NATIONAL SOLID WASTE ASSOCIATION OF INDIA

Waste MONITOR

Volume 4 Issue 1 Dec. 2021

WORLD SPEAKS ABOUT NSWAI

ESTD. 1996

Padma Shri Hema Malini
(Brand Ambassador)

Dr. Amiya K Sahu
(Founder)

Dr. John Skinner
(U.S.A)

Prof. David Wilson
(UK)

Dr. David Newman
(UK)

Dr. Luis Dias
(Hawaii)

Ms. Melissa
(Singapore)

Prof. Agamuthu
(Malaysia)

NEPRA

India's Leading Waste Management Company

- Environmental Advisory and Consultancy
- EPR Execution
- Material Recovery Facility (MRF)
- Alternative Fuel and Raw Material (AFR)
- PCR Granules
- Controlled Facility Management (CFM)
- Circular Economy Projects
- Zero Waste to Landfill Events
- ESG Consultancy

Paving the way for Sustainable Future

NEPRA Resource Management Pvt. Ltd.

708-714, Nobles Trade Center, Nr. Bhuyangdev, Cross Road, Ahmedabad-52, Gujarat, India.
www.letsrecycle.in | info@nepra.co.in | www.eprconnect.in | info@eprconnect.in

CONTENT

Editorial Board

Published by: National Solid Waste Association India

Dr. Amiya Kumar Sahu
President, NSWAI

President's Note

I take immense pride in being the founder of a first of its kind professional NGO, the National Solid Waste Association of India (NSWAI). NSWAI was established in 1996, with a core specialty in providing consultation on waste management to organizations, and individuals. I take this opportunity to briefly narrate its history and my own journey while being at the helm of this organization, watching it grow in the last 25 years.

Until 1996, I was deeply involved in my own professional enterprise on air pollution, rendering services to both private and public sectors in India. However, the motivation to begin NSWAI came about after my continued observations about waste in India and in other countries. As part of my continued education, I attended several international conferences organized by various professionals in developed countries on environment-based subjects, which also included solid waste management.

One particular conference attendance changed the course of my career and got the ball rolling for the creation of NSWAI. The International Solid Waste Association (ISWA) had organized the ELMIA conference in Sweden in 1995, where I had the privilege to closely interact with the then ISWA President and the director of United Nations' Environment Program (UNEP) – Dr. John Skinner. His encouragement to start a national body on solid waste in India was the beginning of a new phase not just for me, but also for India. After several discussions, it was at this conference that I declared to establish NSWAI and represent developing countries.

The year of 1995, was indeed a significant one in terms of a stronger calling to create NSWAI. I received an invitation from a high-level consortium of highly qualified academicians from Universities of Harvard, Barclay California, Singapore, South Korea, and Kyoto to chair the session in Taipei, Taiwan. I was also invited by the World Bank headquarters to be a team leader for solid waste sectoral analysis for Bangladesh. The amount of unprocessed municipal waste spread over huge dump yards there brought to the forefront, the pervasive deep-rooted problems of solid waste and its management. In retrospect, I do think that the awareness about this problem in the developing countries was growing. I say this because, after returning to India, the Chairman of Central Pollution Control Board (CPCB), New Delhi, Padma Shree Dr. Dilip Biswas, invited me to draft guidelines and formulate rules on solid waste for India which was to be tabled in the Indian parliament.

I must admit, in those times, municipal solid waste was considered depreciatory, and hence largely ignored by Indian citizens. To that effect, when it was time to officially register NSWAI, we were seven individuals who came forward for the initiative, however we fell short on the required number of members. Fortunately, while working on a World Bank funded project on a Common Treatment and Disposal Facility (CTDF) for chemical industries near Mumbai, professionals in this field validated the need for this endeavour and extended their support in creating the organization.

NSWAI was formed in September 1996 in Mumbai. The organization's vision was to impart education and create awareness by organising workshops, conferences, seminars and holding regular meetings with Municipal, State Pollution Control Boards, academics, students, NGOs and citizens at large. The very first meeting was organized in Mumbai in October 1996 and the then ISWA Managing Committee member Dr Luis Dias was invited as the chief guest. This meeting was attended by the Municipal Commissioner, Secretary- Environment President Industries Association, scientists, engineers, students, professors, and many others from Mumbai.

NSWAI's achievements are many, however I wish to enumerate some significant milestones for the organization since its inception. In 1998, ISWA formed a working group for developing countries with Dr. David Wilson- ISWA chairman, Dr. Luis Diaz - Cal Recovery USA, Dr. Michel Yedugo – DANIDA, Denmark, and myself representing NSWAI, thus facilitating NSWAI's presence internationally. In 2002, NSWAI announced Clean India mission by disseminating information on waste, and its management to stakeholders. Furthermore, it organized conferences every year in different parts of India through CII, academic universities, industry-based associations, local self-governing institutions and also released newsletters at its annual general body meeting. NSWAI represented India in UNCRD in Zero waste management in Tokyo and South Korea in 2007 and 2009, respectively. NSWAI became a National member of ISWA in 2013, and subsequently I was inducted as Board Member for Asia Pacific Regional development. In 2019, NSWAI was the first body to submit guidelines for EPR (extended producers responsibility) to CPCB and Ministry of Environment and Forest, Government of India (GOI).

NSWAI was nominated as one of the Environment Information System (ENVIS) centres under the Ministry of Environment, GOI, in Municipal Waste sector for India. NSWAI in collaboration with ENVIS published newsletters that covered various themes of Solid waste for Awareness and Education from 2002 till 2016. However, from 2017, NSWAI produced its own magazine, Waste Monitor, which continues to incorporate articles with latest research and understanding of waste management from professionals and colleagues. This magazine is released annually and is distributed to its members and stakeholders.

NSWAI's contributions were recognized across international institutions such as UNEP, United Nations Development Program, and national systems such as Bureau of Indian Standard, Planning Commission of India (now known as Niti Aayog), to name a few. The range of topics rly in the areas of health, environment, and safety. Lastly, NSWAI intends to work in the areas of EPR, capacity building in waste management, and educational services to produce more professionals in waste management in India.

Although NSWAI began with the cause for dealing with Industrial hazardous waste and municipal solid waste, it expanded its reach into the various sub-categories of waste such as plastic waste, bio-medical waste, E-waste, and more recently, automobile waste. In terms of knowledge sharing, NSWAI has supported research and entrepreneurship in the waste sector. Indeed, UNEP has recognized NSWAI as a knowledge hub.

In the last two years however, we were unable to organise a conference due to the pandemic however, we took to the virtual platform. This year also, due to pandemic precautions, we intend to make our presence felt virtually. We are very excited to release the Silver Jubilee issue of Waste Monitor.

NSWAI is extremely proud of its achievements in these past 25 years. I am grateful to all the NSWAI members, past and present, and ISWA colleagues for their continued support. Yes, we took a road less travelled, we endured the hurdles, but we emerged victorious and we intend to continue the work for the benefit of society at large.

Dr Amiya Kumar Sahu
President, NSWAI

Dr. Harshvardhan Modak
Editor, NSWAI

Editorial

On behalf of National Solid Waste Association of India (NSWAI), I, as the Editor in Chief of the Editorial Board, am proud to present to you a special issue of our flagship periodical publication Waste Monitor to mark the completion of 25 years by this august body. Through this magazine, we always attempt to showcase thoughts or experiences of experts in the field of management of various types of wastes. While doing the same, we emphasize creation of a value addition, while doing disposal of the waste.

This issue of Waste Monitor is blessed with messages from Padma Shree Hema Malini – Member of Parliament, Dr. John Skinner – Former President of International Solid Waste Association (ISWA), Dr. David Wilson – Independent Resource and Waste Management Consultant, Dr. David Newman – Former President of International Solid Waste Association (ISWA) and Former President of International Biogas Association about Status of Waste Management in India and Ms. Melissa Tan – Chairman of Waste Management and Recycling Association.

Dr. Luis Dias, former board member of ISWA elaborates on the challenges in the management of municipal solid waste and also points out possible solutions in successfully handling municipal solid waste.

Former President of ISWA, Mr. David Newman touches upon the urgency of addressing the issues of waste by pointing out the changing climate and talks about the status of Waste management in India and its overall impact to the world.

The Waste Management in reference to Landfill sites is highlighted by Dr. Ajay Pradhan and Dr. Vivek Kumar Singh, which also indicates way forward for legacy waste in landfills in India.

Former Director of NEERI, Dr. Rakesh Kumar has thrown light on technical, social and financial constraints in Solid Waste management keeping in mind the SDGs and how can a proper integrated waste management system be put in place in both developed and developing countries to mitigate the problem of waste.

Dr. Aparna Sahu has revived an old concept of composting toilets and their various aspects, especially for use in communities world-over, where open defecation is still practiced. Wherever the modern amenities like proper water supply and sewage collection and disposal is not available, this type of toilet will still be useful to avoid adverse effects of open defecation.

Mr. Nitin Deshpande conducted a workshop on waste to wealth and has shared his presentation in the same. He is already practicing the same on commercial scale at a few sites in Maharashtra and Goa. Thus, it will be worthwhile to know about his practical experience.

COVID waste gave rise to another thought on plastic waste management. Prof. Agamuthu has examined resource circulation system with respect to its role in plastic waste management.

Mr. T. K. Bandopadhyay, an expert in use of plastics in environment, has highlighted the very need of recycle and reuse of plastics products. In absence of a proper all-encompassing system to collect, reuse/recycle plastic products, plastic waste is seen strewn around on planet and even under the sea. Hence it is seen as an environmental hazard, which actually it is not. When such system takes over, discarded plastic products in fact can help reduce environmental hazards in terms of reducing use of coal/oil etc. not only in generation of energy, but use of the same in many manufacturing processes like cement and steel manufacture. These benefits underscore the very need of proper implementation of plastic waste collection and gainful disposal or reuse.

Keeping in mind the current COVID pandemic situation world over, two articles from Dr. Sanjay Joshi and Dr. Bhalchaandra Kurup have highlighted the problems in biomedical waste sector during these trying times and explained the various measures taken to control the same.

Dr. Lakshmi Raghupati, former Director, MoEFCC, Govt of India and visiting faculty, TERI School of Advanced Studies, New Delhi; has showcased an excellent review of Waste to Energy in all its aspects, which will surely benefit the planners and project proponents of such projects.

