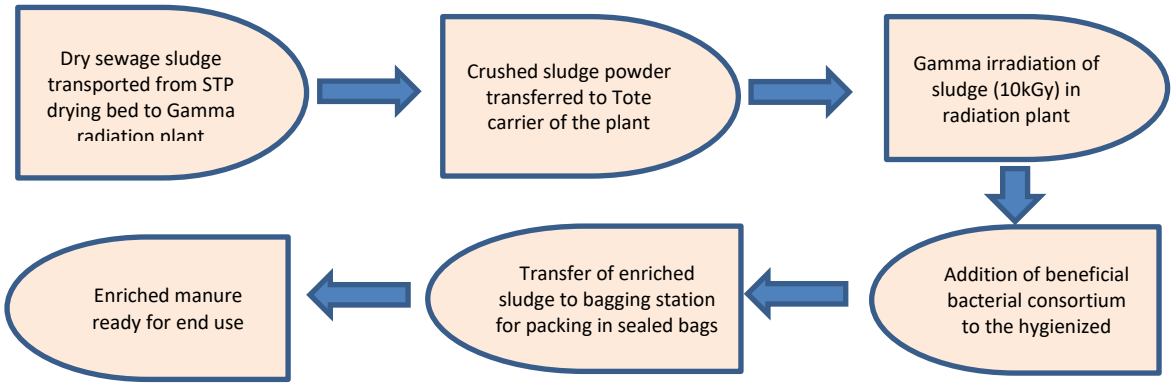

Figure 5: Process flow sheet diagram of Radiation hygienization of sewage sludge

Ahmedabad Municipal Corporation (AMC), in collaboration with Bhabha Atomic Research centre, has set up a 100 tons/day dry sludge hygienization facility in Ahmedabad, GJ, which is first of its kind in the whole world. Similar second facility has been set up by Indore Municipal Corporation (IMC) in in Indore, Madya Pradesh.

3. Healthcare applications

3.1. Water purifier for removal of Arsenic from drinking water

Arsenic contamination in drinking water has been found to be one of the serious environmental and health hazards in several parts of globe, including India. To address this issue, to the best of our knowledge, RIGP process has been used for the first time, to develop a novel, recyclable cellulosic adsorbent filter based domestic and community level water purification systems for remediation of Arsenic from water. Radiation grafted cellulosic adsorbent filter efficiently picks up oxyanion moieties of Arsenic from contaminated water.

The cellulose fabric adsorbent is easy to fabricate in the form of cartridges, which can be regenerated using optimized eluent system and recycled (Figure 6a).

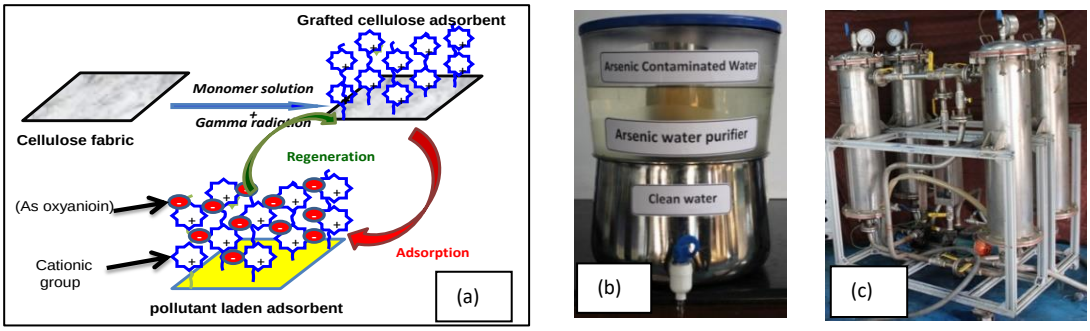

Figure 6: Radiation grafted cellulose based adsorbent for removal of Arsenic from water. (a) Fabrication and working principal, (b) Gravity driven domestic water purifier, and (c) Community scale water purifier

After validation in laboratory using simulated water samples, in batch and continuous flow mode operation, the technology was tested and validated on actual Arsenic contaminated groundwater samples collected from different affected areas. The developed technology could successfully reduce arsenic concentration in the treated water below 10 ppb, which is WHO permissible limits of in drinking water. After successful field trials and semi pilot scale treatment at actual sites, a radiation technology based unique drinking water purification technology was conceptualize and developed for Arsenic remediation from drinking water at domestic as well as community levels. Figure 6b and 6c shows a radiation grafted cellulose adsorbent-based gravity driven domestic water purifier and a community scale water purifier, respectively. The technology has been transferred to interested licensees in a concerted effort towards disseminating the technical knowhow and produce cost effective water purifiers at commercial level for the benefit of the people residing in area suffering with Arsenic water contamination problem.

3.2. Radiation grafted Antimicrobial fabrics

Development of antimicrobial fabrics has drawn enormous interest of several research groups due to recent pandemic and public awareness towards hygiene, as well as wide range of commercial applications of antibacterial fabrics, including antibacterial hospital clothing

and masks, sportswear's, underwear's, ladies' tights, shoe linings, armbands, sleeping bags, toys for children, etc. The antibacterial fabric is generally manufactured either by adding antibacterial agents to the formulation during the initial yarn formation stages or by coating the finished fabric product with antibacterial compounds [15]. However, these fabrics may suffer from the leaching of physically bound antibacterial compounds leading to leaching induced toxicity and declined antibacterial efficacy of the fabric with time. One of the easy solutions to this problem is the immobilization of antimicrobial agents on to the fabric through covalent bonding. A novel single step green RIGP process was used in our lab for synthesizing antimicrobial cotton fabric, wherein quaternary ammonium group (QUATs) containing polymers, such as poly-vinylbenzyltrimethylammonium chloride (PVBT) was grafted onto the cotton cellulose fabric [[16,17]. The QUATs-grafted cotton fabric was tested for its antibacterial activities against gram-positive (S. aureus) and gram-negative (E. Coli) bacterial strains. The quantitative antibacterial analysis was carried out using serial dilution method and, the grafted cotton samples exhibited excellent antimicrobial activity against both gram positive (S. aureus) and gram negative (E. Coli) bacterial strains. For examples, radiation grafted PVBT-*g*-Cotton fabric showed more than 6 log cycle reduction in CFU for S. aureus and E. Coli, within 6 hrs of contact time (Figure 7).

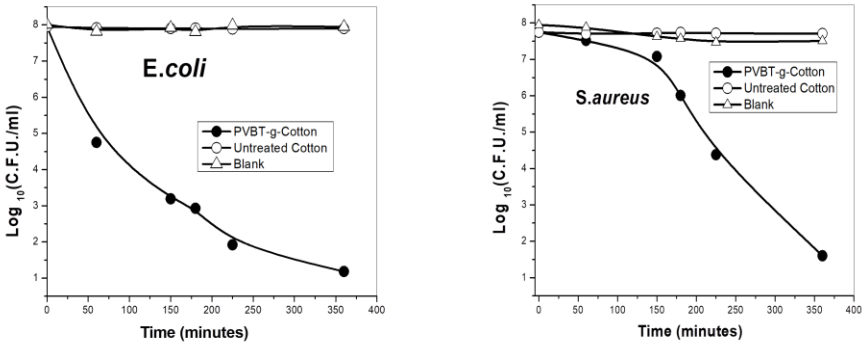

Figure 7: Quantitative Antibacterial analysis of PVBT-*g*-Cotton fabric, untreated cotton fabric and blank using E.*Coli* and *S. Aureus* bacterial strains [16]**.**

3.3. Radiolytically synthesized Ag nanoparticles as uric acid Sensor

Radiolytically synthesized noble metal nanoparticles (Ag, Au) are unique in their ability to exhibit Localized Surface Plasmon Resonance (LSPR) bands. These bands are highly sensitive to the local environment and, therefore, serve as an ideal indicator and transducer for the presence of any external analytes in their vicinity. We have exploited the LSPR properties of the gamma radiolytically synthesized nanoparticles for development of different sensors [18-19].

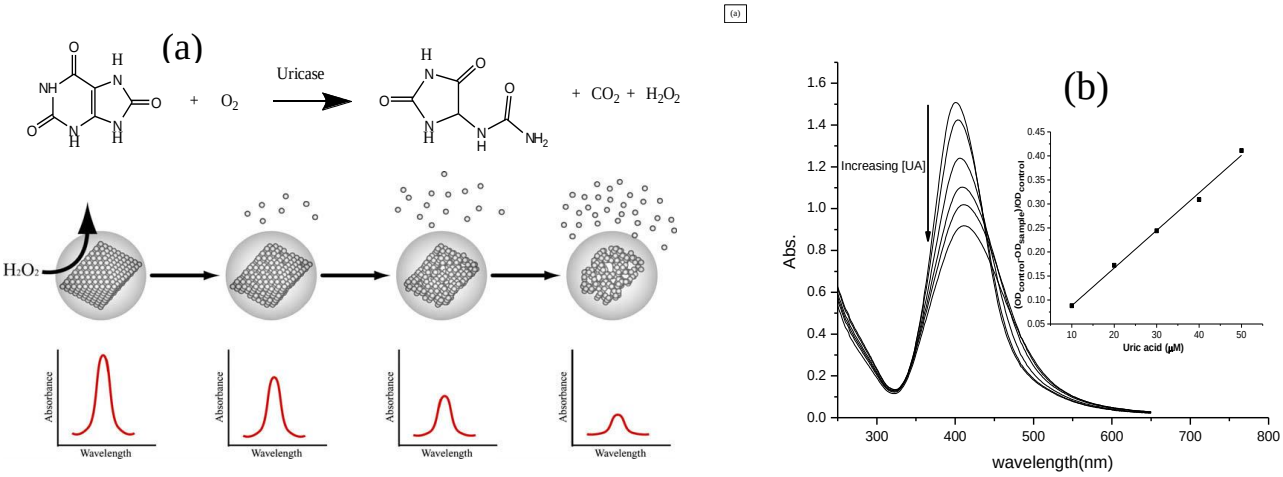

Figure 8: (a) Working principle of PVP-Ag-NPs based Uric acid sensor, (b) LSPR band intensity as a function of [Uric Acid] in presence of uricase (Inset: Linear response plot between relative LSPR band intensity and [Uric Acid])

Uric Acid estimation in blood is very important, as it is associated with diseases such as Hyperuricemia whose symptoms include gout, obesity, diabetes, high cholesterol, high blood pressure, leukemia, renal impairment, cardiovascular complications, etc. Gamma radiolytically synthesized PVP stabilized Ag nanoparticles (PVP-Ag-NPs) have been employed for the detection of uric acid in biological samples [19]. The working principle is based on the oxidation of silver nanoparticles by in situ generated hydrogen peroxide during enzymatic degradation of uric acid, in presence of enzyme uricase (Figure 8a). This resulted into the linear reduction in the LSPR band intensity of PVP-Ag-NPs at 410 nm with increase in the

uric acid concentration (figure 8b). The linear range of detection of uric acid by this method was found to be 0 to $5.0x10^{-5}$ $mol.dm^{-3}$ with minimum detection limit of $5.0x10^{-6}$ $mol.dm^{-3}$. In order to eliminate the use of fresh free laccase enzyme for every time, we have further developed a uricase immobilized radiation functional polymer system which can be reused multiple times for estimation of uric acid [11]

4. Conclusion

Radiation processing is a versatile, environment friendly and efficient technology which have been employed in designing new advanced functional materials for range of environmental and healthcare applications. This includes, development of radiation grafted functional adsorbent based water purification systems for remediation of toxic water pollutants, such as dyes and Arsenic and functional polymers support for fabrication of robust and recyclable biocatalytic system by immobilizing enzymes (Laccase, HRP, Catalase) on to them. Radiation hygienization of sewage sludge is another important environmental application of radiation technology, which not only convert a waste to a value-added manure but also protect the environment and the health of common people. Some of these processes have been converted in to technologies and translated from lab to land. A unique antibacterial cotton fabric developed by using green-one step-RIGP process, and radiolytically synthesized noble nanoparticles-based biosensors have wide range of potential applications in healthcare industry. Therefore, as a part of DAE's societal initiative mandate, radiation technology can play a pivotal role in contributing the 'Swachh Bharat Swasth Bhaarat' mission.

Acknowledgement

Sincere thanks are due to our colleagues who have been involved in the activities reported.

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Biosketch of Dr. Virendra Kumar

Dr. Virendra Kumar, Head, Advanced Material Section (AMS) & Associate. Prof. HBNI, Mumbai, is presently working in Radiation Technology Development Division (RTDD), Bhabha Atomic Research Center, Mumbai. Soon after obtaining his master degree from IIT Roorkee, he joined BARC through 42nd training school batch. He did his 2 years Post-doctoral research from ENSCP, Université Pierre et Marie Curie, Paris, France. Dr. Virendra Kumar was conferred with several awards, including DAE-Scientific & Technical Excellence Award-2016, DAE-Group Achievement Award-2016, IANCAS-Dr. Tarun Dutta Memorial award 2016 and ISRAPS-Dr. P. K. Bhattacharya Memorial Young Scientist award for year 2006. Dr. Virendra Kumar has been working on basic and applied aspects of radiation processing of polymeric materials for environmental, healthcare and industrial applications. His research activities include polymer surface modification via radiation/plasma grafting process for various applications, such as functional adsorbents for removal of toxic pollutants (textile dyes, metal ions), antibacterial surface, enzyme immobilization, radiation synthesized metal nanoparticle based optical biosensors and catalysts, Radiation cured inorganic/organic nanocomposites coating, Stimuli responsive & superabsorbent hydrogels, Antifouling, super-hydrophobic polymer coatings by PECVD process, etc. He has over 76 peer reviewed journals, 05 books, 19 technical reports, 140 conference papers and 40 invited talks to his credit. He has been actively involved in Board of Research in Nuclear Sciences (BRNS) and International Atomic Energy Agency (IAEA) activities in the field of radiation processing of polymers.

RARE-EARTH EXPLORATION IN INDIA

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INTRODUCTION

A groupof 15 geochemically coherent metallic elements are named as "rare-earths" by the International Union of Pure and Applied Chemistry (IUPAC). On account of similar geochemical properties, Scandium (Sc) and Yttrium (Y) are also grouped with rare-earths by IUPAC. All the rare-earths [atomic numbers 57 (La) to71 (Lu)] occurinnature, except promethium (Pm). After initial discovery and extraction,rare earth element (REE) uses have substantially moved upwards to high-purity separated rare earth metals finding applications in advanced electronics,lighting, power generation and military applications. Accordingly, requirement forREEprogressively moved up. In advanced countries, REEare essential to several industrial, commercial and residential appliances and in the increasing electrification ofvehicles. AlthoughREEmayonlybe required in a very less amounts, they will impart life to certain products, rendering them difficult to replace (SmithStegen,2015). In the forthcoming 10 years, major requirement for REEis expected for manufacturing of hybridelectricvehicles(HEVs)andfull electricvehicles(EVs) that will need substantial amount of REE (Weng et al. 2015; Goodenough et al. 2017).HEVsand EVs anticipated growth is from2.3 million units in2016 to over10.1million units in2026(Roskill2016). The accentuated growthislikelyto increase the requirement of neodymium-iron-boron (NdFeB)magnets.Also, another usage of NdFeBmagnets is inrenewableenergygeneration, whichwould become gradually imperative , as governments and industries aim to fulfil stringentclimatechangeandemissionsstandards (Weng et al. 2015; Goodenough et al. 2017). Today's high-tech world is governed by REE, that are considered essential for achieving sustainable development targets (Bertinelli et al.

2019).In this article, an overview of geologic sources and exploration of REE in India is briefly outlined.

GEOLOGIC SOURCES

Rare-earth sources are categories into several types with genetic links to igneous, sedimentaryand secondary processes of formation (O'Callaghan, 2012). Various sources are carbonatites, (per)alkaline granites, hydrothermal veins andpegmatites, quartz-pebble conglomerate,stream placers and beach sands, residual / supergeneweathering, ion adsorptionclays, iron-oxide copper-gold type, and other types (Singh, 2020a).Salient features of only prominent Indian sources (Fig. 1) are given below.

Carbonatites: The term 'carbonatite' is used for carbonate rocks of igneous origin with >50% modal carbonate of magmatic origin and <20 wt.% SiO_2(Le Maitre, 2002).Carbonatite-hosted deposits comprise the most important rare-earth resource globally, especially for thelightrare-earths, constituting between5and15 wt.%REO. The carbonatite of Amba Dongar in Gujarat revealed about 25.70 million tonnes of ore containing 3.46 lakh tonnes REO, whereas carbonatite complex at Kamthai in Rajasthan contains 7.36 million tonnes ore with average grade of 1.62% REO (Singh, 2019, 2020a, b). In north-east India, Samchampi and Sung Valley carbonatites and associated soils contain REE. In south India, carbonatites at Pakkanadu-Mulakkadu-Sevattur revealed significant REE concentrations. Several other carbonatite bodies from other parts of India have analysed elevated contents of strategic and critical elements (Singh, 2020b).

(Per)alkaline Granites: Agpaitic rocks deficient in calcium host REE concentrations adequately high enoughto be economically extractable. REO concentration is normally between 1.5 and 2.5 wt.%, which is facilitated by filling of voids by REE in lattice of minerals created by deficiency of calcium (Walters et al.2011). Such rocks form possible significant resource-bases particularly for theheavy REE(HREE).In India, Siwana ring complex in Rajasthan is emerging as potential hard rock source especially for HREE. Preliminary exploration inputs have revealed a cumulative resource of more than one million tonne of REE in the alkaline Siwana Ring Complex, hosted mainly in agpaitic granitoids and rhyolitic tuffs (Varma, 2019; Singh, 2020a, 2021a).

Hydrothermal Veins: Hydrothermal deposits are spatially and genetically linked with alkaline granite andcarbonatite intrusions, and may form extensive, structurally-controlled, interconnected network of veins (Chao et al. 1992). Generally, they are between 0.5 and 1,400 m long, with a width between 1 cm and 150 cm (O'Callaghan, 2012). The REE minerals in veins are represented by allanite, apatite, monazite,euxenite, bastnaesite, parisite, synchysite and fluorite, enrichment being linked with greater mobility of REE in aqueous systems (Leroy and Turpin, 1998). Hydrothermal-type deposits/occurrences are known from Singhbhum shear zone, south Purulia shear zone and Eastern Ghats Belt in India. In addition, a 320-km long albitite belt in Western India, Rajasthan revealed occasional occurrences of REE-bearing minerals along with several refractory phases (Singh 2020a).

Beach Sands: Rareearth bearing placerdepositsarethe product of weathering,erosion,transportation, sorting and concentration ofmaterial from different types of igneous and metamorphic rocks, with deposition in streams orcoastal settings (Long et al.2010). Nearly 360 placer deposits are known worldwide with Tertiaryand Quaternarycoastalmarinesands (Oris and Grauch, 2002).Coastal placers form most important resources for the recovery of rare-earths, although high thorium content associated with REE minerals of placers has been a discouraging aspect (Walters etal. 2011). The primary rare earth minerals present in the placers include monazite and xenotime. Owing to their presence comparatively as common accessoryminerals in various rocks, they are found in varying concentrations in most of the placerdeposits all over the world (Long et al. 2010). In India, beach placer deposits of commercial importance occur along eastern and southern sea coasts of India (Fig. 1; Singh, 2020a, c).Exploration efforts by employing both routine and innovative drilling and laboratory methods brought to light several heavy mineral placer deposits in different coastal areas (Rajamanickam, 2001; Dhana Raju et al. 2001; Lovson et al. 2005), with variably high concentrations of heavies (Fig. 2). Some inland placer bodies in Kerala, Tamil Nadu, Odisha, Andhra Pradesh, Maharashtra, Gujarat and West Bengal states have also been recognised (Dhana Raju et al. 2001). Someofthecoastline beach placer deposits of India are extensive andrichest, comprising ilmenite,rutile,garnet, monazite,zirconand sillimanite heavy mineral assemblagee. Ilmenite-richmajorbeachanddunesanddeposits are located Kerala(Chavara); TamilNadu(Manavalakurichi,Midalam,Vayakallur); AndhraPradesh;Odisha;andMaharashtra.Theilmenite commonlycontains50- 60%TiO_2andis

suitable fordifferentprocesstechnologies. Ilmenites from Kerala coast have up to 70% TiO_2 on account of conversion of ilmenite to leucoxene (IBM 2018). Zircon, monaziteandsillimaniteconstitutepotentialco-products.

A few beach placer deposits are under exploitation over the last several decades. Mining and beneficiation of beach sand deposits are currently carried out by the IREL (India) Limited, a public sector undertaking of the Department of Atomic Energy, Government of India, and Kerala Mineral and Metals Limited (KMML), a Kerala State Government undertaking (IBM 2018). Abundances of REE-bearing minerals reveal considerable variation in different beach sand deposits (for details see Singh, 2020a).

Stream Placers: Inland stream placers are attractive especially for Y and HREE resources. Major stream placer deposits occur in Chhotanagpur granite gneiss complex (CGGC) terrain in Jharkhand and Chhattisgarh. Sizeable REE-bearing placers occur in four streams, namely, Deo, Girma, Halwai and Pojenga in Gumla-Simdega district, Jharkhand. Other streams in CGGC terrain, which contain heavy rare-earth-bearing stream placers of commercial interest, include (i) Siri-Champajharia-Dhob-Baljora rivers in parts of Jashpur district, Chhattisgarh; (ii) Mahan River basin in Surguja-Balrampurdistricts, Chhattisgarh; and (iii) Kanhar river basin around Khoka, Sarpatwa, Amtiyatola, Bhagtaniya and Kota villages in Surguja (Chhattisgarh) and Sonbhadra (Uttar Pradesh) districts(Rai and Banerjee, 1995; Singh, 2020a, 2021a). Substantial deposition of placers is restricted to point bars and side bars and flood plain sediments (Fig. 3). Accumulation of heavy mineral is high in point bars, especially in top 0.5 m of the bars (Singh and Rai, 1992). Some of these placers are also being mined (Fig. 3) for recovering rare-earth minerals.Minor stream placer occurrences are scattered in various regions of India (for details see Singh, 2020a).

Other Sources: Economically viable REE concentrations also occur in a range of other geologic domains and lithological associations, e.g., quartz-pebble conglomerates, phosphorites and phosphatic sedimentary rocks, marine phosphates (BGS, 2011). Furthermore, seafloor mud has also been focused as a potential resource of REE(BGS, 2011). Details about these Indian sources are available elsewhere (Singh, 2020a, 2021b).

Secondary Sources: Nowadays non-conventional secondary REE resources, especially industrial process residues are also receiving attention as REE sources (Binnemans et al. 2015). In India, some work done has been done to recover REE from various secondary sources (for details see Singh, 2020a; 2021c,d).