Mr. Sampath, an accomplished entrepreneur in waste management, has put forward a concept of producing Hydrogen from wastes. Hydrogen being the future promising fuel for the world, especially to make the operations carbon neutral, its production is very important.

Hydrothermal Carbonization (HTC) is highlighted by Dr. Harshvardhan Modak, which is holding a great promise in quickly converting biodegradable waste and digestate after biogas, into a value-added product. Since this takes place very quickly at moderate reaction conditions, world-over scientists are busy in commercializing the same.

NEPRA's contribution towards practical SWM on commercial scale is exemplary. NEPRA's Material

Recovery Facility (MRF) at Indore, MP, India, has won accolades to Indore city as the cleanest city in India. The working of this MRF unit is described with respect to Sustainable Development Goals in their article.

WeStart Communications has been contributing in handling C & D waste by setting up two plants in the state of Tamil Nadu. Mr. Sundar K. talks about the need of the hour to manage C & D waste, its challenges and the way forward to managing C & D waste.

Dr. Indrani Chandrashekhar, former Advisor, Planning Commission, Govt of India; has tried to introduce the readers to the concept of Environmental Performance Index (EPI), which is used for ranking various countries in the world or even the states in a country, in terms of environmental performance. While writing about the same, she has also shown the evolution of EPI into various formats, e.g. Yale EPI etc. She has shown how they are used to rank the countries and states of India. I am sure this measure of environmental performance will interest the readers.

Mr. Devansh Shah, has rightfully brought out issues of recycle and reuse of Lithium batteries in Electric Vehicles (EV) sector. A system for the extraction of Lithium from the same has to be made ready before boom in EV catches on to avoid dumping of used Lithium based batteries. Lithium being hazardous, avoidance of dumping is of particular importance.

Dr. Ramdas Bhattacharya points out the necessity to address the issue of the management of radioactive waste with its types and to identify and dispose different types of radioactive waste.

Mr. Ishan Vyas has thrown light on sustainable entrepreneurship in renewable energy with reference to India and Gujarat and has identified challenges in the same, while suggesting the way forward.

Over all the articles in this issue of Waste Monitor again address variety of environmental issues, related to various types of wastes and their disposal. I am sure, while it will make an interesting read for the experts, policy makers and administrators in this field, it will also be providing gainful knowledge to the students in this sector.

Note: The interested readers are requested to contact the authors of the respective articles for further details

WORLD SPEAKS ABOUT NSWAI

Padma Shri Hema Malini
Member Of Parliament
Brand Ambassador, NSWAI

Hema Malini

30.06.2021.

I would like to congratulate Dr. Amiya Sahu and the NATIONAL SOLID WASTE ASSOCIATION OF INDIA (NSWAI) on the occasion of its Silver Jubilee Celebration.

25 years of helping maintain public health and hygiene and keeping the surrounding clean is a formidable task. This complex task of saving limited natural resources, preventing greenhouse gas emissions and water pollutants, saving energy and landfill space and providing raw materials for industry is performed diligently by your team. This has greatly resulted in protecting the environment and humanity and is helping the planet, especially India become a safe haven for people to live in good conditions.

Once again congratulations from me and may you, Dr. Sahu, and your wonderful team continue the noble work of protecting humankind and our planet.

Love & Blessings,

Hema Malini.

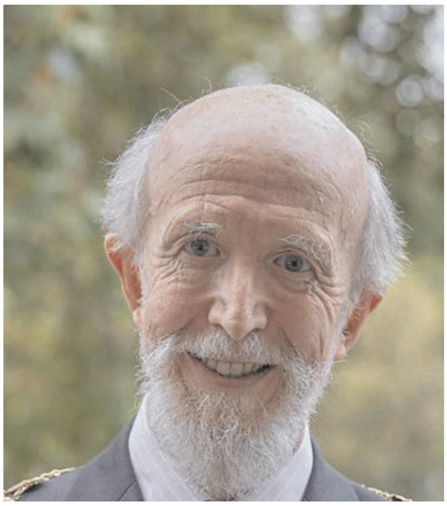
Dr. John Skinner
Honorary Member and
Past President of ISWA

" It is a great pleasure to congratulate you and the members of NSWAI on the occasion of the organization's Silver Jubilee. I do remember the first time we met in the Elmia Conference Center in Jönköping, Sweden in 1995 at the International Solid Waste Association (ISWA) Conference. I was the International President of ISWA at a that time and you consulted with me on your plans to establish a national body on solid waste management in India. I remember thinking that was a wonderful idea because there was so much opportunity for a national organization.

I was so pleased to see that you moved ahead and formed NSWAI in 1996 and you should be very proud of what you have accomplished over the last 25 years. Today NSWAI is the only leading professional non-profit organization in the field of solid waste management in India. NSWAI has grown to over 1500 members world-wide. NSWAI carries out excellent programs in training education and research, and produces first rate conferences and publications. And you Dr. Sahu are recognized as a world-wide leader in the field, and have done so much to bring international perspectives to help upgrade solid waste practices in India. You truly understand how improved waste management practices can make an important contribution to major global issues such as climate change, renewable energy and the circular economy.

I am pleased to recognize NSWAI's accomplishments under your leadership, and I am pleased to convey to NSWAI's members my best wishes and blessings for a successful Silver Jubilee."

Dr. John Skinner



Dr. David Wilson
Independent Resource And
Waste Management Consultant
Visiting Professor In Resource And
Waste Management
At Imperial College London

My Heartfelt Congratulations and blessings on this important anniversary, and I wish all the best for your future.

Dr. David Wilson

Dr. David Newman
Former President, ISWA
newman@iswa.org

I know Dr Sahu and his colleagues are pushing these messages to the Indian Government regularly and my wish is that he continues to do so, and that the NSWAI is recognised for its role in promoting a sustainable future for India.

Best wishes for the next 25 years!

Dr. David Newman

Ms. Melissa Tan

Chairman,
Waste Management And
Recycling Association
Of Singapore

On behalf of the Waste Management and Recycling Association of Singapore (WMRAS) and the Asia Pacific Waste and Environment Alliance (APWEA), it is my pleasure to extend our warmest congratulations to NSWAI on reaching its silver jubilee milestone.

We would like to wish NSWAI all the best to its future endeavour, continue keeping up the good work of advocating environmental habits, and continue extending your reach to enhance waste management by joining hands with individuals and organisations in the industry locally or international.

Once again, congratulations on 25 wonderful years and best wishes for continued success!

With Best Regards,

Ms Melissa Tan

Chairman, Waste Management and Recycling Association of Singapore

GENERAL MUNICIPAL WASTE

Waste MONITOR
Volume 4 Issue 1 Dec. 2021

Management Of Municipal Solid Waste In Economically Developing Countries

Dr. Luis F Diaz
Consultant, Cal Recovery Inc
Former Board Member, ISWA
ludiaz@aol.com

Major Issues Associated with Solid Waste

There are several issues associated with solid waste in economically developing countries; however, the most critical ones include: a substantial population growth in urban centers, a lack of realistic long-term planning, limited collection service areas, a lack of proper disposal sites, use of inappropriate technology, inappropriate methods of finance and, finally a substantial dearth of professionals formally prepared to work on waste management.

Population Trends

The world is facing a substantial population increase coupled with migration from rural areas to urban centres. The populations of the largest metropolitan areas in the world are presented in Table 1. As shown in the table, 8 of the largest 10 metropolitan areas are in economically developing countries. Many of these areas lack the infrastructure to provide basic services to migrants.

Table 1 – Population of the Largest Metropolitan Areas in the World (in millions) (2021)

Tokyo, Japan	**37.3**
Delhi, India	**29.4**
Shanghai, PRC	**26.3**
Sao Paulo, Brazil	**21.8**
Mexico City, Mexico	**21.6**
Cairo, Egypt	**20.4**
Dhaka, Bangladesh	**20.2**
Mumbai, India	**20.2**
Beijing, PRC	**20.0**
Osaka, Japan	**19.2**

Lack of Realistic Long-Term Planning

Unfortunately, plans for the management of solid wastes either are not existent, not updated or have been written by people unfamiliar with the area. In general, these plans are unrealistic in terms of infrastructure, equipment as well as in human and financial resources.

In many municipalities, there is a tendency toward "crisis" management waiting until few options are available. Furthermore, decisions are made in response to solicitations by vendors and there is a lack of training and availability of reliable data.

Limited Collection Service Area

In most urban areas, the economically poor receive minimal, if any, waste collection service while those people living in high-income areas receive between 60% and 80% coverage.

"Marginal areas" simply evolve without any planning and generally do not pay any taxes.

Lack of Proper Disposal

Most communities in developing countries use "dumpsites" where uncontrolled disposal and scavenging take place and have limited access to sanitary landfills. This is mostly due to: difficulties in siting, high capital and operating costs, and low or non-existent tipping fees at the disposal sites.

Use of Inappropriate Technology

This is a typical and common problem in economically developing countries. This is very evident in collection and processing equipment. Furthermore, there is an incorrect balance between labor and equipment.

Usually, equipment is operated beyond economic lifespan (i.e., collection vehicles operated for much longer than 5 to 8 years. Additionally, cannot be properly maintained and replacement parts are not readily available. Equipment used in waste management generally has a short lifespan, nevertheless, the equipment is financed on long-term loans (i.e., 20 to 30 years) and municipalities do not have the resources to service the loan.

Important Considerations in Defining Technical Solutions

There are several issues that must be considered for identifying and implementing appropriate technological solutions in developing countries; however, one critical consideration deals with a thorough understanding of the types, quantities, and characteristics of the waste to be managed. In this rather brief discussion and to reduce the complexities, I concentrate on municipal solid waste.

Role of Waste Characterization

The need for data is extremely important in the development and implementation of a reliable process as such, the data must be site-specific and reliable. As such, the information must be collected following a prescribed methodology and using statistics for sample collection and analyses. International agencies and associations such as the ASTM in the USA have set forth detailed procedures.

The data can then be used in several key activities such as in planning, design of installations and selection of equipment, achieve national goals, and develop markets or uses for the materials that may be recovered.

Waste characterization is, therefore, a critical step in adequate management of solid wastes. The composition of the wastes not only varies from location to location but also as a function of income level as is shown in Tables 2 and 3.

The data in Table 2 show the relatively high concentration of "organic matter" and the amount of plastic in the waste as a function of income.

The information presented in Table 3, shows the variability of the concentration of organic waste generated by different sources.