EXPLORATION

The guiding rule for any mineral exploration is to commence from knownand then go to unknown. In this regard, it begins from literature survey to understand gross geological settings and controls of already known deposits, which guides in targeting new areas having similar geological settings. From regional scale,exploration target is gradually narrowed down by integrating results of remote sensing, geophysical, geological, geochemical, mineralogical studies and elemental analysis. As the REE occurrences/deposits known till date from diverse geological environments in India are radioactive due to the presence of uranium and / or thorium in REE-bearing minerals(albeit with the variable range of radioactivity), gamma-ray spectrometry is helpful in locating radioactive areas for follow-up work. Significantly, due to geochemical affinity of U, Th, REE and other high-field strength elements (HFSE) they tend to enrich together especially in successively younger phases of magmatic differentiates of igneous rocks.Accordingly, the investigative methodology, involving multidisciplinary approaches, adopted for exploration of radioactive minerals have some commonalities in initial stages. Once anomaly is picked up, semi-detailed and detailed exploration is undertaken according to nature and type of REE, U, Th, and associated HFSE mineralization specific methods are adopted in resource evaluation involving multidisciplinary approaches. At all stages of exploration, laboratory studies of samples, involving various analytical techniques, are done to know mineralogy, ore genesis, REE abundances, leading to resource estimation. General sequence of exploration adopted for REE is shown (Fig. 4).As far as possible, multi-elemental chemical analyses of mineralised samples should be taken up routinely done. This data would provide opportunity to assess possible recovery of other associated metals as co-products and by-products along with rare-earths, which will reduce cost of production.

CONCLUSION

The exploration for rare-earths involves multidisciplinary approaches (Fig. 4). While exploration (and commercial exploitation)efforts for beach sand and stream placers are already in progress, searches for rare-earth concentrations have been intensified by exploration agencies in other geological domains, especially carbonatites and alkaline complexes, per(alkaline) felsic bodies, hydrothermal veins and associated weathered profiles.There are vast areas with favourable geological settings in the Indian shield that could be taken up for rare-earth and associated elements exploration on an adjudged priority.

The growth of the REE industry in India needs to have linkage with systematic use of many natural resources in a coordinated way. Large-scale mine (LSM) may be preferred where vast stretches of deposits occur (Fig. 2), whereas artisanal to small-scale mining (ASM) would be appropriate in the case where deposits are of small dimensions and scattered over large area in a region (Fig. 3). Both downstream and upstream sectors should be developed to sustain the REE industry chain. This effort should integrate multidisciplinary expert groups. The REE Industry should form an inseparable part of the *"Atmnirbhar Bharat"* throughMine to Metal to Make in India programme, as envisaged by our Prime Minister of India. In this direction, AMD-IREL-BARC-NFC-DMRL-ARCI-CMAT together can make prominent contributions.

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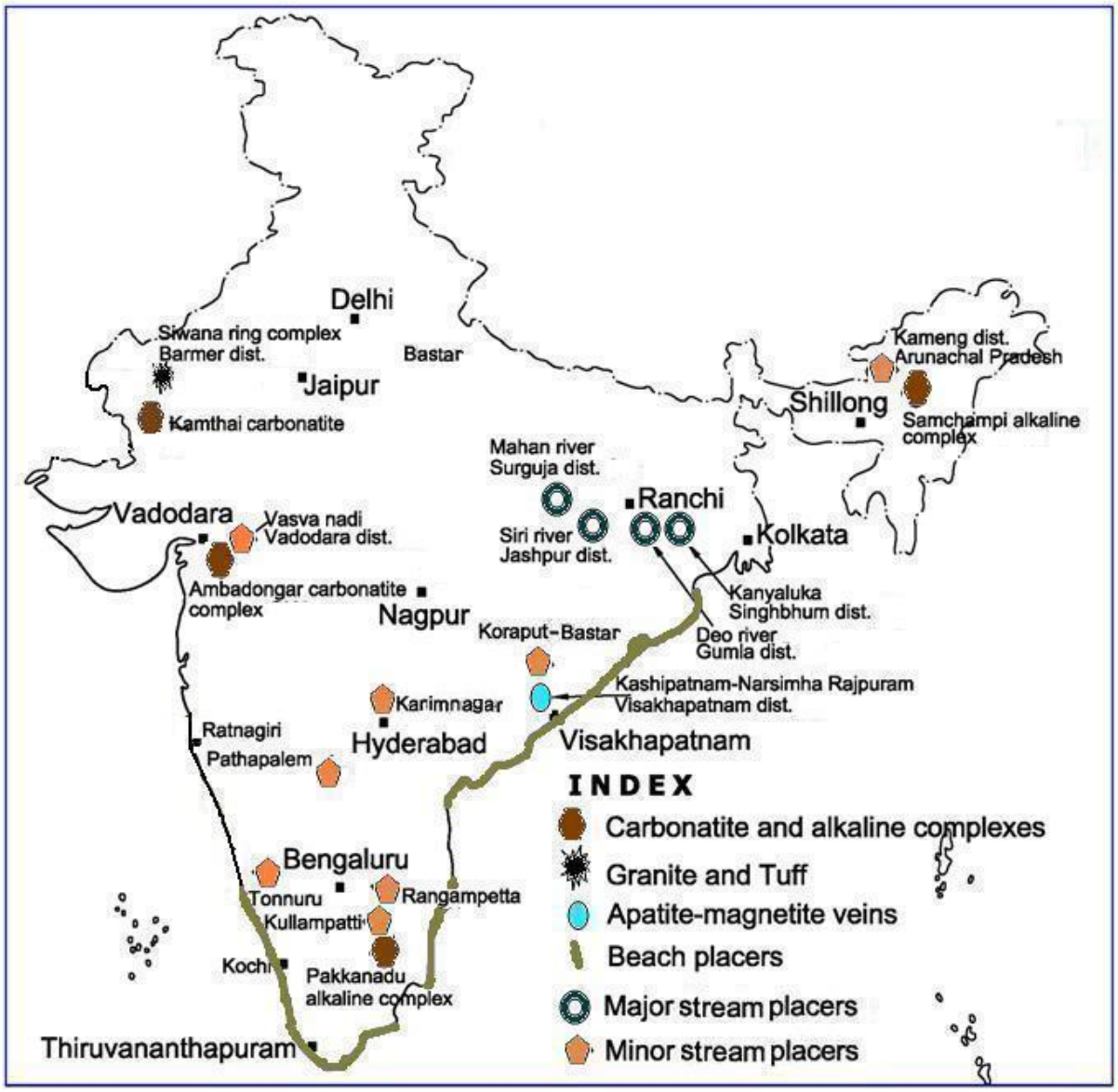

Fig. 1 Geographical locations of selected REE deposits/occurrences of India (After Singh, 2020a).

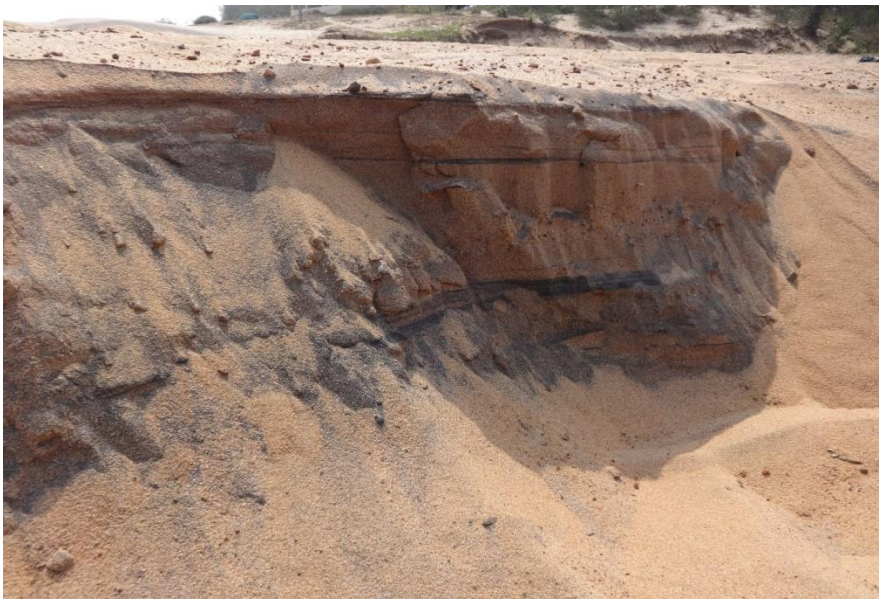

Fig. 2 Beach sand mineral deposit. Note layers of heavy mineral concentrations (Credit: Deepak Rathod).

Fig. 3 Partially mined heavy rare-earth-bearing stream placer deposits in central India.

[For Fig. 4 PDF attached separately]

Fig. 4 Sequential flow sheet for exploration of rare-earths in India (Modified after Dhana Raju, 2005; Singh, 2020a)

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Biosketch of Dr. Yamuna Singh

Dr. Yamuna Singh served over 35 years at AMD, DAE, Govt. of India and retired as Head, MPG Division. He discovered several strategic and critical mineral resources in Central India and Published 160 research papers and 7 Book Chapters. He also edited 16 Volumes of Journals and authored 1 book entitled, "Rare Earth Element Resources: Indian Context, Published by Springer. He is a recipient of several National Awards: (i) National Geoscience Award from Government of India; (ii) S. Narayanswami Award & (iii) Radhakrishna Prize from Geological Society of India; (iv) Prof. S.M. Ramananda Setty Award from Mineralogical Society of India**; (v)** Sitaram Rungta Memorial Award from Society of Geoscientists and Allied Technologists, Bhubaneswar; (vi) Master Tanay Chadha Memorial Geologist Award from Mining Engineers' Association of India, and (vii) Hindi Sevi Samman Puraskar from DAE, Govt. of India. He is an elected Fellow of Telangana Academy of Sciences, Hyderabad and Life Fellow/Member of 15 Scientific Societies/Professional Bodies including ISAS. He is President, Indian Association of Applied Geochemists (ISAG), Hyderabad and Expert Member, Commission for Scientific & Technical Terminology, MHRD, Government of India. He is working as Visiting Faculty, University of Hyderabad and Guest Faculty in Geological Survey of India Training Institute, Hyderabad

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Bridging the Gap between Vedic and Modern Sciences: Nano-centric Characterization of Typical Ayurvedic Bhasmas by using Ultramodern Analytical Techniques

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Abstract

While exploring healthcare applications of nanomaterials, it is intuitively sensed that therapeutic properties of metal based ayurvedic compositions might be associated with the nano-scale features. To bridge the gap between vedic and modern sciences, extensive physico-chemical investigations were performed on Swarnabhasma, Roupyabhasma and Jasadbhasma (prepared in accordance with traditional ayurvedic protocol in toto) using ultramodern analytical tools. X-ray Diffractometry (XRD), Field-Emission Scanning Electron Microscopy (FESEM), Xray Photoelectron Spectroscopy (XPS), Field-Emission Transmission Electron Microscopy (FETEM), High-Resolution TEM (HRTEM), Scanning Transmission Electron Microscopy (STEM) with High Angle Annular Dark-Field (HAADF) and Elemental Mapping were predominantly employed to judge structure, texture, morphology and elemental/chemical composition & distribution in such metal based formulations

Introduction

While exploring healthcare applications of nanomaterials, it is intuitively sensed that therapeutic properties of metal based ayurvedic compositions might be associated with the nano-scale features. To get head start towards this quest, we primarily focused on Au (Swarnabhasma), Ag (Roupyabhasma) and Zn (Jasadbhasma) based herbo-metallic compositions which were prepared and successfully used in the treatment of assorted cancers and other diseases by Pune-based Ayurvedic Physician Dr. Bendale. We have conducted extensive physico-chemical investigations

on such bhasmas. Typical test samples were prepared by strictly following traditional ayurvedic protocol *in toto* under the supervision of Dr. Bendale. Ultramodern analytical tools such as X-ray Diffractometry (XRD), Field-Emission Scanning Electron Microscopy (FESEM), X-ray Photoelectron Spectroscopy (XPS), Field-Emission Transmission Electron Microscopy (FETEM), High-Resolution TEM (HRTEM), Scanning Transmission Electron Microscopy (STEM) with High Angle Annular Dark-Field (HAADF) and Elemental Mapping were employed to judge the relevant aspects of structure, texture, morphology and elemental/chemical composition & distribution.

Results and Discussion

Structurally, XRD patterns confirm the presence of (i) phase-pure face-centered cubic structure of Au in Swarnabhasma and Ag in Roupyabhasma and (ii) ZnO with hexagonal structure in Jasadbhasma (Fig.1). FETEM images disclose presence of poly-dispersed irregular shaped nanoscale morphological features (along with occasional spherical nanoparticles) in case of Swarnabhasma (Fig.2) and Roupyabhasma (Fig.3) while that of poly-dispersed faceted nanoscale morphological features in case of Jasadbhasma (Fig.4). Quite interestingly, spatial resolution for atom to atom chemical mapping by STEM-HAADF-EDS technique revealed notable presence of oxygen in case of Swarnabhasma (Fig.5) and Roupyabhasma (Fig.6) which did not specify presence of the respective metallic oxides by XRD. To ascertain the precise nature (ambient, trapped or chemically incorporated) of oxygen present in these 2 bhasmas, we have carefully examined XPS data. Survey and High Resolution Scans of Swarnabhasma (Fig.7) and Roupyabhasma (Fig.8) revealed prominent presence of chemically incorporated atomic oxygen in such bhasmas probably leading to formation of the surface/sub-surface oxides of the respective metals in such bhasma samples which cannot be ordinarily detected by bulk-technique like XRD. Since Jasadbhasma is predominantly ZnO, the pertinent XRD, STEM-HAADF-EDS (Fig.9) and XPS (Fig.10) data go hand in hand.

Such perplexing findings presented in this talk can surely play an illustrative role in bridging the gap between Vedic science and modern science.

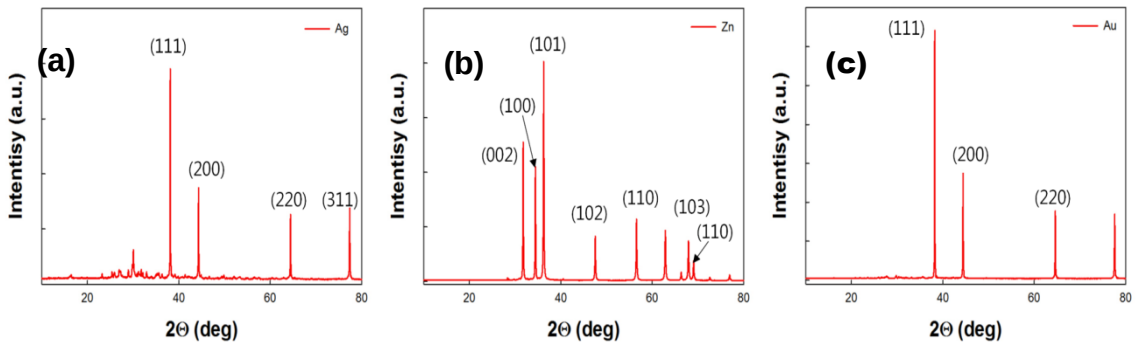

Figure 1: X-ray diffractograms of (a) Swarnabhasma, (b) Roupyabhasma and (c) Jasadbhasma samples

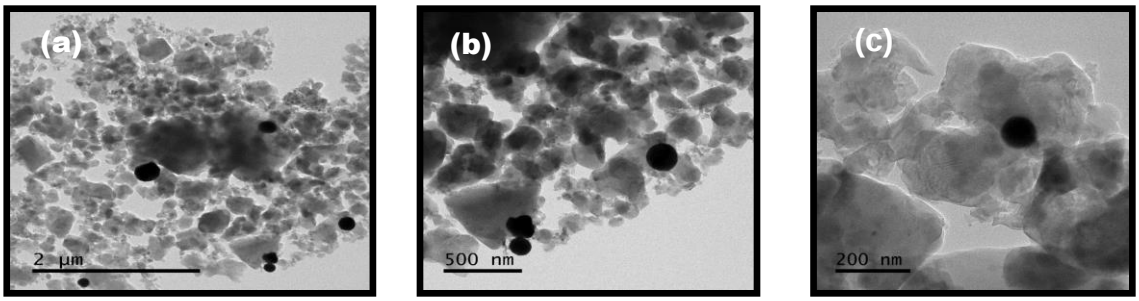

Figure 2: FETEM images of Swarnabhasma sample at (a) low, (b) intermediate and (c) high magnification

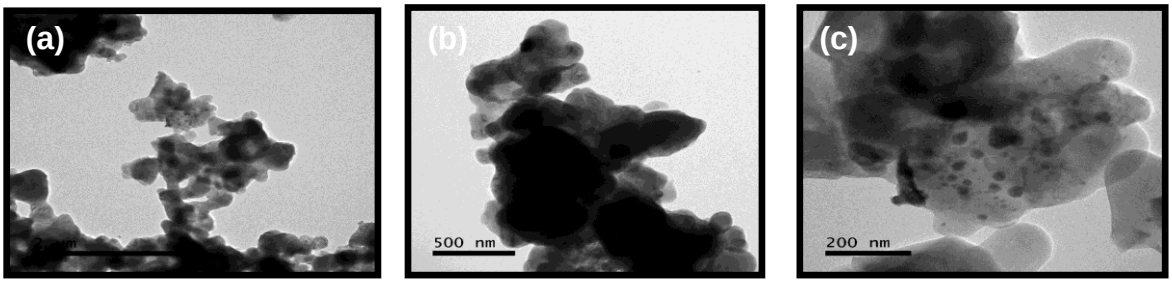

Figure 3: FETEM images of Roupyabhasma sample at (a) low, (b) intermediate and (c) high

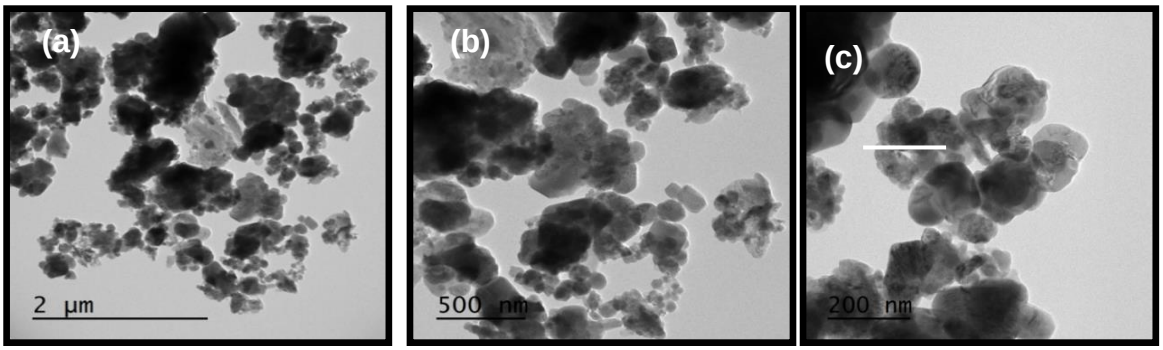

Figure 4: FETEM images of Jasadbhasma sample at (a) low, (b) intermediate and (c) high magnification

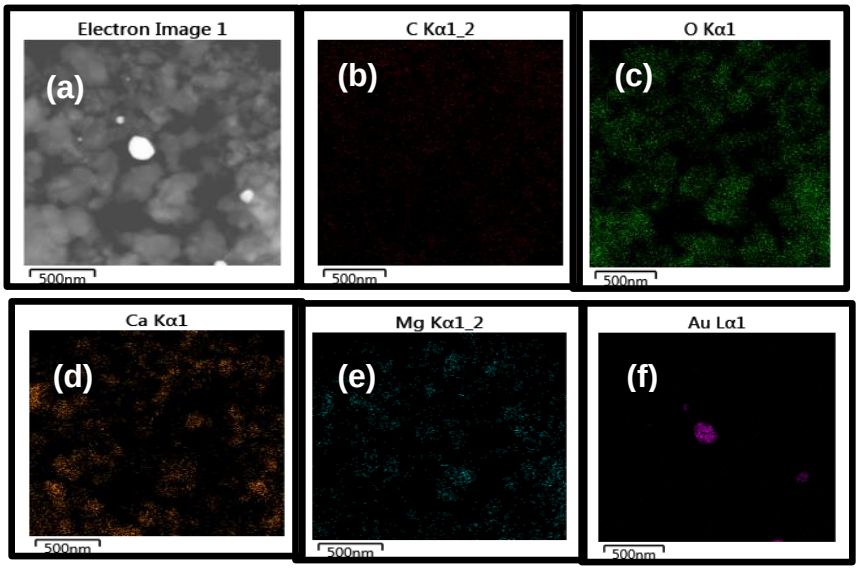

Figure 5: FETEM-STEM-HAADF elemental mapping images of Swarnabhasma sample corresponding to (a) electron image and elemental mapping images corresponding to (b) C, (c) O, (d) Ca, (e) Mg and (f) Au

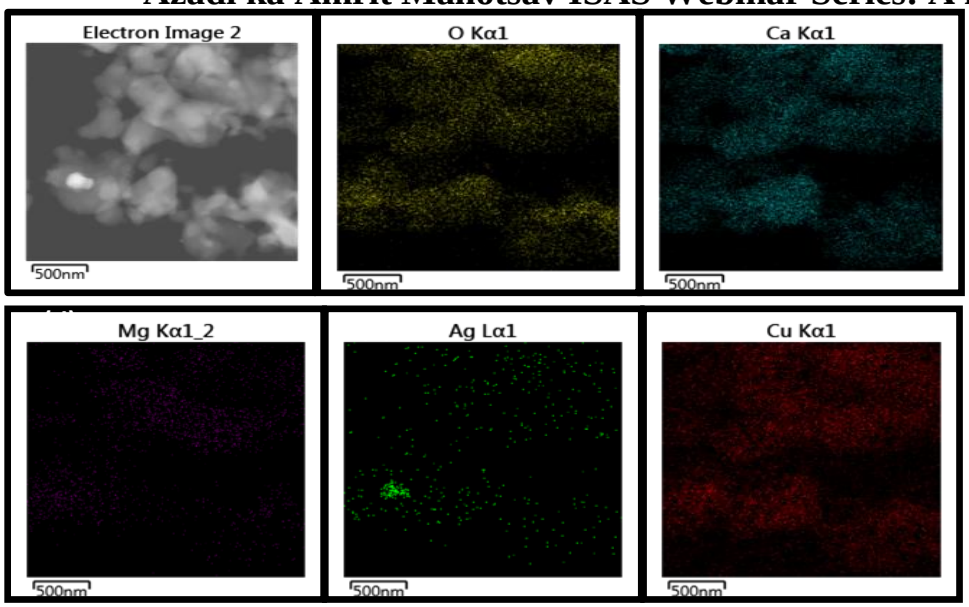

Figure 6: FETEM-STEM-HAADF elemental mapping images of Roupyabhasma sample corresponding to (a) electron image and elemental mapping images corresponding to (b) O, (c) Ca, (d) Mg, (e) Ag and (f) Cu