Table 2 –
Average Composition of Disposed MSW in a Municipality in SE Asia

Material	Low Income	Middle Income	High Income	Industrial	Market	Malls	Offices
Paper	10.99	8.51	13.50	17.91	3.81	15.12	16.66
Glass	3.57	3.57	5.14	1.84	0.20	1.35	1.05
Metals	4.19	5.32	3.91	7.42	0.62	2.03	2.66
Plastic	31.42	32.35	25.71	27.64	9.02	28.09	29.19
Other organic	44.82	41.95	49.26	39.23	86.21	48.60	41.57
Other inorganic	4.95	8.41	2.47	5.26	0.11	4.75	8.06
Hazardous/Special	0.06	0.39	0.01	0.70	0.03	0.06	0.81
Totals	**100.00**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 3
Composition of Disposed Organic Waste in a Municipality in SE Asia

Source of Waste	Kitchen/ Food waste	Yard Waste	Other Organic Waste	Totals
Low-income areas	24.4%	10.8%	9.6%	44.8%
Middle-income areas	17.2%	5.7%	18.6%	41.5%
High-income areas	13.3%	30.9%	5.1%	49.3%
Offices	21.0%	15.9%	4.7%	41.6
Industrial	15.9%	4.4%	18.9%	39.2
Institutional	9.8%	8.8%	10.0%	28.6
Markets	68.6%	7.6%	10.0%	86.2

The results of waste characterization analyses of municipal solid waste conducted by the author in several municipalities in developing countries in different continents have shown that the quantities of municipal solid waste ranges from 0.25 to 1.5 kg/capita/day; and that the per capita waste generation is 2 to 3 times lower than in industrialized countries.

Bulk densities of residential waste fluctuate from about 180 to 500 kg/m3 and the moisture contents of the waste are high (usually 60% or higher) partly due to the amount of food waste (either pre- or post-consumption) in the waste and also due to improper storage of the waste which would become exposed to rain fall.

One of the reasons for concentrating on the organic fraction is the fact that, if properly managed, the organic fraction can make a positive contribution reaching waste diversion goals by using relatively simple procedures.

Additionally, proper management of these waste would reduce the "offensive" nature of municipal waste and would define the size and number of processing facilities.
One technology that be used to manage the wastes is composting. The process can be applied at different scales and using relatively simple procedures. Furthermore, if the process is properly carried out, the output (the compost) could be used locally either at the household level or in farming activities.

However, all the options available for the management of organic residues have some risks associated with them. These include technological, financial, marketing, environmental and public health.

Possible Solutions

As previously indicated, there are several reasons for concentrating on the management of the of the MSW in economically developing countries. However, these solutions have to be put into practice in conjunction with social sustainability which includes public education, establishment of demonstration programs, capacity building (basic training to carried out by knowledgeable professionals), determine affordability, improve existing overall program (storage, collection, etc.), and develop a reliable and well-managed final disposal site.

Keys to success

Based on my experience, the keys to solve the problem of waste management in economically developing countries include:

- Political will to solve the problem of waste management
- Development of realistic plans, and
- Establishment of reliable and well-managed final disposal sites
- On-going monitoring of operations
- Establishment of modern regulatory framework with strict enforcement
- Public education and perhaps a very critical component: Development of programs for the formal education of professionals well-versed on solid waste management.

References:

Diaz, L.F., W. Bidlingmaier, C. Springer and G. Savage, Solid Waste Management in Economically Developing Countries, 2021.

***

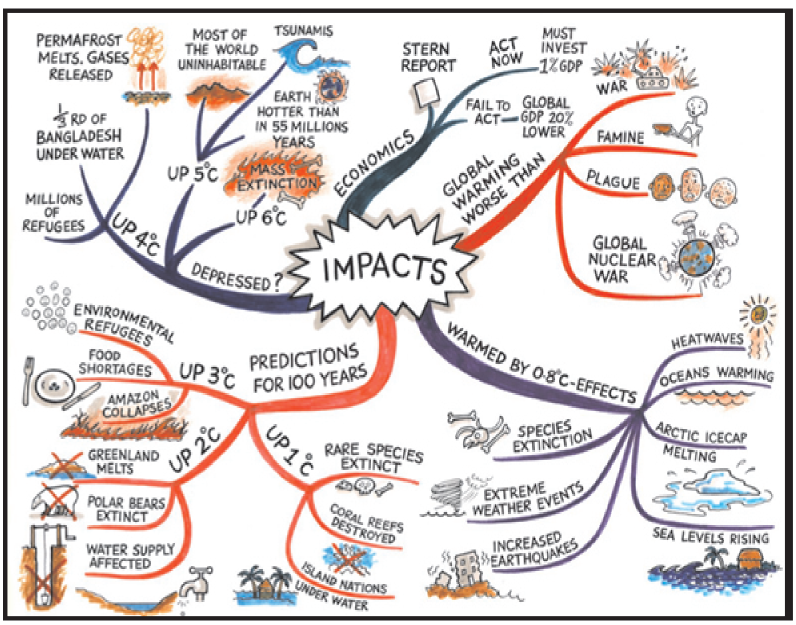
Status Of
Waste Management In India

Dr. David Newman
Former President, ISWA
newman@iswa.org

The world is living through what we all hoped would not happen- the ecological breakdown. In my book I explain how this happened, what we are facing and the solutions we need urgently to implement.

The time for discussion to maintain a liveable planet finished years ago but still we persist in endless debates about how to face the future- the future is already with us and the debates have to stop. We have to apply measures now, even though they will be unpopular in many places around the world, to ensure the survival of the human race into the next century. It is as simple as that.

Burning forests, flooding, record temperatures, desertification, migration, intense storm systems, are all signals that were predicted as long ago as the Stern Report in 2006, commissioned by the UK Government, into the impacts, costs and mitigation of climate change.



This handy little graphic gives us a clear view of where we are and what we are facing.

The graphic is meant to be provocative and it is. We have now reached the bottom of the drawing, with global average temperatures of around 1c higher than pre industrial times and we are rapidly heading towards +2c. As I said, the time for talk finished years ago. We have to act.

In this picture India has historically had little influence on the outcomes of the global ecological collapse. A largely rural society has produced very low GHG emissions per capita, and still does. Compared to a world average in 2018 of 4.6 metric tonnes per capita, India produced 1.8. But that figure is growing fast as India urbanises and industrialises, whilst population growth will continue to drive higher resource consumption for decades to come. As many high emitting nations commit to tough zero emissions goals in the next 30 years, India will continue to increase its contribution to global warming. We will revert to this issue later.

As consumption of consumer products grows so does the issue of waste management- what to do with products and the packaging, once they are discarded?

Managed waste systems in India are still sadly lacking in many parts of the country. Very little waste is recycled and much is not even collected, being discarded into the natural environment. Pictures of the beautiful rivers and coasts of India full of sewage, industrial wastes and plastics are commonly shown as examples of how not to manage waste. The growing volumes of biowaste (food, sewage, agricultural, garden etc) are not just a pollution issue- they release methane when they ferment once dumped and contribute to India's growing GHG emissions. Burning of landfills and dumps is a localised health issue impacting millions whilst the black soot/carbon from these also impacts the climate.

Altogether in India we are in the middle of a major waste crisis.

Both the issue of waste and climate are connected and the implementation of policies which solve one, will automatically help solve the other. Badly managed waste can contribute as much as 7-10% to overall GHG emissions but the correct management of these waste can contribute as much as twice that to reducing emissions- through more recycling, through composting and biogas production from biowastes, from prevented burning and methane emissions.

India has policies which are beginning to address these issues -there are Solid Waste Management Rules in place and there is an association representing the waste industry in India, the National Solid Waste Association of India, led by my old friend Dr. Amiya Kumar Sahu (https://www.nswai.org/). The NSWAI this year celebrates its 25th anniversary and Dr Sahu has consistently voiced his views and lent his experience to help the Government take control of waste management. So far, the Government has not acted fast enough upon these proposals, but he and his colleagues should persist.

Climate change abatement through correct management of wastes is a win-win situation for India-

1. rapid reductions in GHG emissions from uncontrolled burning and dumping of wastes

2. production of raw materials from waste, including badly needed compost to return to soil especially in more arid regions

3. employment and investment- managing waste needs people and equipment

4. cleaner cities and rural areas, and cleaner air and water. The terrible images of New Delhi suffocating from the burning of field crop stubble are seen throughout the world. This is not a good image for India.

5. healthier populations. The health service costs of poor air and water are enormous, especially in a population with so many young people.

6. meeting the international climate obligations of the Paris Treaty.

7. reducing the need to build polluting coal fired power stations and import that coal – a massive saving for the economy and for the climate.

Waste management is the low hanging fruit of climate abatement policies, one that requires technologically modest infrastructure which India can build itself, and one which can be implemented rapidly. With Indian multinational corporations active around the world in activities from the production of steel to automobiles and high-quality technology services, I cannot believe that the industrial capacity of India to handle its wastes is any less than any other country.

What lacks is the sense of urgency and the understanding that waste management can help achieve so many different goals in a short period of time. This requires investment, policies, enforcement, some of which will be unpopular especially to polluting industries. But our health as human beings is more important than the profits of shareholders and Governments, including India, must prioritise our health if they are to serve us well.

The information presented in Table 3, shows the variability of the concentration of organic waste generated by different sources.

***

Municipal Solid Waste Management With Reference To Landfill Site Management In India

Dr. Ajay Pradhan
President And CEO,
C2S2 Pvt. Ltd.
ajay.pradhan@c2s2.in

Dr. Vivek Kumar Singh
Environment
Management Consultant
Chairman, NSWAI

Municipal Solid Waste (MSW) management is one of the most neglected areas of urban development in India. Magnitude and density of urban population in India is increasing rapidly and consequently the civic bodies are facing considerable challenges to provide the basic amenities of supply of water, electricity, roads, education and public sanitation, including Municipal Solid Waste Management (MSWM). With rapid urbanisation, the country is facing massive waste management challenge. Over 377 million urban people live in 7,935 towns and cities and total MSW generation could be as much as 188,500 TPD or 68.8 million TPY (Parvathamma, G.I 2014). Approx. 70% of waste is collected and 30% out of collected waste is treated/processed and remaining 70% waste is dumped in landfill. Today's existing landfills are major challenges for cities where million tonnes legacy waste threat to environment with continuous emission of Green House Gases and contamination of surface and ground water through leachate. Solid Waste Management (SWM) is one among the basic essential services provided by municipal authorities in the country to keep urban centres clean. The present study reveals the current issues and challenges in Solid Waste Management and impact on environmental sustainability

Keywords

Municipal solid waste management, Dump yard Industrialization, Urbanization, Environment, Sustainability.

Introduction

Consistent increase in urban population and Industrialization lead to waste generation and country is facing massive waste management challenges. Solid Waste Management (SWM) is one among the basic essential services provided by municipal authorities in the country to keep urban areas clean. Most of the bigger populated cities have deposited solid waste at a dump yard within or outside the city haphazardly. Waste management rules in India are based on the principles of "sustainable development". With 1.3 billion population of India, accounting for nearly 18% of world's human population. The urban population increased from 286million to 377 million, accounted as 31 percent of total population. It is assumed that the urban population will increase to 600 million and account as 40 percent of total population by 2031 (Panwar et al 2017).

Municipal Solid Waste generated in Municipal Solid Waste generated in India (million tons) top 59 Indian cities (Tons per day)

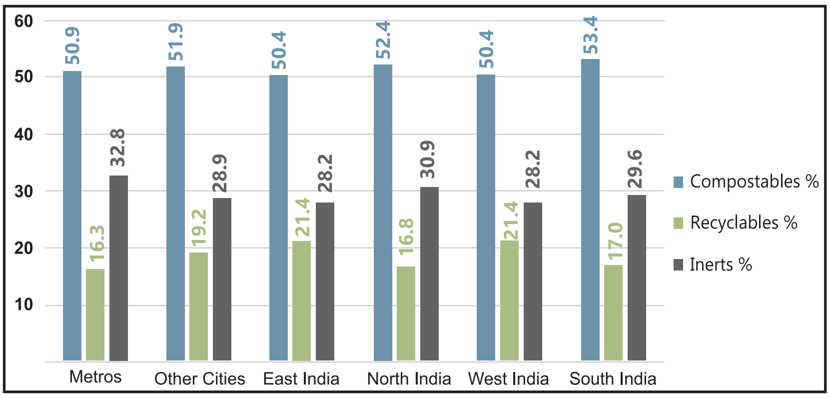
Source: Planning Commission Report, 2014
Source: Central Pollution Control Board (CPCB) Report, 2013

It is estimated that solid waste generated in small, medium and large cities and towns in India is about 0,1 kg, 0,3 – 0,4 kg and 0,5 kg per capita per day respectively. Studies carried out by National Environmental Engineering Research Institute (NEERI) indicated that the per capita generation rate increases with the size of the city and varies between 0,3 to 0,6 kg/day in the metropolitan areas, values up to 0,5 kg / capita / day have been recorded.

Municipal agencies spend on MSWM ranges from about 5% to 25% of their budgets. In spite of sizeable allocation, the present level of service in many urban areas is so low that there is a threat to public health in particular and to environmental quality in general.
As per estimates, 115.000 tons of solid waste are generated per day in the country. Yearly increase is about 5% annually. Urban Local Bodies (ULBs) spend about INR 500 (to INR 1500 per ton on solid waste collection and transportation. For treatment and disposal, the Central Government, under its various schemes provides financial assistance.

Composition of Municipal Solid Waste

As we know that the composition of solid waste depends on a wide range of factors such as food habits, cultural traditions, climate and income. Study reveals that the foremost portion of municipal solid waste is compostable materials (40%-60%) and inert (30%-50%) in Indian cities.

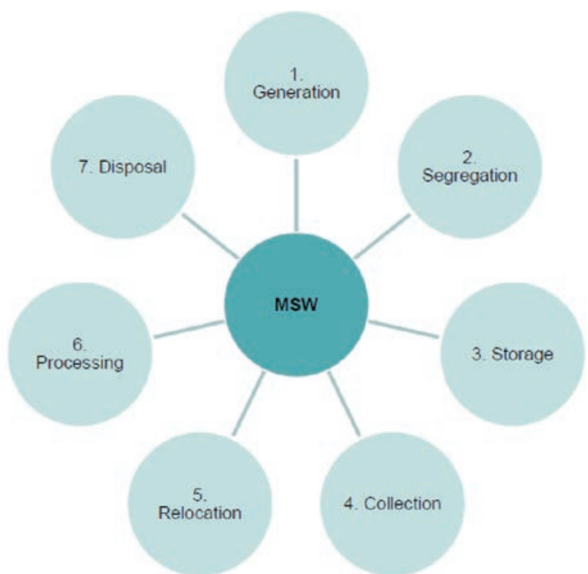


Source : Publication by Aqartala Municipal Corporation

MSW Management - Collection, Transportation and Disposal

MSWM is very important basic service provided by the Government of India and for its management, usually municipalities and other local bodies are responsible under the Municipal solid waste Management and Handling rules - 2000 and revised Solid Waste Management Rule 2016. Presently the "Collection to Disposal" chain is very inefficient.

The entire solid waste management is divided in generation, segregation at primary source, Storage, collection, transportation to the secondary storage/community bins, storage at locality level, transport to processing/dumping sites



In urban India, at a dwelling level, only about 70% waste collection is observed, while the remaining 30% is again mixed up and lost in the urban environment.

Out of total waste collected, only 12.45% waste is scientifically processed and rest is disposed in open dumps (as per CPCB Report 2013).

Challenges of MSW Management in India

The major challenges of solid wastes are accumulation, segregation, transportation, processing and public participation. Continuous dumping of waste in dump yard now major threat to nature affects the living and non-living environment adversely. Now major challenges for all major cities are:

1. Waste Management for daily waste generation - The major challenges of municipal solid waste management in India are:
(i) Rapid urbanisation with increased population and solid waste generation
(ii) Lack of Integrated waste management approach
(iii) Lack of planning and monitoring regulation, laws for disposal and treatment of solid waste and associated adverse impact on environment
(iv) Lack of financial resources
(v) Lack of Public Participation

2. Existing Dump yard/Landfill for legacy waste already dumped in open dump yard (unscientific landfill) is now waste hillocks in bigger populated cities

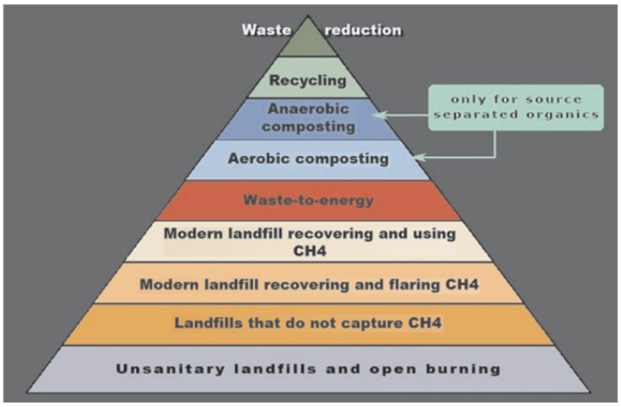
i. Environmental Impacts- The disposal of solid waste in open dump yard leads to pollution of aesthetic and visual environment. The generation of greenhouse gases (specially methane CH_4) from the decomposition of organic wastes in landfills, are the prime source of air pollution. Uncontrolled burning and improper incineration of MSW contributes considerably to air pollution. The direct disposal of solid waste and untreated leachate contaminate the local surface and ground water system.

ii. Health Impacts -The evidence links that gas emission and incineration of waste cause health problem particularly cancer, reproductive outcomes and mortality is inadequate (WHO 2000, 2007). The landfill workers are more susceptible to tissue damage and cardiovascular diseases due to activation of leukocyte and platelets as well as airway inflammation (Ray et al. 2005, 2009) [47, 48].

Most of the existing landfills are acting as only dumping sites with negligible conversion of waste to energy. The reasons are lack of technology, lack of government intention, monitoring, funds and small energy potential.

Way Forward for fresh/Daily waste generation

The best practice of waste management is to reduce the use of material and reusing them could most environment friendly. It promotes nurturing of resources, reduces consumption and leads to innovation in tackling waste management i.e. 'buy, consume and return' in waste management as against 'buy, consume and dispose'.



Integrated Solid Waste management (ISWM) to municipal waste is the application of suitable techniques, technologies and management programs covering all types of solid wastes from all sources to achieve the main objectives of (a) waste reduction and (b) effective management of waste still produced after

3Rs – Reduce, Reuse and Recycle, classify waste management strategies according to their desirability in terms of waste minimization. These "3 Rs" are the foundation of most waste minimization strategies. The aim of this is to extract the maximum practical benefits from products and to generate the minimum amount of waste

Decentralized Municipal Solid Waste Management

It is realized that decentralize waste management is practical solution for MSW Management by providing decentralized facilities near the origin of waste generation. Decentralized treatment practice would reduceburden on urban local bodies for transportation of waste to centralized processing disposal facility.

In India bulk waste generators contribute around 40% of total waste and initiative by all bulk waste generator category, by adopting "at source composting" or "community-based composting" would have significant macro impact in reducing carbon foot prints from organic waste generated as also transported to waste disposal sites. It is observed that some of urban local bodies initiated decentralized waste management and promote "at source composting" or "community-based composting" using organic waste converter for composting of organic waste.

De-centralized Waste Management is a process of segregating the waste at source into dry and wet waste, treating the wet waste using simple composting methods at the source of generation while recycling the inorganic waste such as paper, plastic, glass and metal.

Since the waste is segregated at source, the cost of collection is completely eliminated and better value is recovered by treating or recycling various components of waste. **Followings are the major advantages:**

- Segregation efficacy - Better and more effective segregation of Waste at Source
- Cost and Resource optimisation - reduction of transportation of waste over long distances
- Better value of compost produced by treating organic waste at source of generation
- Better value recovery from recyclables
- Higher onus on the community and hence better community participation
- Better remunerative opportunities to ragpickers and urban poor

Collection at Source - Household level

Waste collection from doorstep i.e. households, shops and establishments are to be so designed by the urban local bodies that it synchronizes with storage of waste at source as well as waste storage depots facility ensuring that the waste once collected reaches the processing or disposal site through a containerized system.