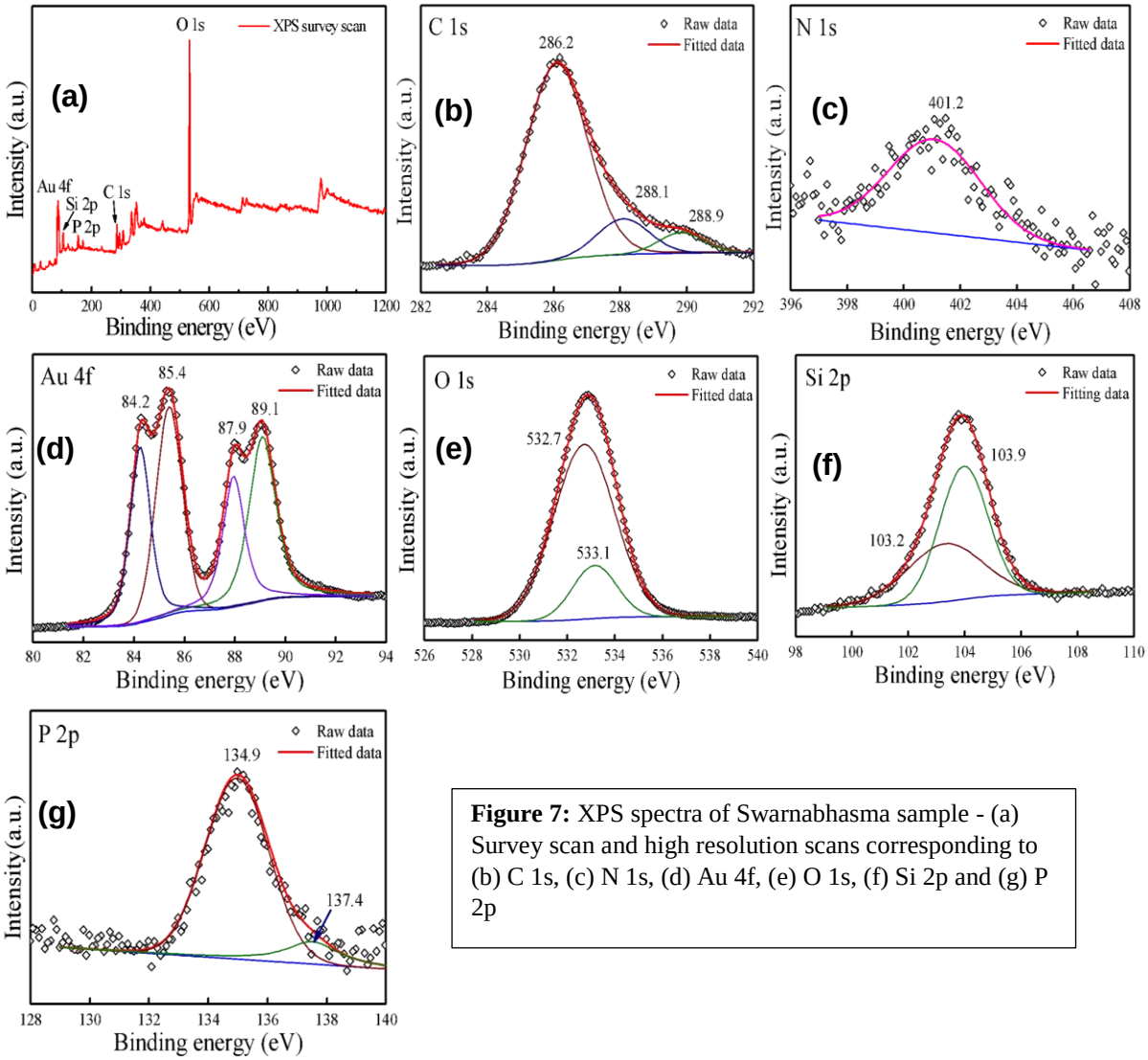

Figure 7: XPS spectra of Swarnabhasma sample - (a) Survey scan and high resolution scans corresponding to (b) C 1s, (c) N 1s, (d) Au 4f, (e) O 1s, (f) Si 2p and (g) P 2p

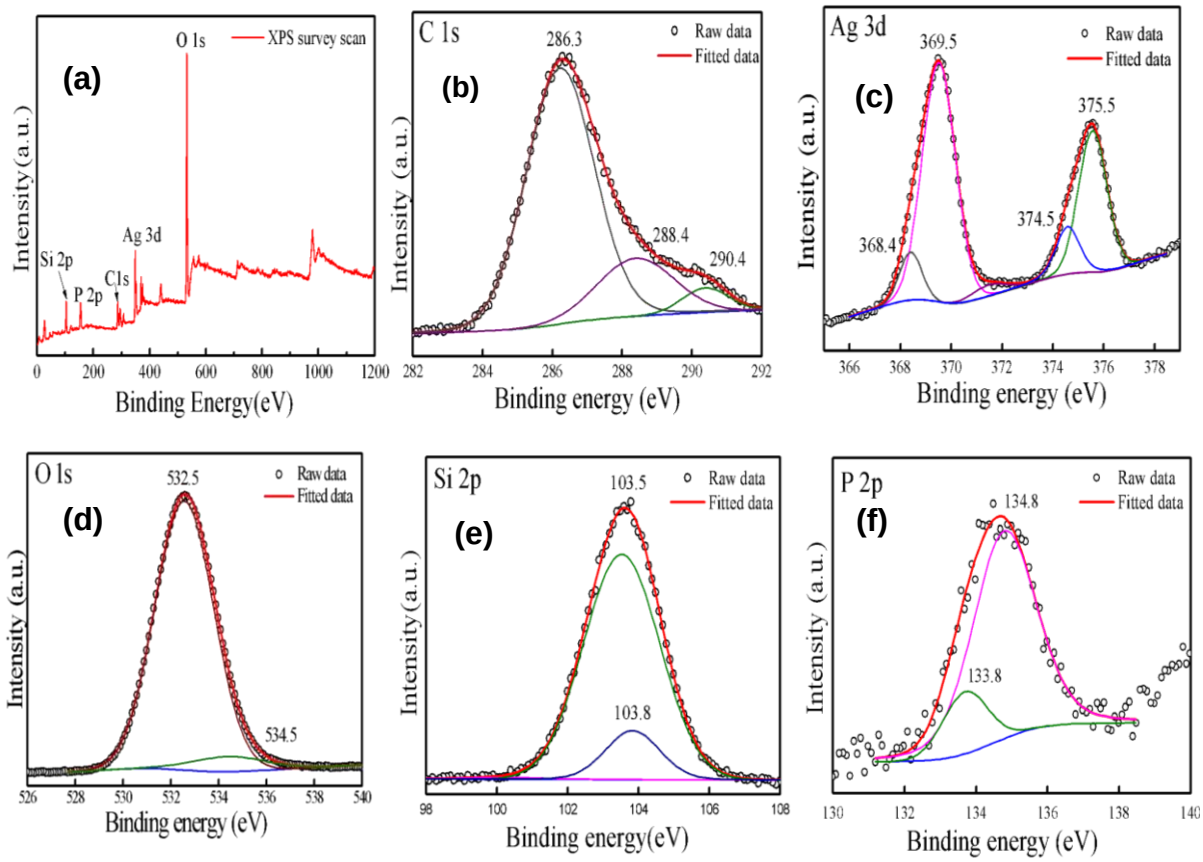

Figure 8: XPS spectra of Roupyabhasma sample - (a) Survey scan and high resolution scans corresponding to (b) C 1s, (c) Ag 3d, (d) O 1s, (e) Si 2p and (f) P 2p

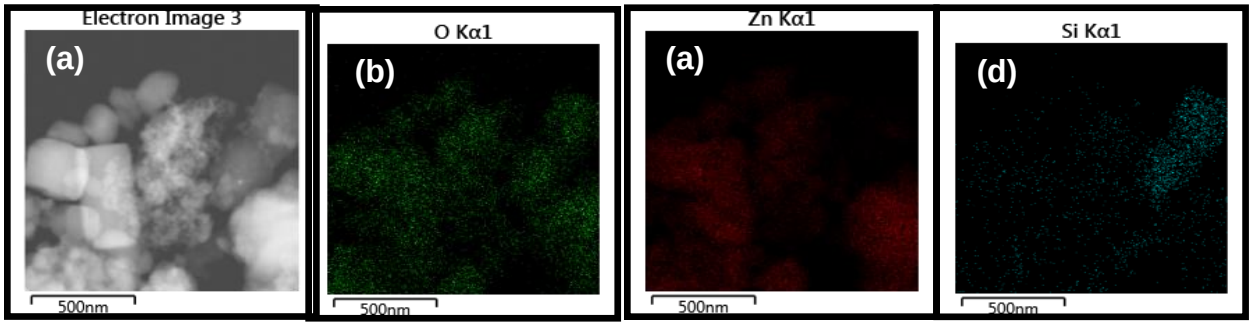

Figure 9: FETEM-STEM-HAADF elemental mapping images of Jasadbhasma sample corresponding to (a) electron image and elemental mapping images corresponding to (b) O, (c) Zn and (d) Si

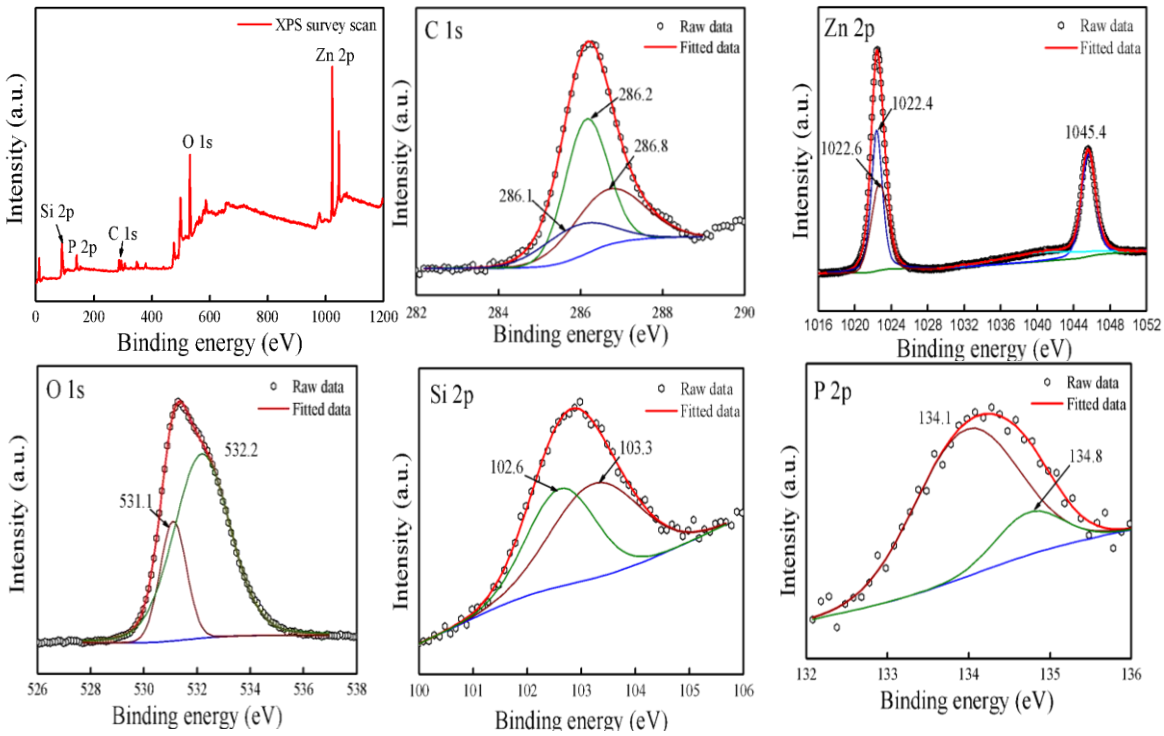

Figure 10: XPS spectra of Jasadbhasma sample - (a) Survey scan and high resolution scans corresponding to (b) C 1s, (c) Zn 2p, (d) O 1s, (e) Si 2p and (f) P 2p

Conclusions

Advanced Non-destructive Materials Characterization performed on Traditional Au,Ag and Zn based Bhasmas reveal presence of Nanoscale features along with mysterious bonding between atomic oxygen and the respective metal especially in Swarnabhasma and Roupyabhasma. This exploration can open up new vistas for structure-(medicinal) property relationship in herbo-metallic ayurvedic compositions.

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Bio-sketch of Dr. Dinesh Amalnerkar

Dr. Dinesh Amalnerkar is currently Professor Emeritus at Department of Technology, SP Pune University. Previously, he served as the Director General of Centre for Materials for Electronics Technology (CMET, Government of India) since February, 2009 till his superannuation in November, 2014. While placed at CMET from January 1991-November 2014, he had taken up long-term visiting assignments in Gifu University, Japan &Korea Research Institute of Chemical Technology, Daejon and short-term assignments at various universities/institutes in Singapore, Switzerland, Slovenia, Bulgaria, Japan and Saudi Arabia. More recently, during 2015-17, he worked as Brain-Pool Invited Scientist and Visiting Professor at Nanoparticles Technology Laboratory (NPTL), Sungkyunkwan University and also at Institute of Nanoscience and Technology, Hanyang University, Seoul, South Korea. Dr.Dinesh Amalnerkar has long-standing research experience in multi- institutional and multi-country settings. His versatile research contributions in Functional Electronic & Nanostructured Materials and recently in Nano-bioscience include 230 research papers in International Journals, 24 Indian Patents, 3 US Patents, 1 Book Chapter and 3 Technology Transfers. He is recipient of the Materials Research Society of India's prestigious Medal Award for the year 2008 for significant contributions in Materials Science.

Exploration for Atomic Minerals and application in Nuclear Energy

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Abstract

Nuclear energy is efficient, clean and green technology. In India, the responsibility of atomic minerals survey, location, exploration, feasibility studies and exploratory mining bestowed with Atomic Minerals Directorate. Uranium is the fuel used in a nuclear reactor for Power Production.

In the webinar talk, dealt the present status of Nuclear Energy in India, Uranium Exploration which is the front-end cycle of Nuclear Power Program. Uranium investigations carried out in different environments associated with defined structural settings in the country help in locating uranium deposits. Exploration strategy followed in Atomic Minerals Directorate for Exploration and Research combined with geochemical parameters controlling uranium mineralization and some important geological concepts like Plate Tectonics were briefed. In addition, highlighted some interesting artifacts and evidences to help us understand the science better.

Key words: Nuclear, AMDER, exploration, energy, uranium, mineralisation.

Introduction

Nuclear energy is fuel effective, clean and green energy compared to the other power generation technologies. To sustain the program, raw material survey, identification of resources of atomic minerals along the length and breadth of the country is being carried out by Atomic Minerals Directorate for Exploration and Research.

Paying homage to Late Dr. Homi J. Bhabha (1909 – 1966) Father of Indian Nuclear Power Program a great visionary, true team leader and his contributions are beyond nuclear science. According to him “For the full industrialization of underdeveloped countries, for the continuation of our civilization and its further development atomic energy is not merely an aid, it is an absolute necessity. The acquisition by man of the knowledge of how to release and use

atomic energy must be recognized as the third epoch of human history." He had envisaged the three stage Nuclear Power Programme. The less availability of uranium compared to the vast resources of thorium has driven for the program.

To appraise the benefits of nuclear energy, briefly explained the status of Atomic Energy in India, a bit about Dynamics of Earth Sciences, some fundamentals of geochemistry and finally uranium and other atomic minerals exploration.

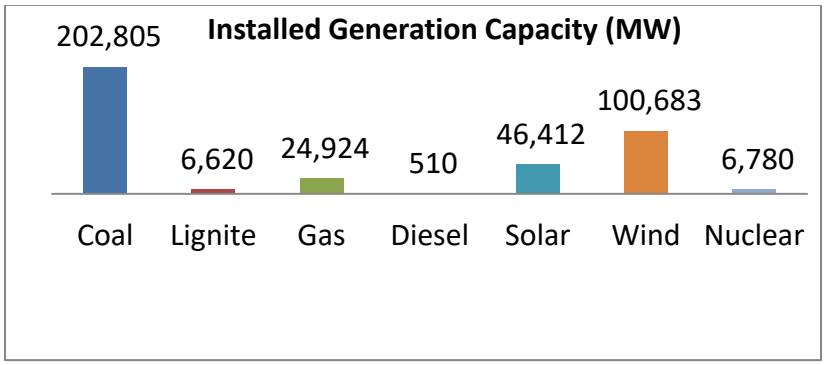
AMD is catering the needs of locating atomic mineral deposits as front-end cycle of nuclear energy. Nuclear power reactor's site selection job is also attended in the middle stage. For waste disposal, suitable site selection is completed at the back end of the cycle.

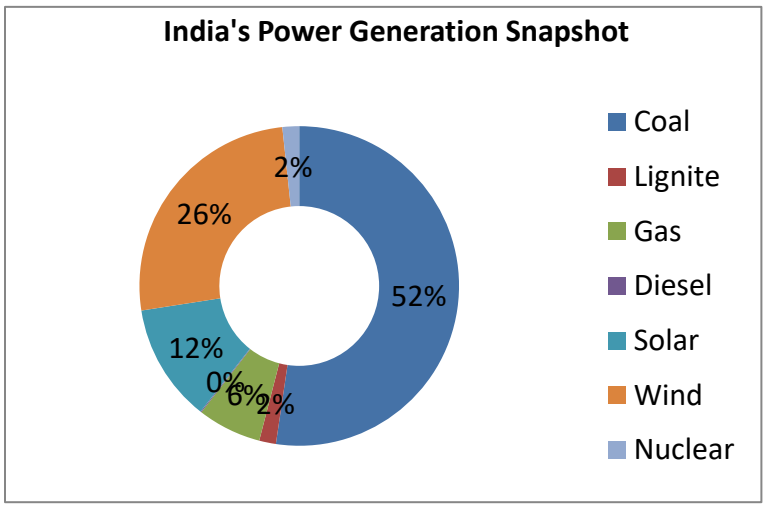
Experimental

AMDER's mandate is to identify and establish mineral resources of Uranium(U), rare metals like Thorium (Th), Niobium-Tantalum (Nb-Ta), Beryllium (Be), Lithium (Li), Zirconium (Zr), Yttrium (Y) and rare earths (RE), which are listed as the 'prescribed substances' under the Atomic Energy Act, 1962.

Set-up: The Directorate functions with seven regional centers viz., Hyderabad, Nagpur, Jamshedpur, Shillong, Jaipur and Delhi with its headquarters at Hyderabad. Besides, two sectional offices at Visakhapatnam and Thiruvananthapuram catering the needs of beach sand and off shore investigations.

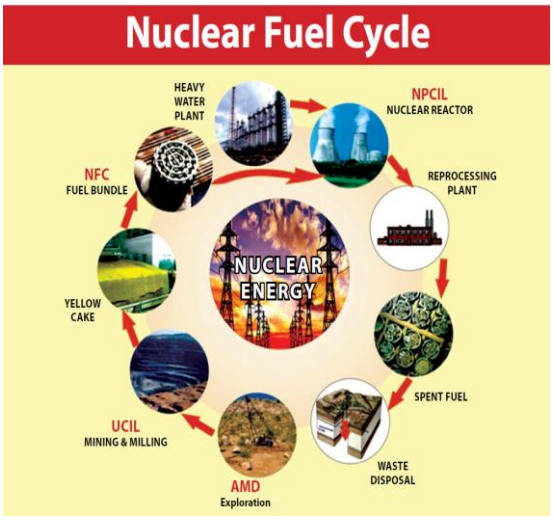
Energy Scenario in India: Installed generation capacity (MW) and India's Power Generation snapshot given below (Source: Ministry of Power, Govt. of India, Central Electricity Authority, Data as of 31 Aug 2021).

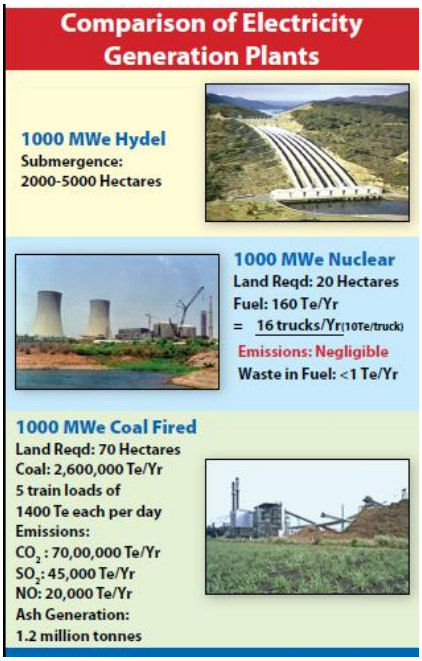




Nuclear fuel Cycle, Comparison of electricity

(Ref. DAE Public Awareness Programme standees)



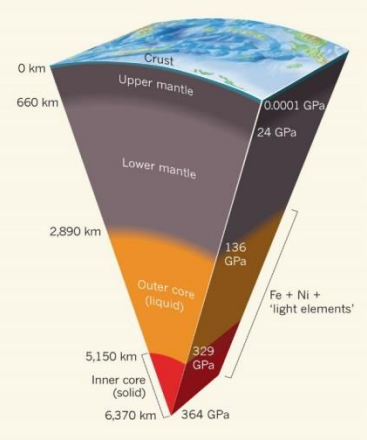


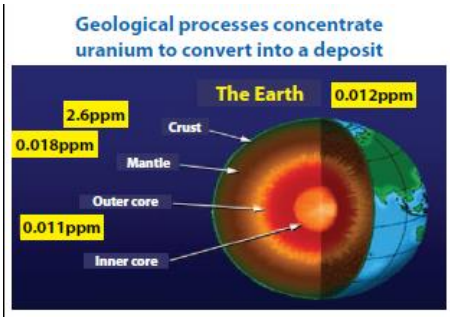
Dynamics of Earth sciences: Four main branches of Earth Sciences – Geology, Meteorology, Oceanography and Astronomy. Subdivisions of geology and its relation to Other Sciences helps in understanding the science better. (Ref. Principles of Physical Geology by Arthur Holmes, pp 9)

Internal Structure of the Earth: It is made up of three main layers namely the CRUST, MANTLE and the CORE. The outer most part 0–40 km is the upper silicate crust followed by denser SIMA (silica magnesia rich rocks) up to 90 km. The Upper mantle of viscous material up to 600 km and dense peridotitic rocks below up to 2900 km represent lower mantle. Upper core up to 5150 km consists of Iron Nickle Iron Liquid Core followed by solid Inner Core till 6370 km.

Average U content of common rocks

Type	Rock	U (ppm)
Igneous	Granite	3-4
	Syenite	3
	Basalt	0.75
	Gabbro	0.6
	Diorite	1.8
Sedimentary	Clay and shale	3.5
	Limestone	2.2
	Sandstone	0.45
Metamorphic	Quartzite	0.5
	Phyllite	2.5
	Amphibolite	0.5
	Schist	2
	Gneiss	3





Ref. (Brian Mason)

Plate tectonics: Alfred Wegener first postulated the concept in 1915. Plates are distinct chunks of outer layer of earth. The lithosphere includes crust and uppermost mantle having a thickness of100 km. The three types of plate boundaries are Convergent, Divergent and Transform.

Convergent: plates hit one another consequential to mountain ranges – formation of Himalayas (collision of Indian and Eurasian plates).

Divergent: plates move away from each other resulting in troughs (East Africa Rift). Mid Oceanic ridges form by this process.

Transform: plate movements relative slip side each other - San Andreas Fault.

Plate Tectonics help in understanding the various tectonic settings in relation to structure and correlation of mineralising events. (Principles of Physical Geology by Arthur Holmes, pp1193-1204)

Major structural Trends: The tectonic fabric of India explains the Cratonic, mobile belts surrounding the cratons and the sedimentary basins formed along the troughs. Different mineralizations are associated with these rifts. Proterozoic and phanerozoic types of uranium mineralization along the Son Narmada rift Zone and the Vein type uranium occurrences along Surguja Shear Zone are the typical examples.

Geochemistry:

Classification of elements by V.M. Goldschmidt based on the affinity to form various types of compounds and relevant to their distribution in Earth's geochemical reservoirs viz., Core, Mantle, Crust, the hydrosphere and the atmosphere. The chemical elements are divided into four groups. Lithophile elements are partitioned into silicate minerals. Chalcophile elements having affinity to form sulphide minerals, show low affinity for oxygen. Siderophile elements form alloys with Fe and Atmophile elements form gases, intense in atmosphere. (Brian Mason)

Geochemical survey involves sampling of rock, water, stream & soil sediment, heavy mineral concentrates etc. Analytical methods, viz., ionic leach, fluorescence (XRF) is used for different elemental estimations. For large, multi-element datasets and to generate targets in near-real time, portable XRF (pXRF) analyzers will be resorted to. Meaningful exploration strategy signifies study of petrology and metallurgy early understanding of ore and gangue minerals how deposits formed and how their minerals can best be liberated. This information is used to identify promising mineralization and focus exploration efforts on the highest priority targets.

Uranium Geochemistry:

Uranium is a large ion lithophile element. It occurs in low proportions in all rocks, soil and water. Main isotopes of Uranium are U238 (99.27%, HL 4.51by), U235 (0.72%, HL 713my), U234 (0.0006%, HL 247my). Some bacteria contain higher concentrations ex. Shewanella putrefaciens, Geobacter metallireducens and Burkholderia fungorum.

Results and discussion

Uranium Exploration: Uranium Exploration strategy was briefed right from reconnaissance survey, favourable geological environment identification, uranium anomaly location, delineation of mineralized blocks, ore body delineation, critical study of ore controls, economic evaluation, feasibility studies, exploratory mining, bulk ore samples for leaching studies, correlation of mining & drilling data and final stage of production mining by relevant field photographs. As a case study, exploration carried in Western part of Kaladgi Basin, Karnataka was explained with the help of aerial survey- remote sensing, geophysical, geochemical, drilling, petro mineralogical and radioactive mineral phase identification inputs. Correlation of mineralized intercepts was briefed by Transverse and Longitudinal sections.

Conclusion

As a sequel, by way of geological investigations of varied nature and appraisal of the areas through integrated surveys, significant discoveries of uranium mineralization were brought to light in favourable belts in Mahakoshal -Vindhyan basin, sandstone type mineralisation in Gondwana sediments in Central India, Vein type mineralisation in Surguja Shear zone, Jharkhand and Unconformity proximal mineralisation in Karnataka. Sound theoretical knowledge coupled with vast field experience, faithful presentation of data, interpretation and zeal to pursue the past events to unravel the truth are some of the essential traits of a successful exploration geologist.

Acknowledgements

I am thankful to my colleagues with whom I have been associated throughout my professional journey over three and half decades in different parts of the country for augmenting uranium resources. Thanks are due to National President ISAS, Dr P P Chandrachoodan, and Dr Raghav Saran, Vice President ISAS for their constant encouragement, remarks and introduction to the august gathering. Also thankful to Dr Sudhakar Dhondge, Chief Guest on 16.10.2021 for his inspiring address and declaring the webinar open. My deep sense of gratitude and appreciation to Prof Amarnath Garg, Dr Rajeev Raghavan, Dr Nilima Rajurkar, Dr Jayappa Manjanna, Dr Adya Vijayalakshmi C for the interest shown in question answer session. Thanks to all the participants

for patient listening and discussions. Finally, I will be grateful to Dr Avinash Bharati, Dr C P Pandhurnerkar, Dr Preeti Mangrulkar, Dr Seema Shrivastav and all members of the organising committee, ISAS Nagpur Chapter for arranging a satisfying knowledge sharing session, the above webinar successfully.

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Bio Sketch Shri R V S Sesha Rao

Bio Sketch Shri R V S Sesha Rao, former Scientific Officer H, Atomic Minerals Directorate for Exploration and Research, has rendered 36 years in the field of Uranium Exploration for the development and progress of the organization. He retired in June 2018 and is settled in Nagpur along with his family. He has completed M Sc Geology (1980) & B Sc (Geology, Physics & Chemistry, 1978) with distinction from Andhra University , Visakhapatnam. Joined Atomic Minerals Directorate at Southern Region, Bangalore in July 1982. He has worked in north eastern region in Shillong, eastern region in Jamshedpur, central region Nagpur and southern region Bangalore. He was a Junior Research Fellow, CSIR prior to joining AMD. The varied geological investigations carried out in different terrains of the country has helped AMDER in exploration strategies for augmenting uranium resources as well as the other atomic minerals for India's Nuclear Program. Few notable career highlights include: • Location of significant uranium mineralization along reactivated fractures in

Chhotanagpur Gneissic Complex (CGGC) – Mahakoshal contact • Dalmakocha area where in the uranium mineralised zone, later taken up for sub surface exploration • Discovery of the phosphate association with uranium mineralized breccia along Lower Vidhyan (Semri Group) rocks in Sidhi district, Madhya Pradesh prompted detailed assessment of phosphate in the area by GSI, Central Region Sesha Rao has more than 50 research publications of national and international repute to his credit.

Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Bioistimulants in Agricuture

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ABSTRACT

There is an ever increasing demand for increased productivity and efficient utilization of available resources from the agricultural sector. These challenges, stemming from an ever increasing population, can be addressed through various ways, viz. Identifying better genotypes, Optimizing growth environment and Designing efficient agrochemicals as plant protection agents. Biostimulants are non-fertilizer materials which, when applied to plants in small quantities, have growth promoting/altering effects. They modify plant physiological processes, act inside plant cells to stimulate or inhibit specific enzymes or enzyme systems and help to regulate plant metabolism. They are considered as BEYOND FERTILIZERS AND PESTICIDES. Biostimulants can be used at various stages of plant life cycle: 1. To induce flowering, 2. To spur growth, 3. Early fruit setting, 4. Increase productivity, 5. To improve nutrient assimilation and 6. To improve abiotic stress tolerance.

Biostimulants, based on their Chemical Nature, are classified into 6 groups: Natural (Phytochemicals); 2. Semi-synthetic; 3. Synthetic; 4. Extracts/Processed Extracts; 5. Microbes (Beneficial) and 6. Combination of above. Natural Biostimulants are often mixtures of a variety of compounds with variety of Biological activities and variety of Mechanisms. Many Biostimulants are likely to have multiple functions, along with its Biostimulant activity, such as:. improving availability of nutrients, providing pesticidal effect, and possibly also hormonal effects. Also different Components of Biostimulants can offer different Mode-of-Action. A large number of Biostimulant Components are now used in different Agricultural sectors. Status of Phyto-products (Natural/Semi-synthetic) and Extracts/Processed Extracts used as Biostimulants in Agriculture and related fields are briefly discussed here.

1. INTRODUCTION:

There is an ever increasing demand for increased productivity and efficient utilization of available resources from the agricultural sector. These challenges, stemming from an ever increasing population, can be addressed through various ways, viz. 1. Identifying better genotypes, 2. Optimizing growth environment, 3. Designing efficient agrochemicals as plant protection agents.

Agrochemicals can be broad spectrum, less expensive to produce and easy to implement due to which they hold immense potential over breeding/genetics based approaches. Agrochemicals have their disadvantages (Toxicity to Eco-system) because of which the concept of Organic Farming has arisen. In Organic Farming – "Plant Biostimulants" or simply called as Biostimulants - a promising and envirmental-friendly innovation, plays a major role.

Biostimulants can be used at various stages of plant life cycle:

1. To induce flowering, 2. To spur growth, 3. Early fruit setting, 4. Increase productivity, 6. To improve nutrient assimilation and 6. To improve abiotic stress tolerance.

1.1. Definiation of Biostimulants

From the time since their discovery in 1930, Plant Growth Regulators (PGR, both Stimulants and Retardants) - both natural and synthetic, have seen a steady growth.

The term Biostimulants, were introduced in early 1980s. Zhang and Schmidt defined Biostimulants as "materials that, in minute quantities, promote plant growth". The phrase 'minute quantities' was coined to distinguish them from genral nutrients and other products used for amending soil, the later being used in larger quantities. At this time very few components - such as Seaweed extracts, Alfalfa meal and Willow bark extract - were considered as Biostimulants.

This was followed by good amount of R&D in this area because of which more and more Products were evaluated under field conditions and considered as Biostimulant candidates. By the end of first decade of this century the list became quite big. To incorporate these new "Biostimulants", new definition was proposed in 2012 by the European Commission. According

to this definition: "Plant Biostimulants are substances and materials, with the exception of nutrients and pesticides, which, when applied to plant, seeds or growing substrates in specific formulations, have the capacity to modify physiological processes of plants in a way that provides potential benefits to growth, development and/or stress responses". Here "nutrients and pesticides" were completely excluded. Another definition was proposed by du Jardin in 2015 according to which: "A plant Biostimulant is any substance or microorganism applied to plants with the aim to enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrient content". This way micro-organisms were included in the "Biostimulants".

Thus Biostimulants are non-fertilizer materials which, when applied to plants in small quantities, have growth promoting/altering effects. They modify plant physiological processes, act inside plant cells to stimulate or inhibit specific enzymes or enzyme systems and help to regulate plant metabolism. They are BEYOND FERTILIZERS AND PESTICIDES.

1.2. Role of Biostimulants in Sustainable Agriculture:

Biostimulants contribute to Sustainable Agriculture by:

1. Improving plant growth (vegetative, reproductive)

2. Improving plant tolerance to abiotic stress on plants, including drought, extreme temperatures and salinity.

3. Enhancing uptake and efficient use of nutrients.

4. Improving soil health by enhancing beneficial soil microorganisms.

5. Enhancing crop quality through plant health and vigor at key stages in the development of crops.

6. Increasing harvestable yields.

7. Indirect effect on Biotic Stress (Pest, Diseases) and
8. Effect on plant nutrition by providing some micro-nutrients.

1.3. Beneficial Effect of Biostimulants:

Biostimulants confer following advantages:

1. Induce germination as well as emergence,

2. Stimulate growth of roots,

3. Promote assimilation of nutrients within plants,

4. Increase tolerance to abiotic stresses and as well as increase water retention in plants,

5. Promotes faster maturity,

6. Increase resistance to disease,

7. Delay seed development triggered senescence

8. Improve crop yields and/or quality.

1.4. Ideal Biostimulant:

An Ideal Biostimulant is:

long acting,

can counters environmental pressures,

has broad spectrum effective on a range of varieties and hybrids,

is easily bioavailable and

has acceptable chemical stability

It should be - Easy to Prepare – Apply –and – Cost Effective.

1.5. Classification of Biostimulant:

Biostimilants: Classified into 4 broad groups.

1. Auxins: Primarily controls growth through cell division and cell enlargement and can be both stimulants as well as retardants (inhibitors). They can cause shoots, buds, and roots. Auxins also act on cell differentiation, aswell as retardants (inhibitors). They cause effect on shoots, buds,

and roots. Auxins also act on cell \ These classes need to be formulated in varying ratios to achieve different objectives, for example, stimulate

2. Gibberellins: Control elongation and division of cells in plant shoots. They act via ribonucleic acid activity stimulation and protein synthesis upregulation in plant cells.

3. Cytokinins: influence cell division, and enlargement, as well as senescence. Also affect transport of amino acids in plants.

4. Ethylenes: As a natural regulator have effect on various cell processes and works in association with auxins.

These classes need to formulated in varying ratios to achieve different objectives, for example, stimulate rooting or to cause early fruting, etc.

Biostimulants, based on their Chemical Nature, are classified into 6 groups:

1. Natural (Phytochemicals); 2. Semi-synthetic; 3. Synthetic; 4. Extracts/Processed Extracts; 5. Microbes (Beneficial) and 6. Combination of above.

2. BISTIMULANT COMPONENTS IN AGRICULTURE

A large number of Biostimulant Components are now used in different Agricultural sectors. Table 1 gives Phyto-products (Natural/Semi-synthetic) and Extracts/Processed Extracts used as Biostimulants in Agriculture and related fields.

Table 1:Biostimulants Used in Agriculture

Phyto-products (Natural/Semi-synthetic)	**Extracts/Processed Extracts**
Abscisic Acid (ABA)	Alfalfa (*Medicago sativa*) Ext.
Acetyl Salicylic Acid (ASA, Aspirin)	*Allium cepa* (Onion) Bulb Aq. Ext.
Adenine sulfate/Adenine Hemisulfate (AdS)	Allium sativum (Garlic) Bulb Aq. Ext.
5 - Aminolevulinic Acid (5-ALA)	*Aloe vera* syn. *A. barbedensis*
6-Benzylaminopyuine (6-BPA)	Apple Cidar Vinegar (ACV)
Brassinosteroids	Bee Honey

Homobrassinoloide	Cinnamon Powder
Caseine hydrolysate	Coconut Water
Cis-Cinnamic Acid (c-CA)	Corn Seed/Maize Grain Ext. (MGE)
Choline chloride (Membrane phospholipids)	*Glycine max* (Soy) Proteins (DSP)
β-Cyclocitral (Prepared from Citral)	*Moringa oleifera* Leaf Water Ext. (MLE)
Follic acid (Vitamin B9)	Mulberry (*Morus alba*) Leaf Water Ext. (MBLE)
Gibberellins (GA)	*Musa paradisica* (Banana) Leaf Ext.
Ploy γ-glutamic acid (γ-PGA)	*Phaseolus vulgaris* (Common bean) Ext.
Glycine (Amino acid)	Seaweed Ext.
Glycine Betaine (GB)	Sorghum (Fodder) Water Ext. (SWE/Sorgaab)
Humic Acid (HA) & Fulvic Acid (FA)	Tea Seed Powder/Saponin-rich waste product
Indole Butyric Acid (IBA)	Vermiwash (VW)
Inocitol/Mayo-Inocitol	*Vigna radiat*a (Mung bean) Ext.
Jasmonic Acid (JA)	Willow (*Salix* spp.) Bark Ext.
N-Acetyl thiazolidine-4-carboxylic acid (NATCA)	*Withania somnifera* Aq. Ext.
Naphthalene Acetic Acid (NAA)	
Phorogluciniol (PG)(1,3,5–Trihydroxybenzene)	
Polyamines (PAs)	
Salicylic Acid	
β-Sitosterol (Phytosterol) (BS)	
Stigmasterol	

Thiourea (TU)	
1-Triacontanol (TRIA)	
t-Zeatin	
Zymostenol	

Let us consider above Biostimulants components in some details with respect to their Mode-of-Action in following 5 categories: effect on: 1. Vegetative growth; 2. Rooting; 3. Reproductive growth; 4. Stress Tolerance and 5. Soil Modification Properties

A. Biostimulants: Phytoproducts (Natural and Semi-synthetic):

1. Abscisic Acid (ABA, Sesquiterpenoid):

1. Vegetative growth - Stimulates the formation and growth of the lateral shoots.

2. Rooting - Stimulates the growth of the root system which includes adventitious roots of the hypocotyl.

3. Reproductive growth - Promotes flowering; plays important role in fruit ripening (strawberry, banana).

4. Stress tolerance - Plays central roles in drought, and high salinity responses, hence generally considered as a stress-related hormone; protect the dormant buds during the cold season, reduces water evaporation by stomatal closure, prevents loss of seed dormancy.

ABA play key role in improving drought tolerance of field crops. Under drought stress condition, ABA synthesis is started in the plant tissues and then it is sent as a stress signal to the stomatal cell. ABA application under drought stress improves drought tolerance by conserving plant cell moisture and improving/maintaining plant growth.

2. Acetyl Salicylic Acid (ASA, Aspirin, Phenyl acid)

1. Vegetative growth - Its application has been found to alter physiological processes of regulation of ion uptake, cell division, cell signaling and stomatal conductance.

2. Rooting - Considered “best rooting hormones” for plant cuttings.

3. Reproductive growth - Induces flowering in crops; has positive effect on fruit appearance of pomegranate fruits.

4. Stress tolerance - Enhanced tolerance to heat, chilling and drought stresses.

3. Adenine Sulfate/Adenine Hemisulfate (AdS, Amine sulfate**)**

1. Vegetative growth - Shoot multiplication enhancement (in plant tissue culture); enhances the growth of isolated meristem tips, induces the proliferation of axillary and promotes the adventitious shoot formation in callus or explants.

2. Reproductive growth - Regulate organogenesis and *in vitro* flowering.

4. 5 - Aminolevulinic Acid (5-ALA, Amino acid)

1. Vegetative growth – Promotes plant biomass accumulation; improves photosynthesis; contributes to plastid-to-nucleus signaling; inhibits ABA-induced stomatal closure; foliar application to plants can increase chlorophyll content in leaves and increases plants' ability to absorb light.

2. Rooting - Promotes seed germination and primary root elongation. Some *in vitro* studies have confirmed the hormonal role of 5-ALA by striking proliferation of callus induction of rooting and shooting with a more effect of the former than the latter.

3. Reproductive growth - improves fruit quality;

- acts as biochemical thinner - thereby thinning fruits by preventing fertilization;

- advances the harvest time of grapes;

- positive effects on fruit weight, fruit color, yield and efficiency index of sour cherry (*Prunus cerasus*) fruits.

3. Stress tolerance - Pre-spraying of ALA enhanced plant tolerance to various abiotic stresses, such as cold and heat stress, water logging, water deficit and salinity stress.

5.6-Benzylaminopyuine (6-BPA, Amine)

1. Vegetative growth - Increases post-harvest life of vegetables by preventing chlorophyll degradation.

2. Reproductive growth - Hormone to induce buds; acts by setting flowers and fruit richness by stimulating cell division; increases in the fruit weight .

Brassinosteroids (BRs, Steroid)

BRs are endogenous plant hormones essential for the proper regulation of multiple physiological processes required for normal plant growth and development. They have a dramatic positive effect on stem elongation.

Under auxin and cytokinin limiting conditions, BRs increase rates of cell division.

BRs also: 1. hastens senescence, 2. hyper-polarize membranes, 3. enhance ATPase activity, and 4. change cortical .They also mediate abiotic and biotic stresses due to salt, drought, temperature extremes and pathogens.

6. Brassinosteroid

1. Vegetative growth - Promotes cell expansion and cell elongation; cell division and cell wall regeneration; promotes vascular differentiation.

2. Rooting - Encourages new root growth.

3. Reproductive growth - Important for pollen elongation for pollen tube formation.

4. Stress tolerance - Can provide protection to plants during abiotic stress.

7. Homo-brassinosteroid

1. Vegetative growth - Promotes cell division and cell elongation; acts synergistically with other endogenous hormones; increases photosynthesis and translocation of assimilation to economic plant parts; increases the levels of enzymes responsible for the synthesis of nucleic acids, proteins and sugars; increases quality of produce.

2. Rooting - Promotes seed germination and increasing early vigor of seedlings.

3. Reproductive growth - Induces flowering, and increasing fruit set and fruit growth.

4. Stress tolerance - Imparts stress resistance under adverse environmental conditions.

8. Caseine hydrolysate (Hydrolysed Milk Protein)

1. Vegetative growth - Plays important role as Biostimulant through the modulation of plant molecular and physiological processes which triggers plant growth; stimulates carbon and nitrogen metabolism and, increases yield and quality of crop.

2. Rooting - Elicited hormone-like activities (Auxin and Gibberellins), promotes root growth; foliar and root applications enhances the uptake and efficiency of both macro- and micro-nutrients; improves nutrient uptake performance of pH-treated plants associated with modifications of root architecture.

3. Reproductive growth - Increases germination.

4. Stress tolerance - Can alleviate the negative effects of abiotic plant stress.

9. Cis-Cinnamic Acid (c-CA, Phenyl acid) (Activity similar to Indole Acetic Acid/IAA)

1. Vegetative growth - Growth-promoting activity (Bio-mass promoter);

- stimulates both cell division and cell expansion in leaves;

- increases biomass.

2. Rooting - Develops larger root system.

Stress tolerance - In rice, β-cyclocitral enhances both root and shoot growth during salt stress.

10. Choline chloride (CC) (Constituent of membrane phospholipids)

1. Vegetative growth - Essential metabolite in plants for growth and development;

- exerts influence on almost every aspect of growth and development;

- exogenous applications has positive effect for greater yield.

1. Stress tolerance - Enables the plant to impart tolerance against abiotic stress due to water.

11.β-Cyclocitral (Prepared from Citral)

1. Rooting - Promotes root stem cell divisions so the root growth and branching is enhanced which makes tomato and rice plant root grow faster; increases primary root and LR growth by inducing cell divisions in root meristems. In rice, β-cyclocitral can also affect root architecture such as the numbers and gravity set-point angle of the roots.

2. Stress tolerance - In rice, β-cyclocitral enhanced both root and shoot growth during salt stress.

12. Follic acid (Vitamin B9)

1. Vegetative growth - Essentially helps plant to grow more heavily and healthily;

- synergistic effects on growth, yield and yield quality of many plant species;

- increases the seed weight, amount of chlorophyll in leaves and synthesis of DNA and RNA;

- has the potential to function as natural antioxidants and growth regulators;

- folic acid treatment increases the productivity of *Pisum sativum*;

- exogenous application of folic acid has positive effect on growth, yield and quality of soybean and strawberry;

- significantly improves growth parameters in potato - plant length, leaf area, chlorophyll, total soluble carbohydrates and total soluble protein.

2. Rooting - Increases the root elongation, germination percentage and stem width at the beginning of germination.

3. Reproductive - Growth (flowering) stimulant; its foliar spray enhances flowering, yield and quality of sweet pepper.

4. Stress tolerance - Folic acid pretreatment reduces the harmful effects of salinity on chromosome aberrances particularly at high salt concentration.

13. Gibberellins (GA, Diterpenoid)

1. Vegetative growth - The most characteristic effects is shoot growth, increased inter-node extension, increased leaf-growth and enhanced apical dominance;

- increased carbon fixation (a secondary effect of increased leaf growth) leads to increased dry weight of plant;

- commercially applied to control the vegetative growth of many crops.

2. Rooting - Treatment with GA does not stimulate growth of intact roots, though some root sections respond by increased growth; stimulates seed germination and also can stimulate root elongation. The seed dormancy is stimulated by gibberellins.

3. Reprodutive growth - Can stimulate flowering and fruit senescence.

4. Stress tolerance - Many forms of dormancy are broken by GA; can increase tolerance to abiotic stresses.

GA stimulates phosphate uptake, potassium uptake, and sulfate translocation from root to shoot in seedlings.

14. Ploy γ-glutamic acid (γ-PGA)

1. Vegetative growth - Can significantly increase the dry weights of shoots in cucumber, wheat productivity, Nitrogen use efficiency, fresh weights of rapeseed and Chinese cabbage.