Collection of putrescible organic waste from the sources should provide daily because of the hot climatic conditions in the country. Segregated recyclable material can be collected at longer regular intervals as may be convenient to the waste producer and the waste collector. The waste collection efficiency in India ranges between 70 and 90% in major Metro cities, here as in several smaller cities it is below 50% (CPHEEO, MoUD 2013). **Followings are prerequisite for waste collection:**

- Training and awareness to all households for segregation of waste
- Door to door collection to be done only when dry waste, kitchen waste and other construction wastes are segregated. No waste to be picked up from house if this is not done.
- All dry waste and construction waste to be picked up once in 3 days only where was kitchen waste everyday
- Sorting and recycling of kitchen should be done at decentralised manner including composting, bio gas, etc. Most of the non-recycle materials should be diverted to incineration if possible.

Treatment and disposal

Integrated Management facility to recycle and reuse of waste material to minimise landfillable waste. A well-designed scientific landfill site for disposal of left out material after processing facility i.e. inert waste will minimise environmental and health risk.

Processing and treatment of municipal solid waste

The main technological options available for processing and treatment of Municipal Solid Waste for Resource/Energy Recovery/ Disposal, are the following:

1. Composting
2. Vermi-composting
3. Anaerobic Digestion/Biomethanation
4. **Incineration** with high end filtration system to check Sox, NOX and other hazardous substances. Incineration of waste is a thermal process, which reduces the waste to 15-20 per cent.
5. Gasification/pyrolysis
6. Plasma Pyrolysis
7. Production of Refuse Derived Fuel (RDF) /Palletisation
8. Sanitary Landfilling/Landfill Gas Recovery

Way Forward for Existing Landfill – Legacy Waste Dump yard

The existence on the territory of landfills without control systems can represent a serious problem for the safety of the population. Recent Problems and accidents in the worldwide show that the presence of a landfill can be dangerous, and not only for pollution (subsoil and atmosphere) but also for landslides and subsidence.

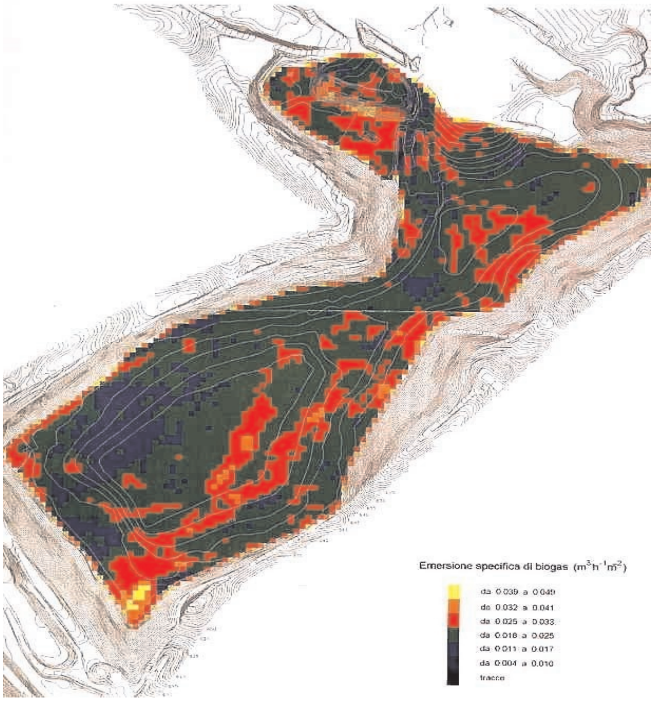
The presence of the biogas and the mechanical effects of his combustion or explosions are often the initial cause of these accidents. For the demolition of the mountains are often usedexplosives and with the same concept explosions of biogas can move massive volumes of waste by making them collapsing. Landfill biogas is the result of the fermentation of the decomposing organic elements of waste in a landfill. This process generates overpressure. Once the alveolar spaces are saturated, the gas naturally tends to escape so that surface biogas emissions usually correspond to the specific biogas production of the waste fill. To counteract the unchecked migration of biogas into the atmosphere or adjacent soils, a system of extraction is usually put into place which serves to harness the biogas before it can reach the outer limits of the waste fill. The gas so harnessed is destined either to be flared or to be fed into a transformation plant to produce electricity.

Biogas Assessment, Extraction and Combustion from Landfill Site to minimize chances for fire erupt and explosion in landfill site. Also, to save environment from greenhouse gases generating regularly from landfill site.

Quantification of Biogas Production in Landfill Site

The landfill biogas production forecast through model to determine the generation of methane, carbon dioxide and hydrogen produced from the waste mass, waste composition and moisture content using a multiphase first order decay equation, for both methanogenic and acetogenic decay.

Landfill Thermography - Aerial Thermography is effective method to assess the gas quantity on landfill surface. This service allows us to assess the surface emissions, any captation irregularities and the potential direction of any migration of biogas outside the site. This aerial analysis can be accompanied by ground instrument tests so as to verify that the thermal variations registered match the effective biogas emissions on the ground.
Thermography permits the logging of the most minute thermal variations on the surface of the waste landfill and/or adjacent land enabling the calculation of thermal energy yield from biogas output. Aerial scan system using a radio remote controlled drone equipped with a thermal micro camera thereby producing more economical thermographic analyses with greater speed and accuracy

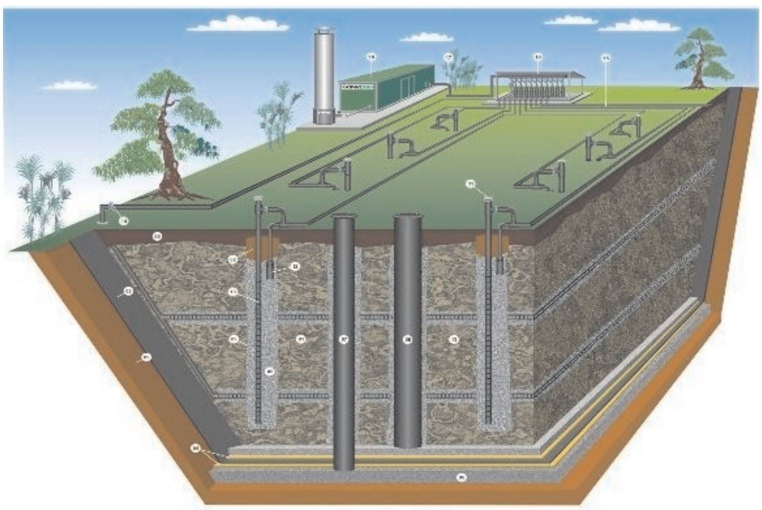


Gas Suction and Combustion

Gas assessment study allows appropriate positioning of gas extraction well in Landfill site. Followings are the gas extraction approach

- Installation of an active gas extraction system. (Horizontal/vertical gas wells, trenches, fans/pumps, regulation station, torch) ¸
- Establishment of passive gas extraction system. (Various forms of oxidation filters at or adjacent to the landfill, ventilation systems, etc.)

Extraction Wells - Gas collection begins in the extraction wells, where LFG is extracted from the waste mass. Extraction wells are typically composed of slotted plastic pipe, surrounded by stone or other aggregate material, that are installed in borings in the waste mass below the surface of the SWD site. Above the surface of the waste mass, the extraction well typically has a wellhead to allow for vacuum adjustment and sampling of the LFG. The orientation of these wells can either be vertical or horizontal, and the decision to use vertical and or horizontal wells will depend on site-specific factors and goals of the LFG project.



Bio Gas Extraction and Combustion Plant - The extraction takes place by means of an automatically controlled gas pump, which takes into account fluctuations in gas production within the landfill. The adjustments to the collection system made necessary due to local fluctuations in gas production are carried out manually at the well heads or, either automatically or manually, in a measuring and control station ground.

Leachate Collection System

Leachate is a liquid that has filtered through the landfill. It consists primarily of precipitation with a small amount coming from the natural decomposition of the waste. The leachate collection system collects the leachate so that it can be removed from the landfill and properly treated or disposed of.

Landfill Capping - Landfill capping to be customized to allow uninterrupted landfill dumping as per requirement and post closure development can be planned for parks, playing

Conclusion and Future Intervention

The attempt has been made to assess the situation and changing trends of management practices of municipal solid waste to find its impact on the performance and planning of recovery/recycle, compost, incineration and landfill facilities. A customize plan for segregation and composting for cities can be supportive considering quantity and quality of waste. Now urban local bodies in opinion to adopt decentralized approach for composting/bio-methanation looking to the challenges of collection, transportation and processing disposal facilities. However, health hygiene of residents and land availability is major challenge for authorities to have decentralized processing storage/facilities.

Management of existing landfill situation become havoc due to absence of proper regulation, laws for monitoring, lack of planning, lack of financial resources, lack of innovative technology and practices. Integrated approach is needed for solid waste management for fresh and legacy waste in existing landfill sites. Due to lack of alternate land for processing and disposal facilities Urban Local Bodies prefer to go for biomining and reclamation of existing landfill site. However, gas assessment, extraction and combustion are required before mining to avoid risk of health, fire eruption and environmental exposure of greenhouse gases.

References:

CPCB. Management of Municipal Solid Waste. Ministry of Environment and Forests, New Delhi, India, 2004, 2013.

CPHEEO, MoUD, GOI, Advisory on Improving Municipal Solid Waste Management Services, 2013

Dr. G.l. Parvathamma "An Analytical Study on Problems and Policies of Solid Waste Management in India –Special Reference to Bangalore City", (IOSR-JESTFT) e-ISSN: 2319-2402, p- ISSN: 2319-2399.Volume 8, Issue 10 Ver. I (Oct. 2014), PP 06-15

Panwar Satya Prakash, Nagpal Sakshi and Sharma, Mohit, "A Review on Present Practices, Issues and Challenges of Municipal Solid Waste Management in India" International Journal on Emerging Technologies 8(1): 647-651(2017)

Ray MR. Airway inflammation and upregulation of beta2 Mac-1 integrin expression on circulating leukocytes of female ragpickers in India. J Occup Health, 2009; 51(3):232–238

WHO. Methods for assessing risk to health from exposure to hazards released from waste landfills. Report from a WHO Meeting, Lodz, Poland, 10–12 April 2000. World Health Organisation WHO, European Centre for Environment and Health, 2000.

WHO. Population health and waste management: scientific data and policy options. Report of a WHO Workshop, Rome, Italy, 29-30 March 2007. World Health Organisation WHO, European Centre for Environment and Health, 2007.

***

Experience In Practical Implementation Of Waste Management Project In Goa

Mr. Nitin Deshpande
Managing Director,
Triochem Sucrotech Engineering And Projects Pvt. Ltd.,
nitin@triochem.in

Preamble: Several articles, speeches and training programs are available about waste management or recycling/ upcycling of the municipal solid waste or plastic waste or other types of wastes. However, the description about practical difficulties in successful implementation of such a project is seldom available.