2. Rooting - Can significantly increase the dry weights of roots, as well as the root to shoot ratio of cucumber seedlings.

3. Soil properties - γ-PGA can affect the Nitrogen turn-over in soil by attracting mineral Nitrogen and enhancing microbial Nitrogen. This would help to temporarily store plant-available Nitrogen, such as fertilizer Nitrogen, when crop demands are small. The stored mineral and microbial Nitrogen would slowly released to crop.

The application of γ-PGA to soil may also affect soil Carbon dynamics.

15. Glycine (Amino acid)

1. Vegetative growth - Growth (flowering and branching) stimulant; shows synergistic effect; plays an important role in vegetative growth; exogenous application can increase Nitrogen status and concentration of mineral elements in plant tissues.

2. Reproductive growth - Shows synergistic effect;

- foliar application of Glycine promotes growth and reproductive growth and the content of essential oil in Jasmine .

3. Stress tolerance - Stress tolerance - It has a chelating effect on micronutrients Iron, Zinc, Manganese, and Copper making their absorption. Soil application of glycine can improve leaf mineral and physiological characteristics which results in higher yield and quality.

16.Glycine Betaine (GB)

1. Preharvest foliar application of GB to banana plant reduces the biochemical and physiological alterations caused by chilling injury.

2. Protects plants from abiotic stresses (drought, heat, cold, and salt stress); it can be applied to leaves or soil to combat dehydration (caused by stress) and prevent crop loss; GB counters stress induced metabolic dysfunctions.

Humic Acid (HA) - Fulvic Acid (FA)

Humic substances are considered as the most important constituents of soils. They form the largest fraction of soil organic matter and play a dominant role in improving soil productivity.

Humic substances are classified as Fulvic Acid with varying pH solubilities with some being soluble at all pH values and some only in alkaline conditions and Humin being insoluble at all pH values.

FAs have the least molecular masses and are the most mobile fraction of humic substances (Molecular weight 250-2500 Da). HAs are soluble under alkaline conditions but are insoluble under acidic conditions. HAs with Molecular weight 50,000 Da are biologically active.

18. Humic Acid (HA) (Considered as a natural rooting hormones)

1. Vegetative growth - Increases cell membrane permeability, oxygen uptake, respiration, photosynthesis and phosphate uptake;

- increases growth, nutrient availability and yield;

- plant fertilization with HA promotes plant growth, development, production and fruit quality of vegetable crops;

- has direct stimulatory effects along with indirect effect on plant metabolism;

- increase fruits and vegetable yields;

- it increases the number of flowers, leaf area and plant height.

2. Rooting - Increases root elongation.

3. Reproductive growth - increases flower yield and quality of gerbera.

4. Stress tolerance - HA improves plant resistance to environmental stresses.

5. Soil properties - Application of HA improves soil aggregation, structure, fertility, and moisture holding capacity. It also increases microbial activity, microbial population, and ion exchange capacity.

HA application - beneficial for nutrient (N, P, K, Mg, Ca, Zn, Fe, and Cu) uptake.

HA stimulates both root and aerial part growth of plants, increase chlorophyll density and may help plant to resist heat and salt stress.

However, when applied to soil, varying fractions of HAs may become insoluble depending upon the soil pH. HAs will also bind to some pesticides reducing their Biological activity.

19. Indole Butyric Acid (IBA) (Auxin synthesized by plants)

1. Vegetative growth - Used on many crops and ornamental plants to promote growth and development and to increase crop yields.

2. Rooting - Mainly used for the induction of adventitious roots (accelerates rooting formation); important ingredient in many commercial horticultural plant rooting products; used on many crops and ornamental plants to promote growth and development of roots.

3. Reproductive growth - Used on crops to stimulate development flowers and the growth of fruits; also used to protect plants during transplantation by stimulating root growth and decreasing shock; used on many crops and ornamental plants to promote growth and development of flowers and fruits; in plant tissue culture IBA is used to initiate root formation in micropropagation.

20. Inocitol/Mayo-Inocitol (Carbocyclic sugar)

1. Vegetative growth - Required for phosphate storage, cell wall biosynthesis, cell-to-cell communication, and storage and transport of plant hormones; play a role in cell division; important for normal plant growth and development.

2. Stress tolerance - Important for the production of stress related molecules.

21.Jasmonic Acid (JA, Sesquiterpenoid)

1. Vegetative growth - Plant hormone - signaling compound involved in the regulation of cellular defense and development in plants;

- JA is directly involved in many physiological processes, including leaf growth, tendril coiling, flower development;

- regulate the production of various metabolites, such as phytoalexins and terpenoids.

2.Rooting - JA is directly involved in root growth; responsible for tuber formation in potatoes and yams.

3. Reproductive growth - has positive effect on flower development;
- Considered for seed treatment to stimulate the natural anti-pest defenses of the plants.

4. Stress tolerance - Stress hormone that regulates plant responses to 1. biotic stresses, such as those elicited by herbivores and pathogens, as well as 2. abiotic stresses such as wounding and ultraviolet radiation.

5. May have a role in Pest Control.

22. **N-Acetyl thiazolidine-4-carboxylic acid (NATCA) (Prepared from amino acid Cysteine and formaldehyde by condensation reaction).**

1. Promotes seed germination and plant cell division.

2. Keeps chlorophyll from being lost.

3. Increases fruit setting rate and fruit yield.

4. Combined with Folic acid as a foliar spray, acts as a "Very Promising Biostimulant".

23. Naphthalene Acetic Acid (NAA)

1.Vegetative growth - Plant hormone – increases stem growth;

- helps to increase cell division and increase overall plant growth;

- increases crop yield and decrease crop drop;

- regulates gender ratio;

- improve blossoms;

- decreases plant ageing and diseases;

- increase grain yield.

2. Rooting - Rooting agent;

- increases root growth;

- finds application in promoting the growth of cuttings, making it particularly useful for breeders and those who are involved in crop transplant.

4. Reproductive growth - Helps fruit growth, increases blossoming, ripening and fruit quality, increases the yield of fruit and decreases the rate at which fruit drops. Can also decrease the amount of seeds in fruit and even produce seedless fruits in some cases.

24.Phorogluciniol (PG)(1,3,5–Trihydroxybenzene) (A precursor in the lignin biosynthesis pathway)

1. Vegetative growth - PG increases shoot formation and somatic embryogenesis in many crops.

- PG has Cytokinin-like and Auxin-like activity; has potential for a range of plant tissue culture studies.

- Useful for maximizing the multiplication rate of woody species which are difficult to propagate.

- PG has also been used to improve the recovery of cryopreserved plants.

2. Rooting - PG exhibits a positive effect on rooting and acclimatization of rooted shoots in micro-propagation of plants;

- PG acts as Auxin synergist.

Exhibits antibiotic effects on *Heliothis armigera*.

25.Polyamines (PAs, Putrocine/Spermidine/Spermine)

1. Vegetative growth – Play an important roles in diverse plant growth and developmental processes.

2. Rooting - PAs regulates in the process of embryogenesis in both angiosperms and gymnosperms.

3. Reproductive growth - Exogenous application of PAs accelerates flower bud differentiation.

4. Stress tolerance - Plays an important roles in environmental stress responses (salt stress, water stress, oxidative stress).

26. Salicylic Acid and other salicylates (SA, Phenolic acid):

Promote root growth in cuttings, seedling, and mature plants of several species.

SA promotes plant photosynthetic rates, production of plant biomass and crop leaf area. It is reported that SA increases the wheat resistance to osmotic stress caused by water deficit conditions.

27. β-Sitosterol (Phytosterol) (BS) (Antioxidant, antimicrobial activities without major toxicity)

Phyto- sterols are precursors in the synthesis of steroid hormones, e.g. Ecdysteroids (insects hormones), and Brassinosteroids (plant hormone).

1. Vegetative growth - a Plant Growth Regulator;

- had a stimulatory effect on growth and yield.

2. Stress tolerance - BS effectively regulates several biological processes to enhance plant resistance against stress factors such as water stress, salt stress, UV radiation stress (abiotic stress) and plant-pathogen interaction stress (biotic stress).

28. Stigmasterol (Phytosterol)

1. Vegetative growth - Foliar application enhances growth and increases productivity of fresh herb and aromatic oil in basil plant;

- a promotive effect on growth, yield and structure of rice plants;

- induces a promotive effect on vegetative growth, anatomical structure of soybean plant;

- increasing stigmasterol concentration can significantly increase sesame growth, seed yield, number of capsules/plant, 1000 seed weight and seed oil percentage;

- Stigmasterol offers promotive effects on lupine plant height and yield;

- offers promotive effect on anatomical structure of stem and leaf of Egyptian lupine.

2.Stress tolerance - Reduces stress; β-sitosterol and stigmasterol accumulate during stress indicating its role as signaling molecules that help in stress adaptation.

29. Thiourea (TU)

1. Vegetative growth - Used to improve plant growth and productivity under normal and stress conditions;

- improves the gas exchange properties;

- improves the root growth and its proliferation;

- exogenously applied, TU improves the sugar metabolism and enhances the proteins biosynthesis. It regulates the plant growth by maintaining higher photosynthetic rate up to the reproductive stage and increases the yield.

2. Rooting - When used as seed pretreatment, TU increases the seed germination; it improves the nutrient acquisition by the root.

3. Stress tolerance - Use of TU is more effective under environmental stress conditions;

- TU is effective in improving plant growth and development. under drought, salinity, heat stress and heavy metal toxicity;

- foliar application of TU is shown to increase the stress tolerance and yield during field trials.

30. 1-Triacontanol (TRIA, Fatty alcohol)

1. Vegetative growth - Stimulant for flowering plants; enhances the physiological efficiency of the cells;

- enhances growth, yield, photosynthesis, nitrogen fixation, enzymes activities, free amino acids, reducing sugars, and soluble proteins of plants;

- enhances plant biomass, chlorophyll, gas exchange parameters, mineral nutrient acquisition, leaf carbonic anhydrase (CA) and nitrate reductase (NR) activity.

- TRIA application increased the plant dry weight, protein, and chlorophyll contents and net photosynthetic rate in rice.

2. Stress tolerance - Plays essential role in alleviating the stress-accrued alterations in crop plants via modulating the activation of the Stress Tolerance Mechanisms.

31. *t*-Zeatin (*t*-Z, Cytokinin isolated from Maize Grain)

The *t*-Z is a natural phytohormone and has the ability to accelerate cell division, induces callus formation, promotes the formation of cotyledons and delays senescence.

1. Vegetative growth - Plant Growth Hormone;

- plays an important role in cell growth, differentiation, induces cell division and stimulates shoot formation.

2. Rooting - Routinely used in plant tissue culture; can also be applied to stimulate seed germination and seedling growth.

3. Stress tolerance- Helps plant to better tolerate environmental stress; has also been shown to promote the resistance of tobacco against the bacterial pathogen *Pseudomonas syringae*.

32. Zymostenol (Cholestrol precursor)

1. Zymostenol is a late-stage precursor in the biosynthesis of cholesterol.

2. It accumulates in cells following administration of microsomal antiestrogen-binding site (AEBS) ligands, such as tamoxifen, which are associated with cell differentiation and a protective type of autophagy.

3. When used alone at a concentration of 20 µM, zymostenol halts the cell cycle at the G0/G1 phase and increases the levels of free sterols, esterified sterols, and triacylglysterols in MCF-7 cells.

B. Biostimulants - Extracts/Processed Extracts

1. Alfalfa (*Medicago sativa*) Extract

1. Vegetative growth - Growth Stimulant used to increase seedling length and dry weight of *Juniperous procera* seedlings.

2. Several crops are known to accumulate dry weight rapidly following applications of small amounts of Alfalfa under greenhouse and growth chamber conditions.

3. Coarsely chopped Alfalfa hay used as band application, increased growth and yield of cucumbers, lettuce, tomatoes, and wheat.

2. *Allium cepa* (Onion) Bulb Aqueous Extract (Anti-bacterial, anti-fungal, anti-oxidant; contains micro-nutrients specially Zinc)

1.Rooting - Can influence the development of root elongation in the cell elongation process in plants; tested on banana root length.

2. Reproductive growth - Foliar application of onion extract on apple (*Malus sylvestris*) trees during dormancy and bud break - flowering percentage and fruit yield characteristics are increased, while number of days recorded to reach full bloom are reduced.

3. Stress tolerance - effect on drought stress of soybean plants: enhanced the tolerance of the plant to drought stress observed.

- high levels of acemannans and saponins provide anti-microbial activities;

3. *Allium sativum* (Garlic) Bulb Aqueous Extract (AGE) (Anti-bacterial, anti-fungal, anti-oxidant)

1. Vegetative and Rooting growth – AGE foliar application to eggplant and pepper seedlings: stimulatory responses in the growth of the vegetables observed.

2. Stress tolerance – AGE foliar application to eggplant and pepper seedlings: resistance against oxidative stress induced by chemical changes observed.

4. *Aloe vera/A. barbadensis*

1. Vegetative growth - Absolutely loaded with nutrients;

- Aloe leaf extract - used to improves vegetative growth of some crop species;

- Aloe leaf powder is used as a Biostimulant to enhance growth and yield of some crop species.

2. Rooting - Rooting substance; *Aloe vera* fertilizer can encourage seed germination and rapid root development, improved cell strength, and contribute to overall superior plant health, growth, and vigor.

3. Stress tolerance - at present many Farmers and Villagers use fresh *Aloe vera* gel for inducing rooting of stem cuttings and air layering of plants.

- contains enzymes and plant hormones that help to reduce transplant shock, and boost the plant's resistance to drought, stress, and disease;

- high levels of acemannans and saponins provide ant--microbial activities;

- this protects plant from pathogenic attack;

- the comulative effect is healthier plants that are more resistant to disease, pest pressure, and abiotic stess.

Considered as a natural rooting hormones.

5. Apple Cidar Vinegar (ACV)

1. Rooting - Can be used as rooting stimulant (used as root treatment); considered as organic rooting hormone.

2. Vegetative growth - Contains phenolic compounds and 30 trace elements;

- has acidic pH; makes soil acidic (healthy for plants);

- has biological activities like anti-oxidant, anti-microbial, anti-fungal and insect control activity;

- can be used as a fertilizer to maintain healthy plants.

6.Bee Honey

Natural growth stimulant.

Considered as a natural rooting hormones.

Several vitamins like Vitamin C and Vitamin B1 present in honey are found to help initiation of roots in cuttings in many plant species.

7.Cinnamon Powder

1. Vegetative growth – Has a stimulating effect for tomato plants.

2. Rooting - Rooting substance.

Antifungal; has potential to inhibit Bortritis *cinerea* growth and also.

Considered as a natural rooting hormones.

8.Coconut Water

- Growth stimulant;

- Cytokines can be extracted and used as Biostimulants.

Considered as a natural rooting hormones.

Coconut water is reported to have many of auxin such as Indole-3- acetic acid, *t*- zeatin and Gibberellins (GA1 and GA3).

9. **Corn Seed Extract/Maize Grain Extract (MGE)**

1. Vegetative growth - MGE is enriched with antioxidants, plant hormones (superoxide dismutase, catalase and peroxidase), vitamins, polyamines, auxins, cytokinins, gibberellins and different macro- and micro-nutrients making it effective Biostimulant.

- MGE - promotes morphological and physio-biochemical processes.

Antifungal; has potential to inhibit *Bortritis cinerea* growth ~~and also~~.

MGE – Evaluated on many crops under Field Conditions with positive effect.

- protects maize from low temperature stress ~~and~~ in wheat from salinity stress.

2. Stress tolerance - Used to prime seeds to enhance plant performance particularly under salinity stress.

- MGE applied to seeds - reported to enhance plant performances under different stress conditions: salinity, draught, nutrient deficiencies and toxicity due to components like cadmium.

MGE – Evaluated on many crops under Field Conditions.

10. ***Glycine max* (Soy) Proteins (DSP)**

1. Vegetative growth - Soybean meal (SBM) - is allowed as a non-synthetic plant or soil amendment;

- addition of DSP - increases the fresh weight of *Brassica rapa*; the growth of *Solanum tuberosum, Solanum lycopersicum*, and *Brassica juncea*.

2. Rooting - DSP (12 mg-peptides/kg-soil) produced thicker roots than a chemical fertilizer; the number of root hairs in *B. rapa* increased and each was elongated when DSP (30 µg/ml) was added.

3. Stress tolerance - Soybean supplies nitrogen into the soil.

11. *Moringa oleifera* Leaf Water Extract (MLE)

1. Vegetative growth - MLE increases plant biomass, dry matter content, branching and yield;

- exhibits Biostimulant activity on many crops.

2. Rooting - MLE - improved seed germination.

3. Reproductive growth - MLE increased flowering, flower retention and increased fruit yield and quality among a wide variety of plant species.

4. Stress tolerance - Effect on chilling stress tolerance in autumn maize;

- protects maize from low temperature stress and wheat from salinity stress.

- MLE contains antioxidants, which prevent, stabilize and terminate the reactions of reactive oxygen species by defending oxidative induced cellular damage. Therefore, external supplementation of anti-oxidants is widely recommended to protect cells from the drought. MLE is a rich source of amino acids, nutrients, auxins, antioxidants, vitamins, and different macro- and micro-nutrients required for plant growth and regulation of enzymes.

- MLE foliar application to crop plants - increased number of roots and plants produce more and larger fruits which ultimately increased 20-35% yield.

- MLE increased soybean (*Glycine max*) yield by 35%.

- MLE improved seed germination, biomass production, and yield of blue panicum grass (*Panicum antidotale*), barnyard grass (*Echinachloa crusgalli*), buffel grass (*Cenchrus ciliaris*), wheat (*Triticum aestivum*), and maize (*Zea mays*). MLE also protected maize from low temperature stress and wheat from salinity stress.

- MLE improved both vegetative and reproductive development of tomato (*Solanum lycopersicum*) plants, including increased fruit yield and quality.

- In agriculture and horticulture, use of MLE has proved beneficial for the growth and yield, deeper root development and better seed germination, delay of fruit senescence, and improved plant vigour and yield quality/quantity. MLE also impart the crops the ability to withstand adverse environmental conditions.

12. Mulberry (*Morus alba*) Leaf Water Extract (MBLE)

1.Species specific plant growth-promotive properties.

2. Application of MBLE promoted the germination and growth of pea (*Pisum sativum*), broad bean (*Vicia faba*)

3. Stimulan activity on wheat crop.

Leaves contains19.4% protein content, anti-oxidants, macro-elements such as Ca, N, K, and Mg with low Na.

13. *Musa paradisica* (Banana) Leaf Extract

1. Contains abundant vegeto-alkali and crude protein.

2. Contains bio-active compounds.

3. Bio-stimulant fertilizer.

4. Can be used as Biostimulant.

14. *Phaseolus vulgaris* (Common bean) Extract

Contains bio-active compounds (Proteins, Minerals, Polyphenols, Auxins).

Can be used as Biostimulant.

15. Seaweed Extracts

1. Vegetative growth - Eco-friendly stimulantes the crop growth and yield; contains growth promoting hormones (Auxins), vitamins, amino acids, antibiotics and micro-nutrients.

2. Rooting - Effect on root development.

3. Reproductive growth - Promotes early flowering, uniform fruit setting and plant productivity.

4. Stress tolerance - Eco-friendly stimulator of crop stress tolerance.

Considered as a natural rooting hormones.

(Commonly used Seaweeds: 1. *Ascophyllum nodosum* (Brown Seaweed); 2. *Gracilaris edulis*; 3. Green microalgae; 4. *Sargassum wightii*; 5. *Spirulina plantensis* (Micro-algae); 6. *Ulva intestinalis* (Green Seaweed).

16. Sorghum (Fodder) Water Extract (SWE/Sorgaab)

1. Vegetative growth - Foliar application - improves photosynthesis, membrane integrity, growth and development.

2. Stress tolerance - Effect on chilling stress tolerance in autumn maize;

- foliar application - affects plant defense system against abiotic stresse;

- seed priming with SWE enhances crop tolerance to salinity stress.

17. Tea (*Camellia sinensis*) Seed Powder/Triterpene Saponin-rich waste product

1. Vegetative growth - Contains high amount of proteins - can be used as fertilizer; pronounced and direct physiological effect on various crops. The effects can be used to enhance crop yield and quality in agriculture and horticulture.

2. Rooting - TPS (dried seed powder-deoiled) improves soil trace elements and promotes the root growth.

TSP - Offers pesticidal and anti-microbial effect, also enhances the resistibility to the pests and diseases;

- TSP is very harmful to earthworms.

18. Vermiwash (VW)

1. Contains several enzymes (protease, amylase, urease and phosphatise), plant growth hormones (IAA, cytokinin, GA3), vitamins, macro- and micro- nutrients, humic acid.

2. VW contains nitrogen fixing bacteria like *Azotobacter* sp., *Agrobacterium* sp., and *Rhizobium* sp., and some phosphate solubilising bacteria.

3. VW serves as pesticide, disease curative and crop tonic and increases the yield of lab beans.
- Rooting stimulant - Tested on banana root length.

4. VW proves to have excellent Bio-pesticidal activities - the plants treated with VW are disease resistant.

5. VW increases soil microorganisms soil improving organic matter decomposition.

6. Vermicompost (VW) and Vermiwash (VC) combination showed significant influence on the biochemical characteristics of the soil.

7. Soil Zn, Mn and Fe content is unaffected with the increasing application of VW.

8. VW is rich in the primary nutrients (N-P-K). Application of VW has been reported to revitalize the soil quality. It rejuvenates the depleted soil fertility and enriches available pool of nutrients, conserves moisture and natural and biological resources.

Considered as a natural rooting hormones.

19. *Vigna radiata* (Mung bean) Extract

1. Contains bio-active compounds.
2. Can be used as Biostimulant.

Willow (*Salix* spp.) Bark Extract (Contains high levels of Salicylic acid/SA and Indole butyric acid/IBA)

1. Vegetative growth - promising effect.
2. Reproductive growth - effects on flowering and callus formation.
3. Stress tolerance - effect on stress mediation.
4. Rooting - Willow water helps cuttings to root.

- Root Promoting Biostimulant (assayed on *Chrysanthemum*); can be utilized to speed-up propagation of soft and semi-hard wood cuttings;

- Approved basic substance with fungicidal properties under agricultural EU pesticide regulation (Regulation (EC) no 1107/2009) since 2015;

- its approved uses are for Argriculture and Viticulture;

- can be used for seed treatment.

A root promoting product "Root Nectar" prepared from Willow bark extract has been found very effective on vegetative cuttings from lavender (soft wood) and chrysanthemum (semi-hard wood). A consistent improvements in the formation of adventitious roots and root branching were achieved. Root Nectar and Willow bark extract can be utilized to up propagation of soft and semi-hard wood cuttings.

20. *Withania somnifera* (Ashwadandha) Aqueous Extract

- Rooting stimulant - Tested on banana root length

- Acts as a potential insect growth regulatory (IGR) - interference with the endocrine system and offers anti-fungal, anti-microbial, anti-oxidant activities.

Banana plantlets with foliar spraying with Ashwagandha Aqueous Extract increased vegetative growth parameters of banana plantlets. The increased growth such as longer plant or higher leaf and root numbers may be due to the highest gibberellin (GA3), auxin (IAA) and cytokinin (zeatin) contained in ashwagandha (11.078, 0.0312 and 0.0149 mg/100g, respectively).

3. CONCLUSION:

Natural Biostimulants are often mixtures of a variety of compounds with variety of Biological activities and variety of Mechanisms. Many Biostimulants are likely to have multiple functions, along with its Biostimulant activity, such as:1. improving availability of nutrients, 2. providing pesticidal effect, and 3. possibly also hormonal effects. Also different Components of Biostimulants can offer different Mode-of-Action.

Challenge is to "Design a Biostimulant Product as per requirements".

Natural Biostimulants Product Development should follow following steps: 1. Selection of Ingredients; 2. Extracts – Standardization (using Markers); 3. Development of Analytical Methods using this Markers; 4. Bio-efficasy; 5. Mode of Action; 6. Composition of Different Ingredients; 7. Compatibility; 8. Toxicity (Phytotoxicity); 9. Safety (Animal); 10. Formulation; 10. Mode of Application (Foliar/Soil/Seed treatment); 11. Shelf Life Studies; 12. Stability Studies; 13. Bio-evaluation (Field Trials); 14. IPR Status (Patenting); 15. Manufacturing and 16. Commercialization. This will lead to New-Novel-Effective-Safe-Cost Effective "Biostimulant Product". New Leads also should be explored by 1. Field observations, 2. Extensive R & D work and 3. Incorporation of Promising Leads into New Biostimulant Products.

Biosketch of Dr. Swati Joshi

Dr. Swati Joshi was formerly the `Senior Scientist' of CSIR-NCL, Pune. During her exciting career of 36 years or so at NCL, she had carried out extensive research in the area of isolation and identification of new-novel molecules, development of botanical pesticides, developement of herbal drugs, neutraceuticals and food additives and had also contributed in the development of processes for obtaining commercially important natural products. She has more than 60 publications in national and international journals including 15 WO Patents. Since last six years, she has been working as Scientific Adviser and Consultant and also as a Evaluator for Funding Agency (BIRAC).

Challenge of Fluorosis

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ABSTRACT

Complications attached with existence of fluoride above permissible limits in drinking water, a burning issue in many parts of India, is well reported. There is beneficial as well as harmful effect of Fluoride on human health. Skeletal or dental fluorosis or both can be the result of sustained intake of fluoride above 1.5mg/l for a prolonged duration by means of water, food or air. Disastrous impact, like permanent crippling for entire life, can also be the result of fluoride presence in markedly high concentration in drinking water. Fluorosis is an irreversible and incurable ailment, the only remedy for which is prevention only. Present day it has threatening impact on health in numerous parts of India as well as the world. In the paper, an attempt has been made to identify sources of fluoride, effect on human health and to develop an approach to deal with fluorosis in the Rae Bareli District.

Keywords: Ground water, SPADNS method, Fluoride, Fluorosis.

INTRODUCTION:

Water covers nearly three-fourth of our Earth's surface and is the most vital component for existence of all living beings. Although present in abundance, not all the water is fit for drinking hence there arises the problem of paucity of drinking water. The existence of excessive fluoride ion, above permissible limits, is a matter of great concern from public health point of view. Natural, as well as man-made causes[1] are responsible for occurrence of fluoride pollution.

Fluoride, the lightest member of halogen family, displays unique properties much varied as compared to other halogens. Fluoride is present as a common element in the earth's crust, in the form of rocks and minerals. Calcium fluoride (CaF_2) is considered as a minor ingredient of natural waters, but it is one of the most important constituents in determining the appropriateness of water for drinking purposes. For healthy growth of teeth, consumption of 1mg/l per day is very much essential, but level exceeding the permissible limit of 1.5mg/L can prove fatal to health[2]. A major geo-environmental problem, these days, in many parts of the world is definitely the Fluoride contamination of ground water and its toxic effects observed even if consumed in minute quantities. Most of the states in India are facing severe problems due to fluoride in ground water[3, 4]

Fluoride can have both constructive and destructive impact on human health depending on its intake quantity as a constituent in food and water. The major source for fluoride ingestion is generally the drinking water, which caters to 75-90 % of the day to day consumption.[5] The amount of fluoride in potable water is the major source for monitoring daily fluoride ingestion. Besides the fluoride concentration in drinking water, sum of other sources for all ingested fluoride also contribute towards ill effects on health. Therefore, consumption of water with 1.0 mg/L fluoride in a warm climate, due to larger water intake, might have negative impact on health, while the same concentration in a temperate climate might show positive effect.

Fluorine, being highly electro-negative, easily binds with the positively charged calcium ions present in bone and teeth. Therefore, if taken in excess, fluoride adversely affects the bones and teeth. In large quantities fluoride can also affect the thyroid gland and kidneys and even cause death in extreme cases.[6]

Positive health effects

Micro quantity of fluoride can have a boosting effect on our health. According to WHO, drinking water should preferably contain 0.5-1.0 mg/L fluoride, because it assists in preventing dental caries. This intake limit is specifically very effective for children who are at the stage of developing their teeth.[8] Fluoride will still help to shield the completely developed teeth. Teeth that have been attacked by dental caries can be repaired with the help of fluoride which dissolve in saliva. Fluoride can also bind to the surface of the teeth and when needed, be

released to help and protect the teeth. With the assistance of fluoride, the metabolism of the bacteria that attack the teeth is retarded and the surface tension is lowered, making it more difficult for plaque, colonies of bacteria, to bind themselves.[9-11]

Bones become very delicate, brittle and break easily in a disease known as Osteoporosis. Fluoride affects the enzyme that controls the formation and degradation of bone, therefore can be used to treat this deadly illness, which would result in quicker production than degradation finally leading to less fragile bones.[12]

Negative health effects:

Fluoride, like any other substance, is harmful in too large doses and the extent of severity depends on the amount ingested over a long and continuous period of time leading to chronic fluoride poisoning or fluorosis. The initial symptom of fluorosis is usually mottling of teeth, starting with white spots which turn to yellowish and finally brownish with passage of time and greater exposure to fluoride. These are the common symptoms appearing on consumption of water containing 1.1-2.0 mg/L fluoride. In case of fluoride concentration exceeding 2.5 mg/L, rough enamel with dark brownish mottling will start spreading throughout the teeth. Deformation of bones, skeletal fluorosis, can be observed in extreme cases, when potable water has a fluoride concentration of 3 to 6 mg/L. The enzymes controlling bone formation and degradation are affected by fluoride and the balance is perturbed. This leads to a situation where the bones start hardening and their density increases. In severe cases excess bone tissue will be deposited, leading to difficulties in bending joints as well as the spinal column, which is a very painful situation.[12]

When the fluoride concentration in drinking water reaches 50 mg/L there is a risk of thyroid changes, at 100 mg/L there is risk of growth retardation, values above 125 mg/L leads to a risk of kidney changes and an acute dose of 2.5-5.0 g will lead to death (Table 1).

Table 1: Effect of different doses of fluoride.[7]

Concentration or dose of fluoride	Medium	Effect
2 parts per 1000 million	Air	Injury to vegetation
1 ppm	Water	Reduction of Dental caries
2 ppm or more	Water	Mottled enamel
5 ppm	Water	No osteosclerosis
8 ppm	Water	Osteosclerosis 10%
20 to 80 mg/day or more	Air or Water	Fluorosis (Crippling)
50 ppm	Water or Food	Thyroid changes
100 ppm	Water or Food	Retardation in Growth
More than 125 ppm	Water or Food	Kidney changes
2.5 to 5.0 g	Acute dose	Death

*ppm equals to the mg/l.

Table 2: Number of Districts in various States of India known for widespread cases of Fluorosis

State	No. of Districts
Assam	**02**
Andhra Pradesh	**17**
Bihar	**09**
Delhi	**04**
Gujarat	**All Except 1**
Haryana	**12**
Jammu & Kashmir	**01**
Karnataka	**03**
Kerela	**03**
Maharashtra	**10**
Orissa	**03**
Punjab	**13**
Rajasthan	**All except 1**
Tamil Nadu	**08**
Uttar Pradesh	**07**
West Bengal	**04**

STUDY AREA:

The district from Uttar Pradesh taken for study is Rae Bareli having population 28, 72,330 according to 2001 census.Height of Rae Bareli District from mean sea level is 120.4 meter.

Morphometric feature of Rae Bareli:

- Altitude 1082.30 m (1350 feet)
- Latitude 25^{o} 49´00´´
- Longitude 81^{o} 34´ 00´´

Meteorological data:

- Rainfall 1200mm
- Humidity 48%

Rock Type Besalt

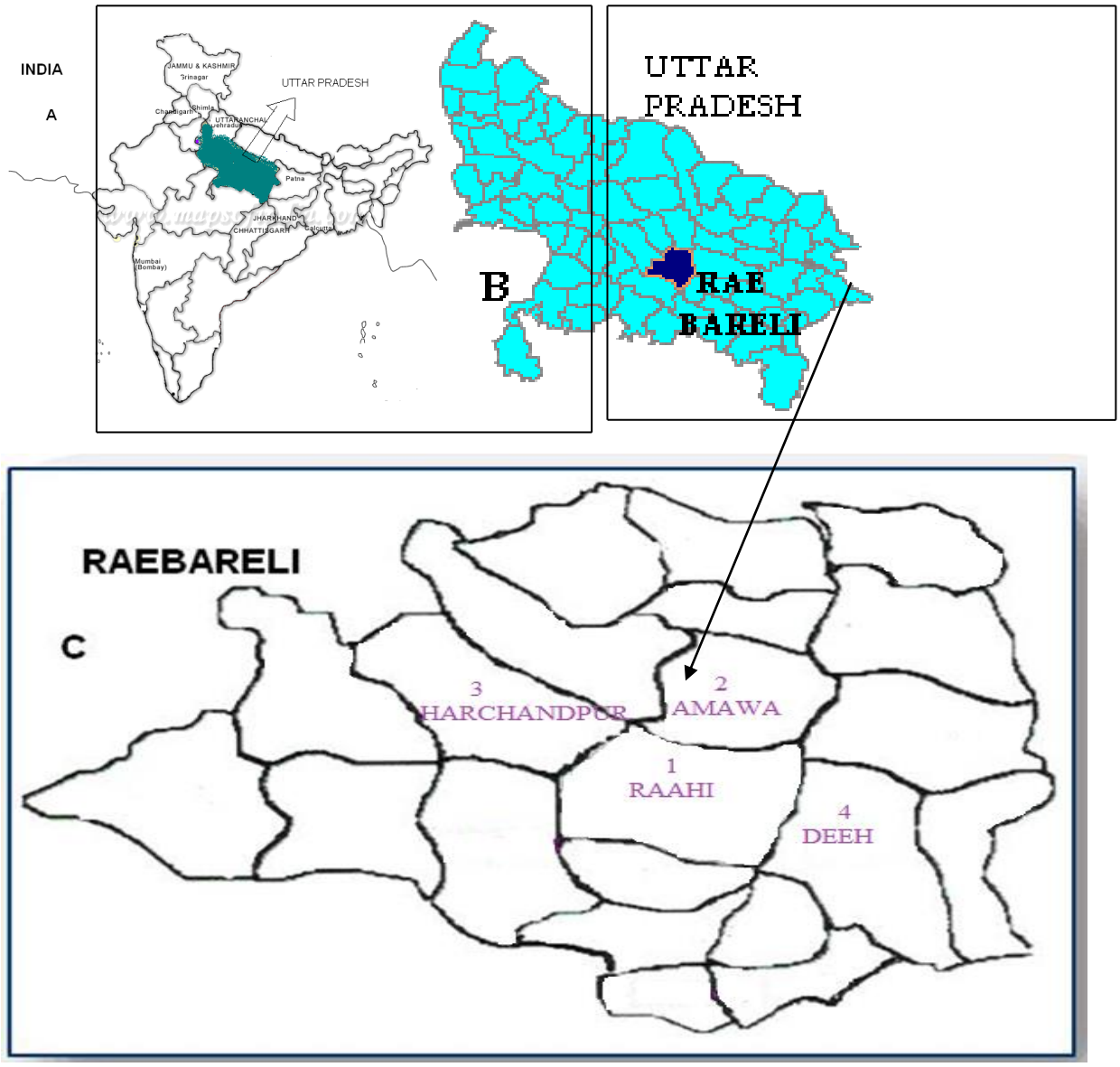


Figure 1: Location of selected block for Fluoride Estimation

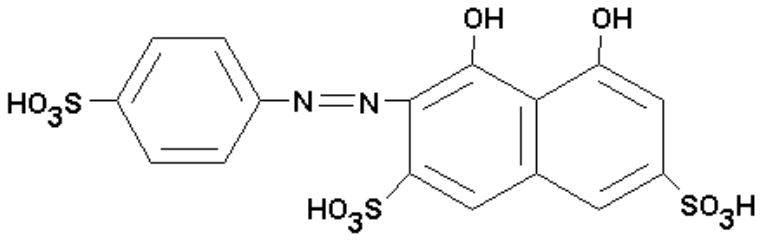
Rae Bareli is divided into 7 Tahseels namely Rae Bareli, Salon, Unchahar, Dalmau, Maharajganj, Tiloi and Lalganj.These 7 Tahseels are with 21 Blocks out of which 4 Blocks have been selected for sampling. From each blocks 3 villages are randomly selected for the present study.

MATERIALS AND METHOD:

Total 36 ground water samples of Hand pump and Tube well from 12 selected villages (using ground water for potable and agriculture use) of Raebareli district were collected using pre-

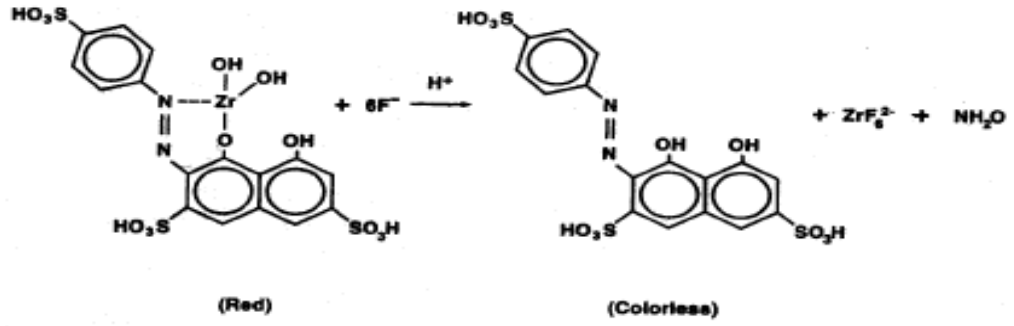
cleaned plastic bottles during Summer (April to May), Rainy (July to August) as well as Winter (November to January) during the period December 2015 to November 2016. Locations are selected in a way that major part of the districts are engulfed and true representation of overall ground water quality of the district in the study area is done.

The collected samples of water were taken to the laboratory for analysis. Fluoride level in ground water is measured by SPADNS method.[13](SPADNS is Sodium- 2- (para sulphophenyl azo) -1, 8 di hydroxy -3, 6 - naphthalene disulphonate).



SPADNS

The colorimetric method of SPADNS involves the reaction between zirconium dye-lake and fluoride, resulting in formation of a colourless complex between the dye and anion. With increase in amount of fluoride, the colour produced becomes progressively lighter and lighter.[9]



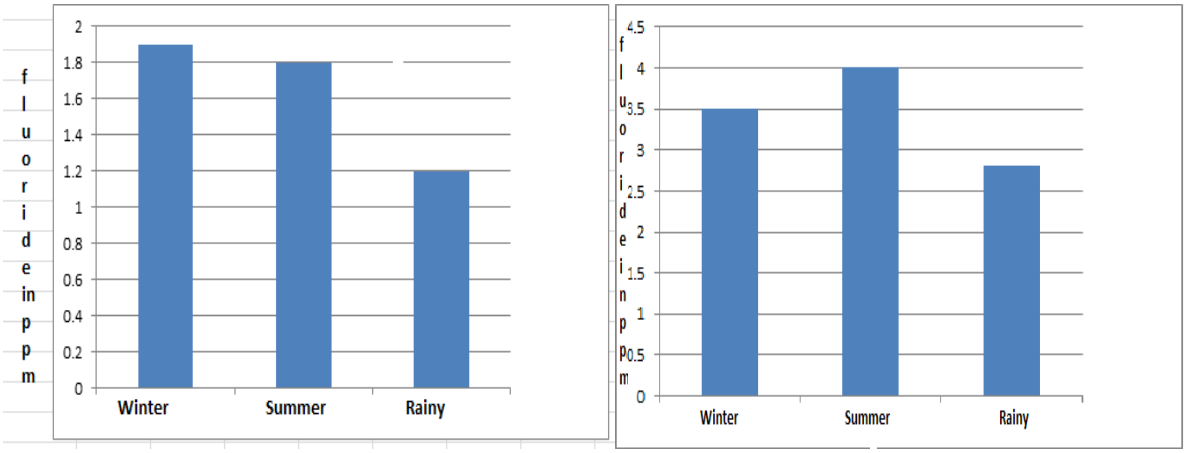
Standard solutions of fluoride were prepared in the concentration range of 0 to 1.50 mg/L and were further diluted to 50 ml with double distilled water. 5 ml of each SPADNS and zirconil acid

reagent are mixed with each standard solution and spectrophotometer is set to zero absorbance with respect to the reference solution. UV-Visible spectrophotometer is used to measure Absorbance spectrophotometrically at a wavelength of 570 nm. With the help of standard curve, amount of Fluoride present in each of the water samples were determined.

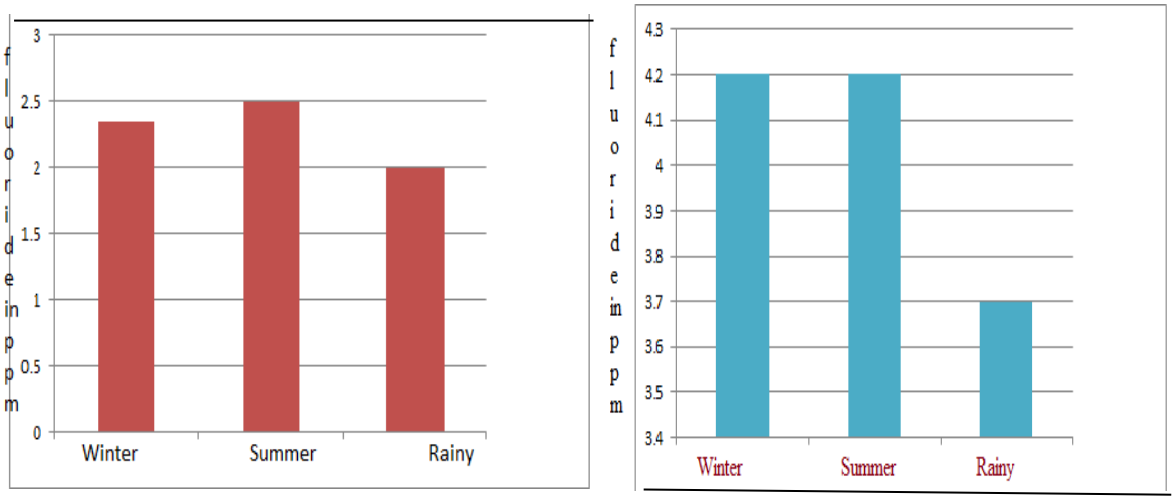
OBSERVATION TABLE:

Table 3 : Values of fluoride concentration during summer, winter and Rainy seasons of the year from December 2015 to November 2016.

S. N.	Selected Villages	Seasonal Readings (mg/lit)		
		Winter	Summer	Rainy
1	Bastepur	**1.70**	**1.80**	**1.20**
2	Jayas	**1.30**	**1.45**	**1.15**
3	Fursatganj	**1.90**	**1.70**	**0.90**
4	Poore Paturia	**3.50**	**4.00**	**2.80**
5	Sankaraha	**1.85**	**1.80**	**0.90**
6	Khairahana	**1.40**	**1.60**	**1.00**
7	Kodra	**2.20**	**2.10**	**1.80**
8	Rohania	**1.90**	**1.80**	**1.50**
9	Pahadpur	**2.35**	**2.50**	**2.00**
10	Poore Narayana	**4.20**	**4.20**	**3.70**
11	Tekari	**0.70**	**0.90**	**0.60**
12	Matiagadar	**1.30**	**1.60**	**1.00**



1.Seasonal variation of fluoride in Raahi 2. Seasonal variation of fluoride in Amaawa



3. Seasonal variation of fluoride in Harchandpur 4.Seasonal variation of fluoride in Deeh

Figure 2: Seasonal Variation of Fluoride Concentration in Selected Block of Rae bareli District U.P.

RESULTS AND DISCUSSION:

After analysis of each of the samples from 12 villages of 4 Blocks in Rae Bareli District, the following results have been observed:

- Poore Narayana from Deeh Block and Poore Paturia from Amaawa Block show a value beyond 4 mg/lit.
- Jayas and Tekari show that the value for Fluoride concentration is below standard limit of fluoride level.
- Amaawa, Raahi, Deeh and Harchandpur Blocks are at verge of fluoride contamination.
- When the concentration of naturally occurring fluoride level exceeds recommended limits then defluoridation becomes necessary. Continuous monitoring and water quality analysis by Government should be frequent, to keep the people safe from the problem of fluoride pollution.
- Dissolved fluoride in drinking water is effortlessly taken up by gastrointestinal tract and the interfering elements like Al, Mg and Ca are unable to intervene. This is propagated fully through the direct bioavailability of soluble fluoride ingested with water.
- The lethal effects of excess fluoride intake through water are abrasion, browning and mottling of teeth. Decreased milk production and lameness can be the result of very high fluoride levels in bone and urine
- The aim of water defluoridation is to avoid the occurrence of this chronic illness which may particularly have drastic effect on the poor and the children.
- The present position in the Rae Bareli district is such that only urgent measures will prevent a crisis situation.

RECOMMENDATIONS:

- The present research in hydro geological area portrays that a methodical and careful survey of delineating fluoride vulnerable zone should be made prior to setting up of hand pumps and tube wells. This process needs sustainable management of the accessible water resources.
- Population, residing nearby, should be educated regarding the lethal impact of ground water polluted with fluoride and also the simple techniques which can be implemented for removal of fluoride.

- Organization of awareness campaign regarding fluorosis should be done and curative methods may be carried out in the villages and schools using various aids like distributing pamphlets and showing some audiovisual clips.
- It is, infact, the need of the moment that a much stronger regional co-operation of organizations such as local N.G.O., Government and other related stakeholders should be sought.
- Immediate short term mitigation programs should be organized in fluoride related water contamination affected areas.
- Some of the critical institutional, policy and technological difficulties are to be met promptly.