The successful implementation involves several factors like, getting the agreements with ULBs in place, getting several clearances from various monitoring authorities in hand, arrangement of financials, getting suitable manpower, training and retaining them to work in such adverse working atmosphere, maintaining quality of the final products to make them acceptable into the market, chasing and receiving the payments and finally maintaining suitable cash flow to make the project survive. On paper this list looks simple. However, getting these papers in hand is a herculean task. Endless follow up, discussions, convincing, submission of applications, modifications thereof, takes toll of enthusiasm of the prospective entrepreneur. Sometimes one begins to feel if the government authorities indeed want such projects to come up? Perseverance is absolutely essential during the period of implementation. At many places, unprofessional practices have to be faced. Gentlemen, I have survived all this to materialize couple of such projects.

Background: Over past two decades, I have successfully implemented industrial liquid waste disposal projects, diligently complying with exacting standards prescribed by Environment authorities. They involved final disposal of one of the most obnoxious liquid waste i.e. Spent wash from molasses-based alcohol distillery. I implemented these projects not only in several states in India; but many places abroad also (South America, Philippines, Vietnam, Paraguay, Colombia and Brazil). On account of this success and reliability with which I completed them; the monitoring agencies involved were quite impressed. They strongly suggested that I should take up projects in municipal solid waste (MSW), plastics waste, e-Waste etc.

I learnt more about these wastes through good offices of National Solid Waste Association of India (NSWAI), Mumbai and Environmental Club of India, (ECI)Pune. I also became office bearer in these NGOs. I am thankful to both these organizations for providing me insight in solid waste management.

I operated a composting-based vegetable waste disposal project near Pune for a few years to get some hands-on experience. I further tried out my hands on composting of food waste, plastic waste collection and recycling into granules through ECI. Later, after I became Member Technical Advisory Team, JNPT, New Mumbai, I tried to implement some solid waste disposal projects in JNPT in collaboration with NSWAI. The overall experience, emboldened me to think of investing in such ventures.

I had several discussions with top government officials at Goa and Maharashtra. I realized that they were and are still desperately seeking project proponents, who are reliable and trustworthy in terms of compliance with government norms. With the advent of Swachh Bharat Mission, the pressure for actual project implementation was high.

Due to my previous successful track record in distillery waste management, they strongly recommended to take up similar projects in MSW and plastic waste management.

Projects Implementation:

Goa Project: Goa Waste Management Corporation (GWMS), Panaji, Goa gave me an opportunity to set up a pilot project at Verna Industrial Area. My company, Triochem formally entered into agreement with GWMS to execute a project for proper disposal of 10MT/day of dry mixed solid waste from adjoining area. My company invested for the machinery and is also responsible for working capital.

We are running it for past several months, wherein 10MT/day waste gives 6MT/day of RDF and 4MT/day of plastic waste.

The RDF fraction is submitted to Cement factories (Dalmia or JK in Karnataka). The disposal of this waste entitles my company to get EPR certificates, which are traded amongst 80 Corporate Companies, fetching a revenue of about average Rs.5/kg. The mixed plastic waste is converted into granules for recycling.

The whole project is run by 20 labors, 1 supervisor and 1 manager. Day by day the operations of the project will improve to produce higher value products. I express deep sense of gratitude towards GWMS and other Goa officials.

Project at Pimpri-Chinchwad Municipal Corporation (PCMC), Dst. Pune: I

I entered into an understanding with Environment Conservation Association and Greenscape Eco Management Pvt. Ltd. both NGOs working in field of waste management.

This project is supported by PCMC, MPCB and MIDC together. PCMC allotted us one acre of land with some infrastructure in place free of charge for 15 years in Bhosari Industrial Area near Pune. We are implementing a project of plastic waste recycling center. In addition, we are also setting up a Training and Hobby Center, which will conduct training courses in waste management for the interested students and public at large. We shall be processing 10MT/day plastic waste and e-Waste for converting the same into various value-added products, including plastic to oil. Here too, I express deep

Way Forward: Over the years, I had heard many lectures and presentations given by many experts in this field, advising the public at large on how to manage the waste. However, when I thought of being an actual entrepreneur in the waste management, these resources were seldom useful to implement a greenfield project.

However, my interaction with NSWAI, not only gave me an insight into implementing such projects, but also enlightened me about the tremendous need for such projects in India. NSWAI is trying to implement educational projects at several reputed management facilities in the country. I am thankful to NSWAI for the same.

I wish to consolidate in the present scale projects. I will also try to replicate them at many other locations. As per my experience, many small-scale companies can find gainful work in this field

and there is tremendous scope for such projects. I wish to be a knowledge source for upcoming entrepreneurs in this field in various states. I am of the opinion that instead of going suddenly into big projects and failing, such small projects have better chance to survive. Small is beautiful indeed. It has a better surety of success and greater potential for providing gainful employment to many unemployed youths. I once again express my thanks to all the government institutions, officials and non-officials, NGOs and last but not the least, my colleagues in these projects and staff members and workers.

★★★

Technical, Social And Financial Constraints In Solid Waste Management

Dr. Rakesh Kumar
Former Director, NEERI
r_kumar@neeri.res.in

Human population in the wake of urbanization and to fulfill his basic needs knowing or unknowingly is impairing the environment. Since the early decades, nature has been considered as a sink for all the different type of waste produced by the human civilization. Human activities contribute to all kind of pollution viz., air pollution, water pollution, etc. one of the most common but neglected sectors is solid waste which has a very deadly environmental concern.

Items which are discarded by a human after use on an everyday basis are known as solid waste (SW). Municipal solid waste (MSW) is a kind of waste which is generated from household or collected through street sweeping. MSW is highly heterogeneous in nature. An average MSW contains a substantial amount of food waste, paper, plastic, metal, construction, and demolition waste, inerts, etc., according to the World Bank report (2018) the generation of the solid waste in the year 2012 was approx. 1.3 billion tonnes which amount to a footprint of 1.2 kg/person/day. This report also estimated that by the year 2015 the MSW generation is expected to rise by 2.2 billion tonnes [1]. According to Ministry of Urban Development (MoUD 2016), CPCB reported that in the year 2014-2015 the total waste generated for 34 states and union territory was 1,43,449 TPD and out of the total waste generated approx. 1,17,644 TDP (82%) of MSW was collected and 321,871 TDP (22.9%) was processed [2,3].

According to the census 2011, the progressive growth rate of MSW in India is 407.64% which is a kind of high [4-5]. The report published by the Shanghai manual 2010 for sustainable urban development in the 21st century mentions that world waste production is expected to be approx. 27 billion tonnes per year by 2050, on the third of which will be come from Asia. The major contributor is expected to be from China and India [6].

SDG Goals and the Waste Management

Thus, managing MSW properly has now become very essential and crucial parameter to deal with. Time has now come to achieve a solution for global sustainable development. One cannot achieve the Sustainable goals (SDGs) without solving the problem of waste management. The (SDGs) in fact is woven around the very concept of waste management. The informal sector work effortlessly but are given not much credit even their health aspects is totally ignored. The SGD 10 (Reduced inequality) and SGD 17 (Partnerships for the goals) are formulated to justify their importance in society along with their health in concern. Likewise, SDG 3 (Good health and Wellbeing), SDG 13 (Climate Action), SDG 6 (Clean water and sanitation) gives emphasis on the solution created by the adverse effect of MSW. SDG 4 (Environmental and health training and awareness) SDG 5 (Gender Equality) focuses on the education and environmental awareness among the people and also the participation of women in the waste management sector [7].

Municipal Solid Waste Management (MSWM) in Developed and Developing Countries

Waste management practices prevail both in developed and developing countries. But when the condition of waste management for both is compared, then it is found that developing country still lacks in progress. The urban poor of the developing countries is especially suffered by the unsustainable waste management. Lower and middle-income countries always end the cycle of the MSW either through open burning or by unregulated dumping resulting in an array of problems [8]. Developing countries are also having a low collection of MSW due to irregular collection service. The major constraints associated in waste management in developing country are:

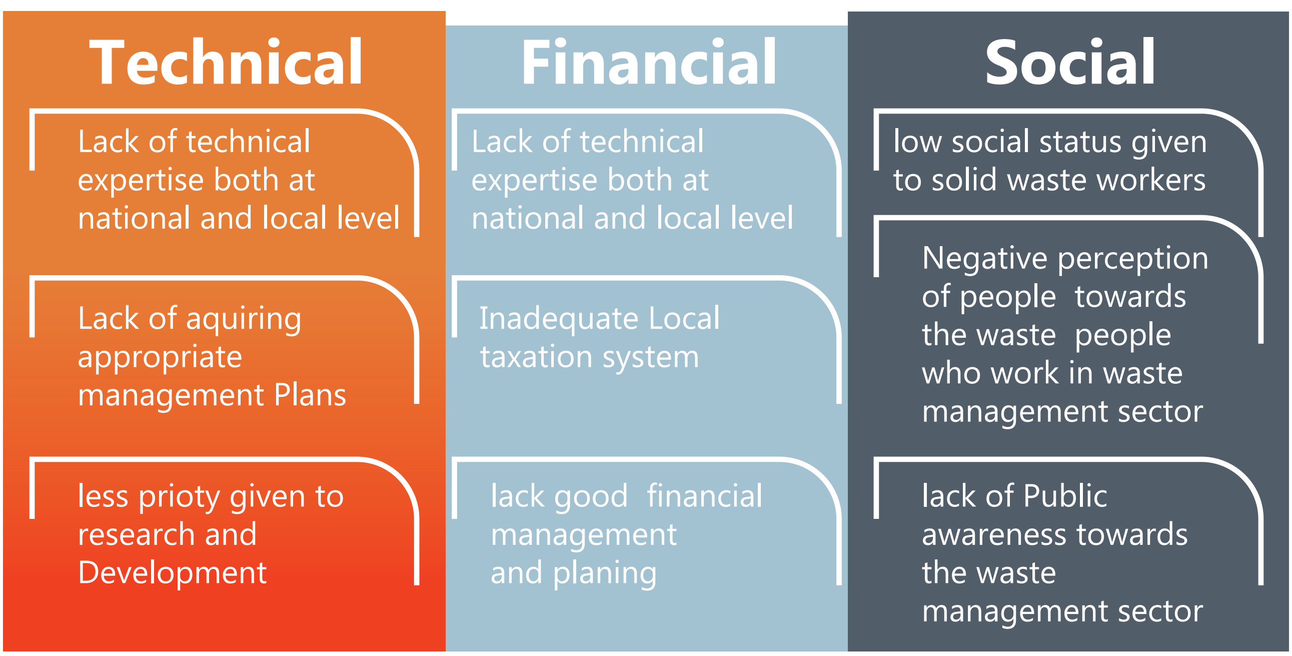


Fig 1: Technical Financial and Social Constraints of MSWM in developing Country [8]

Integrated Solid Waste Management Program to mitigate the problem of waste management

The developing countries immensely need Integrated Solid Waste Management (ISWM). This management practice covers the complete life cycle of waste along with the information related to the environmental impacts and the financial aspects of the proposed waste management plan. In terms of economic and environmental benefits integrated municipal solid waste management (IMSWM) is the best methodology which can solve the consisted problem of waste management [9]. IMSWM considers both the direct factors such as such as transformation, collection, treatment, and disposal and in direct factors viz., use of raw material and energy coming out of the waste. By considering both the factors, IMSWM also follows the 'Waste-Hierarchy Law.' IMSWM keenly considers the goal and focus of the waste management.