CONCLUSION:

This study for the first time spotted high fluoride in the underground water and wells of various places in Rae Bareli district. Future horrifying outcomes of fluoride pollution can be minimized beneficially through frequent monitoring and Defluoridation. Awareness Programme through communication, Demo, fieldwork can encourage hygiene and health promotions particularly in the remote areas of the region. Awareness should be also given regarding the fact that boiling of water for disinfection does not help in removing fluoride, but consequently result in increasing the concentration of fluoride in water. Frequent water quality analysis by the Government and regular monitoring should be done to keep the people safe from the problem of fluoride contamination. Areas having high fluoride content should be mapped carefully and ensured that drinking water is fetched from safe low fluoride areas.

Prevention of fluorosis

a. Detection at an early stage
b. Tracing the source of Fluoride
c. Identifying the aspects responsible for fluorosis and its intensity
d. Assimilating the programmes of fluorosis prevention in Health-care missions
e. The spreading of fluoride induced disease may be prevented by initial removal of the source of fluoride and providing safe drinking water.

f. Quick supplementation of diet with essential nutrients, vitamins and anti-oxidants should be promoted.

Fluorosis is not treatable but it is preventable

i. Fluorine is the most electro-negative element spread as fluorides in the environment. The key means of fluoride intake by humans is water.
ii. Fluoride is dispersed in skin, erythrocytes, liver, cardiac and skeletal muscles. It can cross the cell membrane promptly.
iii. Fluorosis, a major health problem, is the consequence of consuming water with high fluoride levels for a long period of time.
iv. Fluorosis is specifically categorized by skeletal manifestations and dental mottling such as osteoporosis, osteosclerosis, crippling deformities etc.

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Bio-sketch of Dr. Sheila Srivastava

- I am Dr. Sheila Srivastava Associate Prof. & Head, Department of Chemistry, Feroze Gandhi College, Raebareli, U.P. (Affiliated to University of Lucknow)

- 20 students awarded Ph.D. under my supervision
- Published more than 150 research papers in International and National journals of repute.
- Completed 6 major and 4 minor research projects sponsored by UGC, CST
- Authored three books

SWASTIIK

Safe Water and Sustainable Technology Initiative from Indian Knowledgebase

Dr. Vinay M. Bhandari

Chief Scientist, CSIR- NCL Pune

Abstract

Safe drinking water is necessary to prevent occurrence of large number of waterborne diseases and to save millions of lives, one of the most priority themes for developing country like India. It is essential to develop methodology which provides safe and healthy drinking water at low cost with substantial ease of operation, scale-up and without harmful disinfection by-products. CSIR-NCL's water disinfection technology, SWASTIIK, a hybrid hydrodynamic cavitation technology, can provide alternative to existing disinfection processes, mainly for chlorination. The technology is effective for eliminating harmful bacteria, gram-negative (*Escherichia coli*) and gram-positive (*Staphylococcus aureus*). Also, complete removal was achieved for antimicrobial resistant (AMR), gram-positive methicillin resistant, *Staphylococcus aureus* and relatively less researched, gram-negative opportunistic pathogen, *Pseudomonas aeruginosa*. The present study, for the first time, reports possible use of different natural oils such as eucalyptus oil, clove oil, peppermint oil etc. in conjunction with hydrodynamic cavitation. Exceptionally high rates were obtained for practically complete removal of all types of bacteria, within less than 10 minutes, for a very small concentration of oil, 0.1%. The increased rates of disinfection using oil/extract can drastically reduce the time of operation and consequently reduce cost of disinfection. A possible mechanism indicates cell destruction through the rupture of cell wall, oxidative damage and possible DNA denaturation. The developed methodology, Safe Water and Sustainable Technology Initiative from Indian Knowledgebase, SWASTIIK, has the potential to provide viable alternative to chemical disinfection methods with operating cost of only 0.036 $\$/m^3$ (~Rs. 2.5/ m^3 or 0.25 Paisa per liter).

Introduction

In the recent times, availability of safe drinking water has become a major challenge as a result of an increasing human population and environmental pollution. As per the WHO estimates, approximately 785 million people lack access to a basic source of drinking water, while the drinking water supplies of some 2 billion people are contaminated with pathogenic bacteria associated with feces, resulting in diarrhea, dysentery, typhoid, and polio (WHO, 2019). WHO endorses that "*The potential health consequences of microbial contamination are such that its control must always be of paramount importance and must never be compromised*". Thus, it is utmost important to effectively remove the pathogenic bacteria using economic and sustainable technology.

Even though water disinfection can often be accomplished with conventional treatments such as chemical and physical methods, most of these have limitations or drawbacks in the form of inadequate efficacy and limited applicability (Gogate et al., 2001). The problems associated with conventional physical methods (e.g. heating, radiation, microwave, filtration, UV irradiation, plasma) are difficulty in large scale scalability, high cost and prolonged treatment times. UV irradiation typically has insufficient light scattering ability and is ineffective towards bacterial photoreactivation repair mechanism. Membrane technology such as Reverse Osmosis also have operational difficulties along with fouling problem, many times requiring frequent replacement of membrane thereby increasing the cost of the treatment. Despite widespread use, chlorination and ozonation have been viewed as environmentally unfriendly in recent years due to their unpleasant odors and due to generation of disinfection by-products that can be poisonous and mutagenic (Gogate et al., 2007).

Some of the disadvantages of chlorination methods can be eliminated using adsorption technologies employing newer adsorbents/nanocomposites that are capable of eliminating bacteria (Kirti et al., 2018). Recently, hydrodynamic cavitation is being considered as a suitable greener process for disinfection due to its simple operation, easy scale up, and no harmful byproduct formation.

Philosophy behind SWASTIIK process

India is rich in its culture and its vast knowledgebase of over 5000 years or so. Also, the ancient Indian philosophy views symbiotic relationship of human and nature and suggests many solutions to the health related problems by going back to the nature and natural medicines. Ayurveda is an ancient scientific literature that provides many guidelines in this regard. SWASTIIK, a modern hybrid hydrodynamic cavitation technology draws its inspiration from this Indian philosophy while contemplating solution to the age old problem of sustainable technology for safe drinking water. It has potential to provide alternative to the existing disinfection technology such as chlorination. The SWASTIIK technology, for the first time, reports hybrid cavitation methodology using number of natural oils such as clove oil, eucalyptus oil, peppermint oil for disinfection of water. The antibacterial properties of a large number of essential natural oils such as Eucalyptus, clove oil are well reported (Bachir et al., 2012). However, there are no reports for the real life application in drinking water treatment or in cavitation. The developed hybrid technology using natural oil in cavitation can achieve 100 % disinfection of bacteria with significantly reduced cost of operation.

SWASTIIK is effective for destroying common bacteria such as *E. coli*, *S. aureus*, and also antimicrobial resistant bacteria (AMR) and difficult, opportunistic pathogen *P. aeruginosa* and therefore has positive implications for possible commercial applications and for rural use. Its relevance is also because the World Health Organization (WHO) listed *P. aeruginosa* as one of the critical bacteria due to its adaptive response towards several antibiotics (WHO, 2019).

The Process

Hydrodynamic cavitation is a physico-chemical process involving formation, growth and collapse of cavities, by using specific cavitating devices such as orifice and vortex diode. The collapse of the cavities/bubbles (implosion) produces conditions of extreme pressure (~1000 atm or more) and temperature (~5000 K or more) at the point of implosion and as a consequence, homolytic cleavage of water molecule occurs resulting in generation of hydroxyl radicals that

can participate into chemical oxidation of organic species (Mane et al., 2020a,b, Mane et al., 2021, Ranade and Bhandari, 2014). CSIR-NCL developed a newer type of cavitating device employing vortex flow, called as vortex diode, for water and wastewater treatment that is found to be highly effective in the disinfection of water. The vortex diode requires low pressure drop of just 1 bar or less, as compared to conventional device orifice (2 - 10 bar) for complete destruction of bacteria. A water disinfection technology developed by the CSIR-NCL known as SWASTIIK (Safe Water and Sustainable Technology Initiative from Indian Knowledgebase) makes use of natural oils having antimicrobial properties in the cavitation process. Extreme conditions of cavitation, localised high temperature and pressure, shock waves, oxidizing species such as hydroxyl radicals or hydrogen peroxide and consequent oxidation destroy harmful microorganisms, without using any external chemicals or reagents.

SWASTIIK gives high efficiency and high disinfection rates, no disinfection by-product, and is a green process to eliminate pathogenic bacteria.

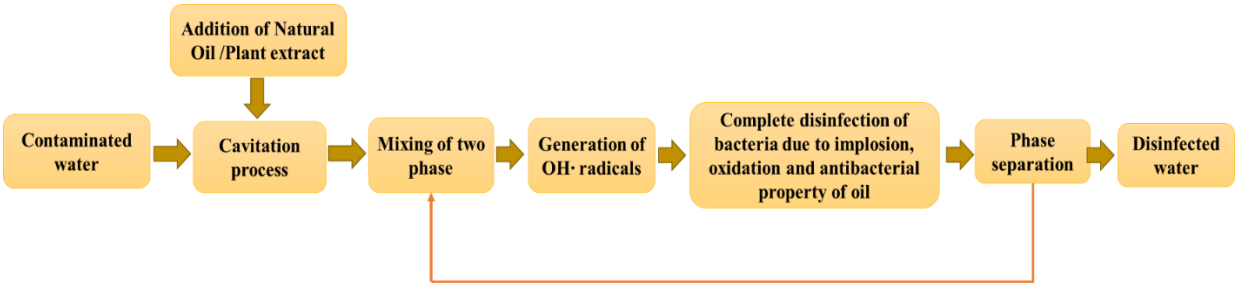

Fig 1: SWASTIIK process for disinfection of water

SWASTIIK, for the first time, provides a proof of concept for hybrid cavitation process using different natural oils (0.1% v/V) such as peppermint oil, clove oil, eucalyptus oil etc. and for eliminating different microorganism such as *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and antibiotic resistance bacteria. SWASTIIK demonstrated very high rates of disinfection and complete disinfection within 5-10 min. with vortex diode, at low pressure drop of 1 bar and a low dose of 0.1% natural oil as an additive. Plausible mechanism of disinfection involves extreme conditions due to cavitation, and oxidative damage of the cells due to hydroxyl radicals generated during the cavitation. It is reported that important constituents of

microorganisms such as proteins, lipids, DNA and polysaccharides can also be affected by oxidation. Moreover, the active compound present in the natural oil can react with the phospholipids of the cell membrane thereby altering its permeability and also denature cell protein. The denaturation of cell protein causes cell death (Zupanac et al., 2019).

Possible Applications and Societal Benefits

The conventional processes for water disinfection are in general not sustainable due to complex, not so environment friendly nature and cost-intensive features. Thus, practical and affordable application of such techniques is not difficult for either household use or for large scale water treatment installations. CSIR-NCL's SWASTIIK technology has the potential for household as well as large scale implementations. SWASTIIK process operating cost for disinfection is only ~ 0.036 $/m3 (~ 0.25 Paisa per litre). The technique can also be integrated with other established methods such as adsorption for increased effectiveness/ cost optimization.

A very interesting possibility emerges in the form of exploiting health benefits of specific oils, with appropriate designs. Peppermint oil is used in food and pharmaceutical cosmetics. Menthol, as a raw material, is used in toothpaste, confectionary, etc. and can be taken orally in dietary supplements. Peppermint oil seems to reduce spasms in the digestive tract. Similarly, clove oil is known for healing properties etc. Detailed investigations in the regard are therefore required, especially from the Medical fraternity to establish the health benefits.

Conclusion

SWASTIIK technology, for the first time, revealed the effective combination of ancient Indian knowledgebase and modern cavitation technology for complete destruction of pathogenic bacteria. The developed green process eliminates the use of harmful chemicals and can provide alternative to existing chemical processes such as chlorination with comparable operating cost of only 0.036 $/m3 (~0.25 Paisa per liter). The developed approach highlights importance of going back to nature for finding solutions to the problems of modern times.

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Innovator's brief profile

Dr. Vinay M. Bhandari is presently working as a Chief Scientist and Professor-AcSIR, in the Chemical Engineering & Process Development Division of the CSIR-National Chemical Laboratory, Pune, India. He worked as a visiting faculty at Tohoku University, Sendai, Japan in 1998-99 and also as visiting scientist at Korea Institute of Energy Research, Daejeon, South Korea during 2004-05. He has more than 200 publications/presentations; 2 US patents; filed >10 patents and has recently co-authored book entitled, "Industrial wastewater treatment, recycling and reuse" (Elsevier, 2014). He has developed 3 technologies based on hydrodynamic cavitation for Disinfection of water, for Industrial wastewater treatment (commercialized in India & abroad) and for Desulfurization of fuels. His desulfurization work received GYTI award for Technological Innovation, conferred by the Hon. Vice President of India on 6th July, 2019. His research interests include Chemical and Environmental Engineering, and Industrial wastewater treatment, recycle and reuse.

Installation & Recovery of Monazite, Xenotime and Rare earth bearing Minerals in riverine placers of Siri River Areas, Jashpur District Chhattisgarh.

M. G. Shinde

Atomic Minerals Division (former)

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Abstract:

Rare metals like Nb, Ta, Li, Be, Cs and REE from La to Lu, besides Scand Y find diverse applications in various sectors of industries such as electronics, manufacture, medical science, technology, renewable energy, agriculture besides nuclear energy. In view of their wide utility, their extraction and recovery from their minerals in riverine placers assume global importance. The extraction from Siri River area and tributaries in Jashpur district Chhattisgarh was carried out under AMD exploration and extraction program. A plant with requisite machinery and equipment was installed for the purpose and an adequate flow sheet was designed. Details of the installation of Plant, recovery of mineral concentrates, their up gradation and various other facets have been discussed in the paper.

Rare Metal and Rare Earth Investigation

Form the last five to six decades RMRE investigation group carrying outinvestigations for the resources of metals and important minerals.

The Niobium (Nb), Tantalum (Ta), Lithium (Li), Beryllium (Be), Cesium (Cs) includes in Rare Metals and Lanthanum (La) to Lutetium (Lu) besides Scandium (Sc) and Yttrium (Y).are includes in Rare Earths: (REE).

Objective:

Xenotime bearing placers exist around Kunkuri area in Siri River and tributaries of Champajharia nala and Baljora nala placers have been worked out for obtaining Xenotime, Monazite and REE Mineral concentrates.

As the Global demand for rare earths have increased in recent years and increased more and more uses, the areas are taken for establishing recovery plant at River site.

Executive Summary:

Type of deposit and Important locales	Riverine Placers. Significant xenotime concentration is located in Siri River (28.5km length), Champajharia Nala (6.5 km length) and Baljora Nala (10 km) in Ib River basin.
Toposheet No.	64 N/13 &14 and 73 B/1 & 2
Accessibility	Well-connected from Jharsuguda, Raigarh and Ranchi
Regional Geology	Archaean meta sedimentary and meta basic rocks. The vast stretch of granitic rocks form the western part of the Chhota Nagpur Granite Gneiss Complex. With emplacement of a variety of younger granites (Middle Proterozoic), pegmatites, aplites and dolerites. Amongst the younger granites (1005 $\pm$ 12 Ma), three different types are identified. i) Medium grained grey coloured two mica granite, ii) Fine grained biotite granite and iii) Coarse grained pink coloured two mica granite.
Mineralogy	Xenotime, Monazite, Ilmenite, Magnetite, Garnet, Zircon, Apatite etc.
Nature of heavy mineral deposition	Along River course in Island bars/Braid Bars, Side bars, Point Bars and Flood plains
Radioactivity	1.5 to 2 xbg in source granite/pegmatites. However, Placer bars record 5 to 20 xbg. Concentration of heavy minerals is found to increase with increase in radioactivity.
Grade of HMC	0.50 to 3.89% in placer bars considered for reserve estimation. The cut off being 0.50% HMC. However, lean grade (0.20 to 0.45% HMC) placer bars do also exist.

<table>
<tr><td>Analytical Results</td><td><table>
<tr><td>Source rock</td><td>Upto 53 ppm Y</td></tr>
<tr><td>Raw Sand</td><td>0.06 to 0.08% Xenotime</td></tr>
<tr><td>Concentrate</td><td>3 to 5 % Xenotime,
2 to 3.50% Y_2O_3</td></tr>
<tr><td rowspan="2">Upgraded Product
(Magnetic Separation)</td><td>Xenotime rich: 18-22% Y_2O_3</td></tr>
<tr><td>Monazite rich: 3-4.5% Y_2O_3</td></tr>
</table></td></tr>
<tr><td>Future Prospect</td><td>The available heavy minerals concentrate in placer bars of Siri River, Champajharia and Baljora Nala could sustain recovery operations for more than 10 years.</td></tr>
</table>

Regional Geology:

The area around Kunkuri consists of Archaean meta sedimentary and meta basic rocks form the western part of the Chhotanagpur Granite Gneiss Complex (CGGC). Amongst the younger granites three different types are identified Medium grained grey colored two mica granite. Fine grained biotitic granite and coarse grained pink two mica granite.

REE Minerals:

0. Bastnaesite: Y Ce $(CO_3)FOH$

Fluro carbonates of Cerium Yttrium Carbonates Contain 60 % REO Y_2O_3 0.1 – 0.30

Hard rock deposit

China Bayan OBO 2.73-42-75%

Mountain Pass 9.89- 13.18%

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1. Monazite: (La Ce Y Th) PO_4

   A rare earth Phosphate concentration contain 55-60 % REO, 1-2 % Y_2O_3& 8- 10 % ThO_2

2. Xenotime: YPO_4

   A Phosphate of Yttrium concentrate contain 25% Y_2O_3 40 % REO 0.30 % U

3. Fergusonite : Y (Nb, Ta)O_4 Oxide

4. Fluocerite : (Ce, La Y) F

Location of Area:

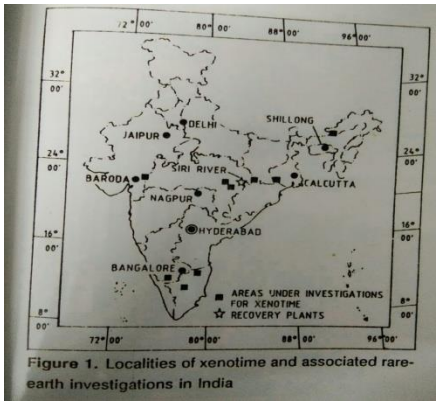
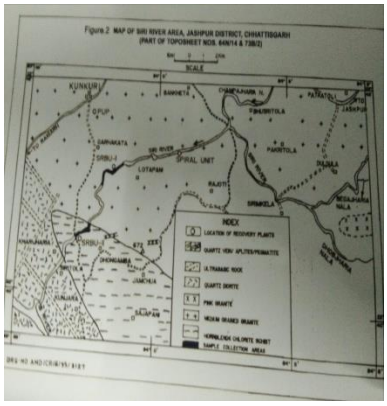
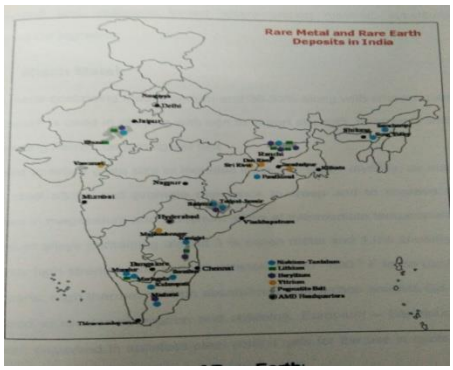


Figure 1. Localities of xenotime and associated rare-earth investigations in India





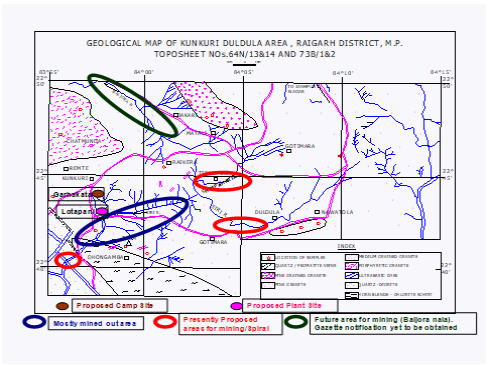


Fig.2

Placer Bars in Siri River

Placer Bars in Champajharia Nala

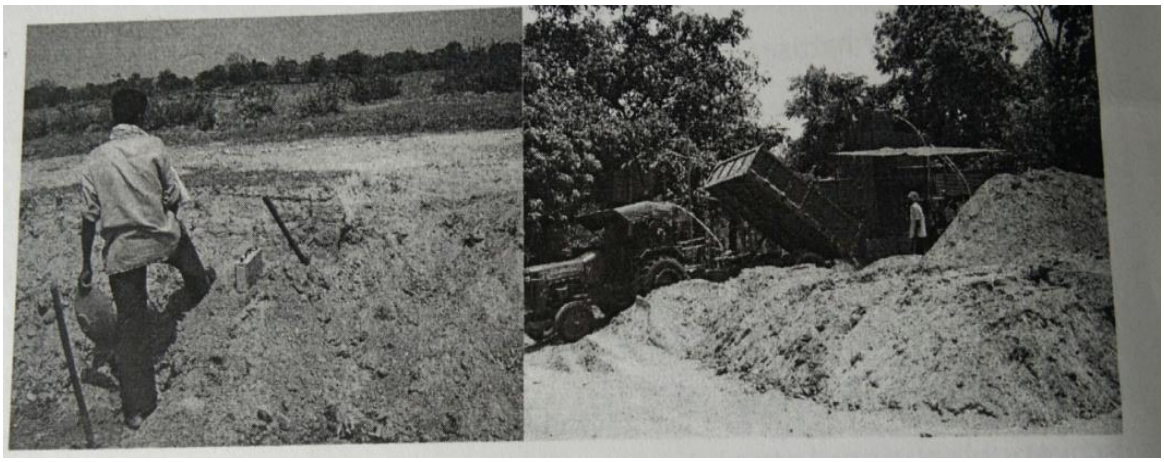
Placer Bars in Baljora Nala

Vertical Stratification in Placer Bar

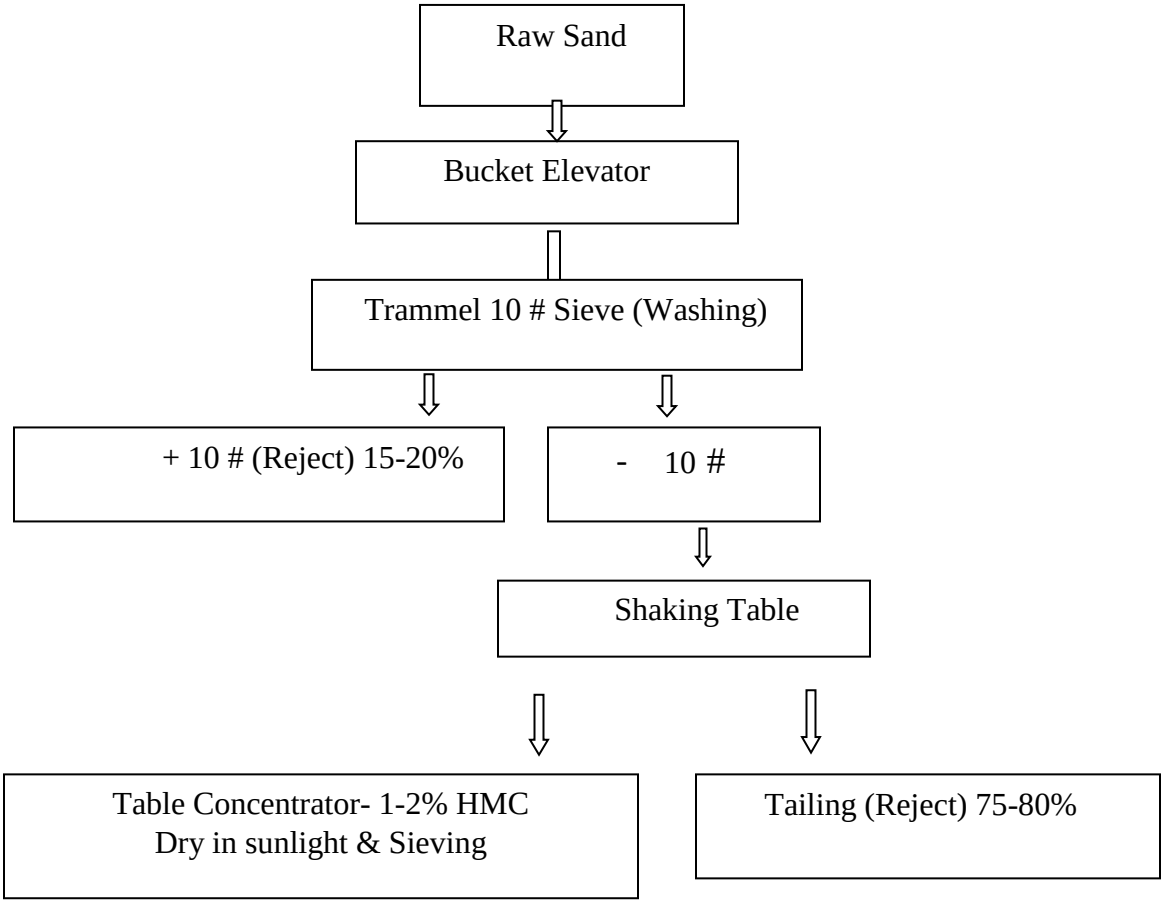
Checking of Radioactivity:

Mining, Excavation and Transportation of Raw sand:

Transported Sand at Plant Site:



Flow Sheet:



Treatment of Raw Sand and Siri River Unit

Mineralogy:

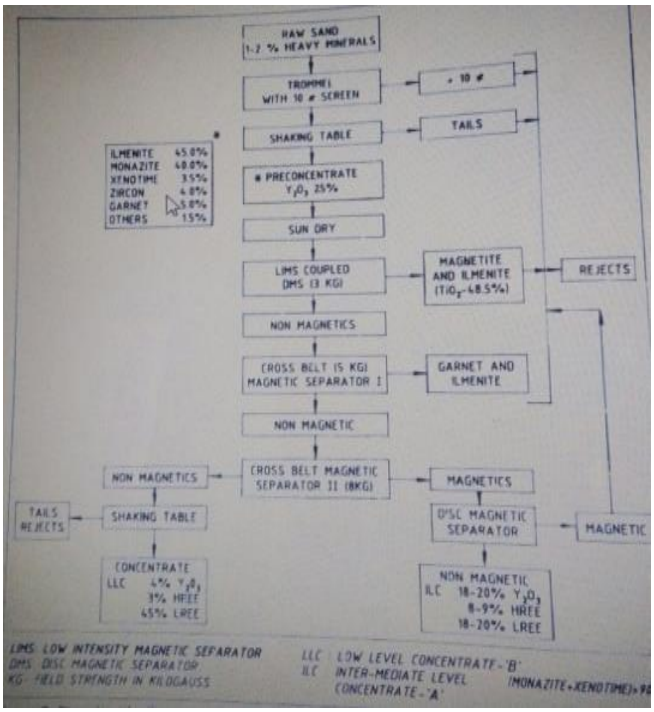
Heavy Mineral concentrates in Raw Sand and Poly Mineral Concentrates

Minerals	Raw Sand %	Minerals %
Magnetite	0.01- 0.50	1-5
Ilmenite	0.8 -1.0	40-45
Monazite	0.6- 0.8	35-40
Xenotime	0.06- 0.08	3-5
Garnet	0.01- 0.02	1-2
Apatite	0.02- 0.04	3-4
Amphibole & Rutile	4.01- 0.02	1-2

Total Heavies: 1-2%

The heavy mineral concentrate further up graded by using High Tension Magnetic separator and upgraded the Xenotime and Monazite products at Siri River.

Flow Sheet - High Tension Magnetic Separator:



Complete Chemical Analysis of Poly Mineral Concentrate:

Elemental oxide	Value in %	Elemental oxide	Value in %
La_2O_3	5.90	ThO_2	3.85
Ce_2O_3	10.95	Nb_2O_5	0.40
Pr_2O_3	1.10	Ta_2O_5	<0.10
Nd_2O_5	4.20	ZrO_3	1.15
Sm_2O_3	0.90	SiO_2	10.60
Eu_2O_3	0.033	TiO_2	16.90
Gd_2O_3	0.68	P_2O_5	15.15
Tb_2O_3	0.097	SnO_2	<0.10
Dy_2O_3	0.68	WO_3	<0.10
HO_2O_3	0.15	FeO (T)	16.00
Er_2O_3	0.49	MnO	1.45
Tm_2O_3	0.08	Al_2O_3	1.00
Yb_2O_3	0.48	CaO	0.82
Y_2O_3	5.30	Na_2O	0.37
U_3O_8	0.135	K_2O	0.24

Total REE- 31.11%

Total LREE- 23.08 (La to Eu)

Total HREE – 8.03 (Gd to Lu including Y)

Chemical Analysis of Xenotime & Monazite rich products:

Chemical analysis	XenotimeConc. (9 kg, 7.50 Wt. % of HMC)	Monazite Conc. (14 Kg 39 Wt %of HMC)
Total REO including Y	52.61 - 53.48	53.73 - 54.26
LREE	1.82 - 2.59	47.87 - 49.80
HREE	14.80 - 15.24	2.15 - 2.51
Y_2O_3	35.61 - 36.09	2.31 - 3.35

ThO_2	0.90-0.96	9.36-9.79
U_3O_8	1.05 – 1.10	0.49 – 0.53
P_2O_5	32.20 – 32.54	28.91- 29.88
SiO_2	1.41 – 2.01	1.57- 2.04

Applications of Rare earth Elements:

REE are an interesting group of metals that are strategic materials in the world economy. Global demand is found for rare earth elements due to increased more uses. Rare earth elements (REEs) are key constituents of modern technology and play important roles in various chemical and industrial applications.

Industrial applications of REE:

Electronics: TV Screens, Computers, Cell phones, silicon chips, monitor displays, long life rechargeable batteries, camera lenses, LEDs, compact fluorescent lamps - CFLs, baggage scanners, marine propulsion systems

Manufacturing: High strength magnets, metal alloys, stress gauges, ceramic pigments, colorants in glassware, chemical oxidizing agents polishing powders, automotive catalytic convertors

MedicalScience: Portable X- ray machines, X- ray tubes, magnetic resonance imagery (MRI) contras agents, nuclear medicine imaging, cancer treatment applications, genetic screening tests, medical and dental lasers

Technology: Lasers, optical glass, fiber optics, radar detecting devises, nuclear fuel rods, mercury vapor lamps, highly reflective glass, computer memory, nuclear batteries, high temperature superconductors

Renewable Energy: Hybrid automobiles, wind turbines, bio fuel catalysts rechargeable batteries

Agriculture: Used as fertilizers and feed additives.

Nuclear Energy applications of REE:

Because of high thermal neutron cross section properties certain REE proved to be very useful in nuclear applications

1. Yttrium Hydrides: Use of Hydrides as Hydrogen moderates and Yttrium oxide used as diluents in nuclear fuel.
2. Cerium: Cerium used as burnable fusion in reactor for control rods for stopping reactor in case of accident.

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Bio-sketch of Dr. M G Shinde

Dr. M G Shinde, Superannuated from Atomic Minerals Directorate for Exploration and Research (AMD). He had expertise in XRF technique, besides expertise in Nb-Ta Recovery from mica belts (Bihar), exploration and extraction of monazite, xenotime and rare earths bearing minerals in riverine placers (Siri River areas, Jashpur distt. Chhattisgarh), Heap leaching of uranium recovery (in Kasha Kandi, Shimla distt. And Khiya, Andalada, Hamirpur distt. Himachal Pradesh etc.)

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Sl. No.	Date	Speaker	Topic	Organized by
1.	4 July 2020	Dr. A.P. Jayaraman, Ex. BARC	Bright Sparks of Analytical Chemistry in Space	ISAS HQ/Kerala
2.	11th July 2020	Dr. R.S .Jayasree, SCTIMST	Nano sensors and Analytical Techniques for the detection of COVID-19	ISAS HQ
3.	18th July 2020	Dr. R. Gopalan, ARCI, Chennai	Science & Technology of Key Functional Materials for Sustainable Energy Applications	ISAS HQ
4.	25th July 2020	Dr. V. Balaram, Ex. NGRI	Spectroscopy, Society and Environment	ISAS HQ
5.	1st Aug 2020	Prof. Anilkumar Gopinathan, VIT, Vellore	Biotechnology, a Potential Tool to Optimize Aquaculture	ISAS HQ
6.	8thAug 2020	Dr. R. Ratheesh, Director, CMET, Hyderabad	Sustainable environment friendly E-waste cycling Technology in India: Opportunities and Challenges	ISAS HQ
7.	14th Aug 2020	Dr. K.N.Ninan, Former Deputy Director, VSSC, ISRO	Indian Mars Orbiter Mission: A unique Scientific Achievement	ISAS HQ
8.	22nd Aug 2020	Dr. MRA Pillai, Group Director, Molecular Group of Companies, Kochi	Emerging Trends in the Application of Nuclear Medicine for the Diagnosis and Treatment of Cancer	ISAS HQ
9.	29th Aug 2020	Dr. Avinash V Bharati, RCOEM, Nagpur	Environmental Remediation by Nanomaterials: A Photocatalytic Approach	ISAS HQ
10.	5th Sep2020	Dr. V.P. Venugopalan, Former Director, Bioscience Group, BARC	Nuclear and Biotechnological Applications for Sustainable Agriculture and Food Security	ISAS HQ
11.	12th Sep 2020	Dr. R.B. Grover, HBNI & Member, AEC	Vision of Early leaders for the development of Atomic Energy in India	ISAS HQ
12.	19th Sep 2020	Dr. B. Vijayakumar, ESL, Kudankulam, Tamilnadu	Nuclear Power for Clean, Green and Sustainable Energy Security	ISAS HQ

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13.	26th Sep2020 (Valedictory Meet)	Dr. Dinesh Srivastava, Chief Executive, NFC, Hyderabad	Indian Nuclear Fuel Technology, an Exemplary Success through Self reliance	ISAS HQ
14.	11th October, 2020	Dr. K.L Sebastian, Former Professor & Dean-Research, IIT, Palakkad	Strange & beautiful world of Quantum Mechanics- Part I	ISAS Kerala
15.	12Th October, 2020	Dr. K.L Sebastian, Former Professor & Dean-Research , IIT , Palakkad	Strange & beautiful world of Quantum Mechanics- Part II	ISAS Kerala
16.	17 October 2020	Dr. V. Balaram, Ex. NGRI	Platinum group elements in road dusts, soils and waters of major world cities and their impact on the environment and human health	ISAS HQ ISAS Nagpur ISAS Tamilnadu
17.	17th October 2020	Dr. Mahesh Hariharan, Prof & Dean , IISER, Trivandrum	A glimpse of molecular spectroscopy - Part I	ISAS Kerala
18.	18th October 2020	Dr. Mahesh Hariharan, Prof & Dean , IISER, Trivandrum	A glimpse of molecular spectroscopy – Part II	ISAS Kerala
19.	24th Oct 2020	Dr. Reji Varghese, Professor, IISER , Trivandrum	Applications of spectroscopic techniques in organic chemistry- Part I	ISAS Kerala
20.	3rd Nov2020	Dr. Reji Varghese , Professor, IISER , Trivandrum	Applications of spectroscopic techniques in organic chemistry – Part II	ISAS Kerala
21.	7th Nov 2020	Dr. Vinesh Vijayan, Professor, IISER , Trivandrum	Introduction to statistical thermodynamics –Part I	ISAS Kerala
22.	8th Nov 2020	Dr. Vinesh Vijayan, Professor, IISER , Trivandrum	Introduction to statistical thermodynamics- Part II	ISAS Kerala
23.	9th Nov. 2020	Dr. Subi Jacob George, JNCAR, Bangalore	Towards life like dynamic materials	ISAS Kerala
24.	22nd Nov 2020	Dr. Nand Lal Mishra, BARC	X-ray Absorption Techniques for Material Characterization and Environmental	ISAS Nagpur

			samples	
25.	19th Dec 2020	Dr. Balakrishna Poduval, Ex. HBNI & BARC	Role of Natural Immunity and Vaccine in Management of Contagious Diseases	ISAS Nagpur
26.	15th January 2021	Dr. Dasgupta, BARC	A Journey to Graphene and its Derivatives	ISAS Nagpur
27.	30th Jan 2021	Dr. Joshi A.S. Former Head, Advanced Laser & Optics Division, RRCAT, Indore	Design and Development of High Energy, High Power Nd-Glass lasers	ISAS HQ
28.	13th Feb 2021	Dr. Sahana MB, ARCI, Chennai	Lithium ion Batteries and Beyond for Electric Vehicle Applications	ISAS HQ
29.	27th Feb 2021	Dr. Sinha DK, Director, AMD	Helium Exploration in India	ISAS HQ
30.	6th March 2021	Prof. Manjana J, RCU, Belgavi	Recover of Valuable Metals from Spent Lithium Battery	ISAS HQ
31.	13th March 2021	Dr. John Philip, IGCAR, Kalpakkam	Nanotechnology: Genesis, Growth and Future Prospects	ISAS HQ
32.	20th March 2021	Prof. (Dr) Anantha Raman, CUSAT	The Advent of a new non Vdw Solid in the Realm of Nanotechnology	ISAS Kerala
33.	27th March2021	Dr. Sreeja Lakshmi, IIST, Trivandrum	Space Biology and Bioastronautics: The Emerging Domains of Research in India	ISAS HQ
34.	3rd April 2021	Dr. Thacker NP, NEERI, Nagpur	Management of Unintentionally Produced Persistant Organic Pollutants (UpPOPs) in India	ISAS Nagpur
35.	10th April 2021	Dr. Balaram V, NGRI, Hyderabad	Microwave Plasma Atomic Emission Spectrometry: A New Analytical Tool for Geochemical, Mineral Exploration and Environment	ISAS HQ
36.	17th April 2021	Dr. Anu Gopinath , KUFOS, Kochi	Impacts of Micro and Nano plastics in the Marine Environment	ISAS Kerala
37.	24th April 2021	Dr. Vijayan KK, ICAR, Chennai	Biotechnology as Driver of Aquaculture and Blue Economy	ISAS HQ
38.	1st May 2021	Dr. E.P. Yesodharan, CUSAT	Pollution and COVID 19: Love- Hate Relationship	ISAS Kerala
39.	8th May 2021	Dr. Raghav Saran,	Trace Elements, Significance and	ISAS Nagpur

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		AMD	Appropriate Analytical Techniques	
40.	15th May 2021	Er. Gokul D, SDSC, ISRO	Space Technology Applications- Reaching the unreached	ISAS Chennai
41.	22nd May 2021	Prof.Chandrabhas N, Director, RGCBT, Trivandrum 9448682721	Raman Spectroscopy: From Basics to Applications	ISAS HQ
42.	29th May 2021	Prof (Dr) Nilima Rajurkar, S.P.Pune University, Pune	Radiopharmaceuticals for Diagnosis and Therapy	ISAS Nagpur
43.	5th June 2021	Dr. DK Dubey, Director,DRDE, Gwalior	Analytical Regime of Chemical Weapons Conventions	ISAS HQ
44.	12Th June 2021	Dr. A. Agnihothri, Director, JNARDD, Nagpur	Aluminium the Strategic Metal, Emerging Technologies, and its importance in India	ISAS HQ
45.	19th June 2021	Dr.Pranav Kumar, BARC	Electrospray Ionization Mass Spectrometry: Instrumentation and Applications	ISAS Nagpur
46.	26th June 2021	Dr. Manchanda, Vice President, Indian Nuclear Society	Perspectives on Separation Science and Technology	ISAS HQ
47.	3rd July 2021	Dr. Anil Kakodkar, Former Chairman, AEC	"Science and Technology Approach for Atma Nirbhar Bharat"	ISAS Nagpur
48.	10th July 2021	Dr. Krishna Khairnar, NEERI- CSIR, Nagpur	Saline Gargle RTPCR test for Covid 19 – as developed by NEERI-CSIR	ISAS HQ
49.	17th July 2021	Prof. S.T. Nandibewoor, Karnatak University	Electroanalytical techniques for the determination of Biomolecules	ISAS Belgavi
50.	24th July 2021	Dr. V. Balaram, Ex NGRI, Hyderabd	Climate change and Global warming- What lies ahead?	ISAS Nagpur
51.	31 July 2021	Prof. Dinesh Mohan, JNU, New Delhi	Sustainable biocharr- A smart solution to Biomass burning, Soil management, Water purification and Carbon sequestration	ISAS Baroda
52.	7th August 2021	Dr.M. Shaneeth, Head, Fuel Cell Division, VSSC	Fuel Cell Green Hydrogen Economy	ISAS HQ

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53.	14th August 2021	Prof. Dinesh Rangappa, VTU, Belgavi	Nanomaterials for energy storage / device materials: Synthesis, processing and challenges	ISAS Belgavi
54.	21August 2021	Mr. Agam Khare, CEO, Absolute Food	Future of Food- Feeding 10 billion people by 2050	ISAS Nagpur
55.	28August 2021	Dr. GS Kapur, Director (R&D) IOCL, Delhi	Crafting a sustainable future for plastics through circular economy	ISAS HQ
56.	4th Sept 2021	Dr. Virendra Kumar, BARC	Radiation Technology- a versatile tool with multifaceted applications	ISAS Nagpur
57.	11th Sept 2021	Dr. Yamuna Singh, AMD	Rare earth exploration in India	ISAS HQ
58.	18th Sept 2021	Prof.S.K. Patil, Vice Chancellor, IGKV University, Raipur	Peaceful applications of Radiation Techniques in Crop Improvement and Food Technology	ISAS Baroda
59.	25th Sept 2021	Prof (Dr) Alok Srivastava, Punjab University	Research at trace and ultra trace level using conventional and nuclear analytical techniques: an Overview	ISAS Nagpur
60.	2nd Oct 2021	Dr. Dinesh Amalnerkar, Ex. Director, CMET, Pune	Pune Chapter inauguration and Bridging the gap between vedic and modern sciences: Nanocentric Characterisation of typical ayurveda bhasmas by ultra modern analytical techniques	ISAS HQ, ISAS, Nagpur ISAS, Pune
61.	9th Oct 2021	Dr. Jayaprakash, Principal Scientist, CTCRI - ICAR, Thiruvananthapuram	Challenges and solutions in Pest management strategies in Agriculture	ISAS HQ
62.	16th Oct 2021	Dr. Sesha Rao, Former Scientist, AMDRE	Exploration for Atomic Minerals and Applications in Nuclear Energy	ISAS Nagpur
63.	23rd Oct 2021	Prof. Chitharanjan Hegde, NIT, Suratkal	Electroplating: A facile route for Material synthesis	ISAS Belgavi
64.	30th Oct 2021	Dr. B. Venkataraman, Director, IGCAR, Kalpakkam, Chennai	Discovery of Radioactivity and the high impact of Radioisotopes and Radiation techniques on Modern development	ISAS Pune
65.	6th Nov 2021	Dr. K.N. Ninan, Former Deputy	An overview of Global warming and strategies for its mitigation	ISAS Kerala

		Director, VSSC		
66.	13th Nov 2021	Dr. Swati Joshi, NCL, Pune	Biostimulants in Agriculture	Isas Nagpur
67.	20th Nov 2021	Dr. Boli Therattil, HOD, Chemistry, St. Aloysius college, Trichur, Kerala	The Art of Gem Identification	Isas Kerala
68.	27th Nov 2021	Prof (Dr) C.K. Jayasankar, Former Pro-Vice Chancellor, Sri Venkateswara University, Tirupati	Optical Optimisation of Rare earth doped glasses for laser and fiber applications	ISAS Nagpur
69.	4th Dec 2021	Dr. MLP Reddy, NIIST, Tvm	Lanthanide Molecular materials as probes for bioimaging applications	ISAS HQ
70.	11th Dec 2021	Dr. Harish Barshila, NAL	Characterisation of thin and ultrathin coatings	ISAS, Belgavi
71.	18th dec2021	Dr. Sheila Srivattava, Feroz Gandhi College, Raiberalli	Challenges in Fluoresis	ISAS,Nagpur
72.	25th Dec 2021	Dr. D. Navaneetham, Founder & Director Foundation For Research On Rare Diseases and Disorders	Virus, Immunity and Omicron	ISAS Tamilnadu
73.	6th Jan 2022	Dr. P.K. Mohapatra, Radiochemistry Division, BARC	Actinide extraction in to room temperature Ionic Liquids	ISAS Nagpur
74.	8th Jan 2022	Dr. Vinay M. Bhandari, NCL-CSIR	SWASTIIK – Safe Water & Sustainable Technology Initiative from Indian Knowledge Base	Pune
75.	15th Jan 2022	Dr. S. Ganesh, Chairman, Dept of Physics, Mangalore University	Microtron and its Applications	Belgavi
76.	22nd Jan 2022	Sri S.K. Malhothra, Former Head, Public Awareness Division, DAE	Contributions of DAE in the development of post independent India	ISAS HQ
77.	29th Jan	Dr. R.K. Bhandari, Former Director,	Particle accelerators for Basic research	ISAS HQ

	2022	VECC, DAE	and Societal applications	
78.	5th Feb 2022	Dr. Rajkumar Malayandi, Abbot Pharama	Reverse Engineering in Pharmaceuticals product development: Analytical perspective	ISAS, Baroda
79.	12th Feb 2022	Dr. N.G. Shinde, Former Scientist, AMD, DAE	Installation & Recovery of Monazite , Xenotime & Rare earth bearing Minerals in riverine places of Siri River Areas, Jashpur District, Chhattisgarh	ISAS, Nagpur

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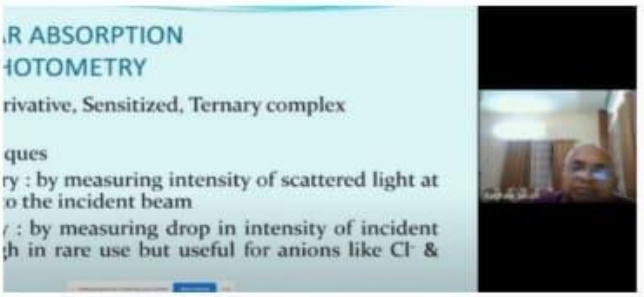

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