In the category of goal, IMSWM emphasized on the reduction of waste at the point source, Enhancement in the rate of recycling and reuse, promotion of the appropriate waste processing and it also encourages the safe disposal of the waste. IMSWM focus on the organizational setup and assesses the basic condition of the waste stream. It promotes 4R principle and also looks upon the coordination between NGOs and government bodies to keep running the SWM program without any hindrance. The tactical and Strategic planning system is also important in the waste management systems along with the IMSWM. Short and long-term planning should also be chock out properly while implementing an IMSWM [10].

World Bank Global Aid towards MSWM

A municipal budget often comprises 20%-50% in order to have an effective waste management plan. The World Bank offers and advises on the SWM through its diverse services and range of products [11]. It gives emphasis on the entire life cycle of the waste. The World Bank supports capital investment to build up the basic infrastructure of the system. It also advises on sound policy and long-term planning. It also promotes the citizen engagement and uplifts the social inclusion through its projects [11].

The World Bank has spent over $4.7 billion in 340 solid waste management programs in different parts of the worlds since 2000 [11].

East Asia and the Pacific	Indonesia $100 million loan to reform waste management practices for around 70 participating cities	China $80 million to household kitchen waste seperation
Europe and Central Asia	Azerbaijan loans to support the rehabilitation of the main landfill	
Latin America and the Carribean	Argentina wa given $40 billion to reduce and properly treatfood waste	Jamaica Result based finacing and Infrastructure investments t waste collection services
Middle East and North America	Morocco- $500 million for a series od development policy loans inorder to strenthen private sectors partnerships	West Bank- loans were given for construction of three landfill sites to benefit 2 million residents who resided near them
South Asia	Nepal- $4.3 million project to improve waste management collection services	Pakistan- $5.5 million dollar project to support a composting facility in Lahore
Sub- Saharan Africa	Liberia - $10.5 million to improve the waste managment and for contruction of new sanitary landfill	Bukina Faso- $67 million loan since has been provided since 2005 to support solid waste sector

Fig 2 : Aid provided by the World Bank to support Solid Waste management Plans [11].

Conclusions:

Solid waste plays an important role in various category of the sustainable goal. Post 2015-SDG, SWM sector is considered as a striving objective which is interconnected to the different SDG goals. A proper MSWM can help to provide sanitation, sustainable human settlement, and sustainable consumption and can help to reduce the adverse effect on the climate change [12]. Proper MSWM looks after the following aspects:

Need to look upon the opportunities provided by all services	• Proper SWM begins from the very nascent stage. it gives keen imphasis right from generation of waste upto its disposal. • During the management of the (SW) service providers, finacial aspects, efficiencancy of private sectors, Technical expertise should be taken care of.
Different level of involvement and risk needs to be considered	• Private sectors provides different levels of financial and technical risks, for a sound MSWM. All the available options needs to be considered in order to cater risks, preference of the public entity needs to be considered.
Recovering the cost investment and operation with minimal risk by proper planning	• Solid waste services are normally unprofitable • Revealing actual figure of the financial reports, complete risk analysis report needs to be provided so that useless investment can be cut out and sustainable plans could be chock out
Imphasised on integrated and functional solid waste systems	• Complete strategy on waste manamgent including life cycle assessment needs to cater out inorder to chalk out integrated soild waste management plan.

Fig 3: Aspects of Proper MSWM [12]

Along with the above aspects enriched awareness of the decision makers helps to achieve a sustainable solid waste management plan. An informed decision leads to sound socio-economic and industrial development. Encouragement of financial aids and tax incentives helps to develop recycling industries and business related to solid waste. A change of policy is needed while transferring technology to the recipient countries so that the technology would be more beneficial in the recipient countries.

References :

1. http://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management Accessed on 27/08/2018

2. Ministry of Urban Development Part II Manual on Municipal Solid Waste Management (2016) Swachha Bharat Mission, Central Public Health, and Environmental Engineering organization

3. Ministry of New and Renewable Energy (2018) Generation of Solid waste unstarred question no 2974, Lok Sabha, Government of India

4. Census of India, 2011. Ministry of Home Affairs, Government of India, New Delhi, India:http://censusindia.gov.in/ Accessed on 29/08/2018

5. Provisional Population Totals- India (2011) Size, growth rate and distribution of population: http://censusindia.gov.in/2011-prov-results/prov_results_paper1_india.html

6. Singhal S., Pandey S., 2001. Solid waste management in India: status and future directions. TERI Information Monitor on Environmental Science 6: 1-4.

7. https://wasteaid.org.uk/waste-sustainable-development-goals/ Accessed on 30/08/2018.

8. https://www.gdrc.org/uem/waste/swm-fogawa1.htm

9. Ramachandra, T.V. 2011. Integrated management of municipal solid waste. In S.R. Garg (ED.), Environmental Security: Human and Animal Health, pp. 465-484. Lucknow, India:IBDC

10. Kumar, S., 2016 Municipal Solid Waste Management in Developing Country Taylor and Francis ISBN-13:978-1-4987-3774-6

11. http://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management Accessed on 01/09/2018

12. http://blogs.worldbank.org/sustainablecities/time-rethink-how-harness-private-sector-improve-sustainable-solid-waste-management Accessed on 02/09/2018

✱✱✱

The Future Of Composting Toilets : Initial Musings About Its Adoption

Dr. Aparna Sahu
Consultant And Senior Researcher,
Turiyan Psyneuronics Pvt. Ltd
aparna@psyneuronics.com

Composting toilets have existed since the 1870's though its design has evolved significantly since its first model. In urban areas, it has multiple benefits to offer such as, reducing water and wastewater flows within a building, management of human waste, production of fertilizer for non-edible plants, reduction in use of drinking water to flush toilets, allowing for a circular economy. In areas where open defecation is still prevalent and practiced by about 700 million people globally, composting technology could provide safer sanitation solutions. These benefits would be further relevant with the increasing population and anticipated shortage of resources.

Despite the potential benefits of composting toilet technologies, users continue to be hesitant about adopting it. This article makes a preliminary attempt to explore the reasons behind its slow adoption and proposes strategies as well as a plan for wider adoption of composting toilets from a behavioural point of view based on a review of literature.

Strategies that can be implemented to reduce the hesitation in adopting Composting toilets:

As far as urban areas are concerned, some of the identified reasons for slow or absence of adoption of composting toilets in urban areas include, lack of awareness, perceived odor and maintenance issues, and active management of waste by the user. Maintenance requirements include, turning the compost in its bin for its processing, adding bulking agents for the right carbon to nitrogen ratio in the compost, emptying the chamber when the compost is ready, and cleaning the toilet without much use of water. Some of these requirements may be considered as additional chores when compared to the maintenance of the very affordable and no chore requiring water based flush toilet. Moreover, with the current access to water at a very minimal cost, use of composting toilets may be perceived as unnecessary.

Some of these issues related to composting toilets have obvious solutions such as education for awareness and clarity on perceived issues, improvement in technology to make these toilets more appealing, and smoother operations to obtain compost. Other issues such as active involvement of the user for management of waste and viewing the use of these toilets from a status point of view are more on the consumer behavior side and need addressing based on the understanding of human behavior.

Strategies to aid adoption based on an understanding of consumer behavior:

While scientists in developed and developing countries appreciate the utility of composting toilets, laymen in these countries are likely to disparage it, perhaps due to implicit biases about the technology based on the exposure or awareness they have had in the past. The following model is considered for the adoption of composting toilets, as it can provide a framework for adoption of new technology which is brought about for the people's use.

The Unified Theory of Acceptance and Use of Technology (UTAUT) model has been applied in the information-technology area for employee technology use and acceptance. The model uses four core factors to determine users' intention to use a technology: Performance expectancy, effort expectancy, social influence, and facilitating conditions, in order to evaluate the utilitarian value (extrinsic motivation) for adopting/using the product. Performance expectancy is the extent to which using a technology is likely to be useful for consumers for certain activities; effort expectancy is the amount of effort associated with consumers' use of technology; social influence is the extent to which consumers are influenced by significant others' (e.g., family and friends) beliefs about a particular technology; and facilitating conditions refer to consumers' perceptions of the resources and support available to use the technology. The UTAUT-2 is a modified version of the first model wherein the authors theorize that individual difference variables of age, and gender modulates the relationships between the UTAUT variables. For example, in terms of facilitating conditions, some people speculate that older individuals are likely to have difficulties in processing new or complex information due to age-related cognitive compromises; males more than females are likely to invest more effort in pursuing goals despite continued difficulties or constraints. Furthermore, the improved model incorporates hedonic motivation, experience and habit, and price value to account for behavioural acceptance of a new technology. Hedonic motivation refers to the gratification derived from using a technology, and it has been shown to play an important role in determining technology acceptance and use. Price value is consumers' cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them. Experience (Habit), as conceptualized in prior research reflects an opportunity to use a target technology and is typically operationalized as the passage of time from the initial use of a technology by an individual. In terms of habit, □ people found that prior use was a strong predictor of future technology use.

Based on the UTAUT2 model, some of the factors for resistance as well as potential ways of dealing with them are discussed below.

Culture:

In their review paper, people acknowledge that culture plays a pervasive role in the attitudes and actions of people; particularly, there is the issue of whether waterless toilets will be accepted by some cultures. That said, newer technologies do accommodate for composting toilets to work with some amounts of water. While some cultures may not readily accept such toilets in the near future, it is likely that in order to contribute towards a greener environment, they might be more willing to adopt other methods for conservation of water. Indeed, issues such as handling human excreta can be seen as repulsive). This could also apply to handling of composting toilets that require the user to process it. Hence, regular maintenance services by composting companies might aid in its adoption.

Governmental policies and regulations

One strategy that helps in attracting the interest of users is governmental regulations as well as policies that provide subsidies allowing adoption and as a result leads to a better learning curve of a new-to-market technology. Not having policies, and guidelines or regulations for installation, is a barrier for the willing population to adopt these toilets. On the other hand, having too many permits for installation of the toilet and handling of compost may also be a deterrent in adoption. Technological design, certifications for safety as well as regulatory bodies may have to work together to help make the use and disposal process as convenient as flush toilets without compromising on safe use and handling. With potable water continuing to be an affordable commodity for use in toilets, an increase in water costs and mandated installations in new constructions and renovations may also help the adoption of toilets by directing behaviour towards water conservation.

Marketing :

From a marketing perspective, price, promotion, product, and place (4 p's) are factors that influence adoption of a new product. The appropriate marketing language could arouse people's interest. For instance, people may not purchase a product just because it is “green”, however, almost a $0 operational cost may be an attractive selling point.

With increased media use, people's reliance on visual information such as appeal and design has grown exponentially in the past years. For instance, a study found that visually appealing solar panels were more readily accepted. Likewise, marketing for composting toilets will need to involve not only the highlights of usability features, but also management features, in addition to its appearance.

Use of emotions in marketing communication: Individual differences (independent of culture as a factor) in disgust are likely to be a barrier for certain viable sustainable alternatives to prototypical products. Hence, using emotional advertisements about how sustainable products such as use of composting toilets today can impact the society/world in the long run could help. Fear based imagery in advertisement is known to elicit activations in specific areas of the brain, which involve areas of reasoning, and memory. To put it simply, people who are shown fear-based imagery are more likely to be aware of the problem at hand, appraise the problem emotionally, and are likely to recall the information at a later point. Hope-based information dissemination has also been used previously for other environment-based phenomena. For instance, some people reported in a study with young adults that instilling constructive hope about climate change was positively associated with pro-environment behaviour. Some prople provide directions to marketing agencies on communication of scientific information in a positive manner such that people are motivated to assimilate it for their understanding.

Adoption in phases using the aforementioned strategies – A proposal

Adoption of composting toilet technologies can be structured and introduced as a new technology entering the market. A three-phase adoption strategy is described in this section incorporating strategies reviewed in this article.

Phase -1 In phase 1, the public sector can take leadership and introduce the technology in public owned buildings (e.g., municipal buildings) and public places. This introduction of technology can be followed by policies and regulation in the public sector for wider adoption via new constructions and renovation upgrades.

Phase -2 In phase 2, private sectors (i.e., businesses) could be aided with composting toilet adoption using subsidies, tax rebates, and policies or mandates, both for new construction and renovations.

Keeping the markets in mind is essential. It may be useful to start with drought-stricken areas or areas with water disputes due to lack of access to water but where affordability of the toilet is not the largest of all issues. In other words, beginning the transition with markets willing to adapt and adopt the new technology would be easier. For instance, the ecotourism industry has gained popularity in recent years and this might be a viable market for the use of composting toilets considering the mindset of the customers that choose ecotourism (Verma and Chandra, 2016). Such situations allow for people to experience the technology in a commercial set-up. If they are satisfied with its use, they can move a step closer by adopting it when they have a chance. This introduction of technology can be followed by policies and regulation in the public sector for wiser adoption.

In addition, enabling large scale composting could help with efficiency in the operational phase of these toilets where waste is collected, cured and handled elsewhere. Outsourcing this part of maintenance to the public sector can make the technology "easy to use" at the user end and this could therefore aid its adoption.

Phase 3 - Once the public and private sectors have these adoptions and a considerable percentage of the population is exposed to these toilets through their workplaces or through public places, and their functioning, models for adoption in the residential sector could be developed. Policies and regulations can help adoption in all new constructions, as well as, renovation upgrades. It is essential to extend the adoption to renovation upgrades considering existing constructions constitute the largest building stock contributing to the larger portion of wasteful use of potable water to flush toilets.

Conclusion :

The structured implementation in phasing out water-based toilets and phasing in of composting toilets is clearly anticipated to take several years. In these years, research and customer interest-based growth in design, appeal and functioning of this technology, like any other technology is also anticipated to help further the hedonic motivation in adoption of the composting toilets.

***

PLASTIC WASTE

Waste MONITOR
Volume 4 Issue 1 Dec. 2021

Is Plastic Circular Economy, The Solution?

Professor Agamuthu Pariatamby
Jeffrey Sachs Center On Sustainable Development
Sunway University, Malaysia
agamutup@sunway.edu.my

Examining the resource circulation system and its role in plastic waste management

The management of plastic waste is a big concern. Out of the 7 billion tonnes of plastic waste generated between 1950 and 2015, only 9% was recycled globally. Currently, Global annual generation of plastic is 400 million tonnes and 86% of this will eventually become waste.

In developing countries, plastic waste is mainly disposed of, along with other constituents of municipal solid waste (MSW) such as food waste, paper waste, and glass, in some form of landfill (88% of waste ends up in landfill).

Developed countries, on the other hand, segregate MSW and adopt energy recovery and recycling of plastic waste. In 2018, for example, the European Union recycled 32.5% of plastic waste while 42.6% was utilized for energy recovery.

Yet, 5–13 million tonnes of plastic, approximately 1.5%–4% of global plastic waste, end up in oceans as marine litter every year. Plastic, including microplastics (plastics less than 5 mm in size), constitutes 60%–80% of marine litter and poses grave threats to marine life.

Marine fauna is known to ingest microplastics which could block digestive tracts, eventually leading sea creatures to starve and die. Recent studies show that humans may also be ingesting microplastics through seafood consumption.

Plastic circular economy could play a significant role in managing plastic waste sustainably. It promotes and maximizes the resource circulation of plastic waste, whereby the waste becomes valuable through reuse and recycling.

Plastic waste can be used to substitute raw material. Reusing plastic or using recycled plastic is energy saving too as it could avoid the manufacturing of virgin plastic (i.e., new plastic) and even reduce the demand for petroleum which is used in plastic manufacturing.

We could implement plastic circular economy in various ways. One way is through extended producer responsibility (EPR), a policy approach where manufacturers and importers of plastic products are responsible for their products' end-of-life management.

By putting the onus on manufacturers and importers in managing their waste effectively, EPR ensures that the price of plastic products incorporates the cost of their safe disposal. EPR can consequently reduce plastic waste disposal, encourage conservation of resources, increase plastic recycling rates, and promote eco-designed plastic products.

Another way to implement plastic circular economy is through a refund system. This involves charging consumers an extra amount for the purchase of a plastic product (e.g., water bottle, container) on top of its original price, and then refunding them that extra amount when they return the product. Sometimes, consumers are rewarded with discount coupons or points after returning the product.

In Japan, for instance, the refund and reward system has been implemented since 2006. Using smart card technology, individuals who return recyclable plastic products to a recycling centre via a vending machine are rewarded with points or coupons that are redeemable for goods in participating supermarkets.

We can also recycle the plastic waste collected materials through EPR or the refund system. However, issues such as plastic waste contamination, mixed polymer waste, and unknown pro rata composition of mixed polymers pose a challenge to plastic recycling.

Plastic waste could be contaminated when it is disposed of along with MSW. In some cases, plastic waste such as juice bottles or syrup bottles is already contaminated with leftovers.

Plastic products made of mixed or heterogeneous polymers create mixed polymer waste instead. Reprocessing mixed polymer waste poses its own challenges and not knowing the pro rata composition of mixed polymers makes recycling harder.

We must overcome these challenges to implement plastic circular economy more successfully. To reduce the contamination of plastic, for example, we could adopt a stricter policy on waste segregation.

In addition, plastic recycling is not always economically feasible, particularly when obtaining virgin raw material (i.e., petroleum) is much cheaper. Governments could provide subsidies to manufacturers or importers of plastic products to alleviate the cost of labor in plastic recycling.

Further research is needed to improve plastic recycling rates and maximize the potential of recycling. Researchers could look into inventing new recycling techniques, solving the issue of plastic composition, creating automated waste-sorting machines, etc. In the meantime, plastic circular economy provides a sustainable solution to current waste management problems.

***

Plastics Waste Management Through 100% Recycling / Recovery

Mr. Tushar K Bandopadhyay
Technical Director,
Indian Centre For Plastics In The Environment (icpe)
Senior Advisor,
National Solid Waste Association Of India (nswai)
tk.bandopadhyay@gmail.com

"ONLY 9% OF THE TOTAL 9 BILLION TONNES OF PLASTIC WASTE IS RECYCLED CURRENTLY"

Introduction :

Plastics are one of the most ubiquitous man-made materials on Earth. The plastics products attained a phenomenal growth from production from 1.5 MN Tonnes in 1950 to about 350 MN Tonnes 2015. They have created undesired waste on earth resulting in a severe environmental challenge, while attaining market value of 750 billion U.S. dollars by 2027. But if recycling of this plastic waste is addressed properly, then the overall benefit would be phenomenal.

When the UN Report on 'Single – Use Plastics, A Road Map for Sustain ability', was published on the World Environment Day, 2018; it also declared that "Only 9% of the total 9 billion tonnes of plastic waste is recycled currently". This became the most frequently discussed point among the policymakers in the governments and stake holder's world over. India was the host country of the World Environment Day Event in 2018. The Report had drawn up a 10-point roadmap for governments for practically curbing several types of 'single-use plastics products' including that of 'single use plastics bags (SUPBs)'. However, the report did not hesitate to add:

> **Single-use paper bags have less impact of littering, compared to SUPBs, but often have higher impact on most other environmental categories (Climate Change, Ozone Depletion, Acidification, Eutrophication, Land use change). When defining policies on bags, these trade-offs should be evaluated in the specific geographical context.**

A publication by Science Advances, reported that from 1950 to 2015, total global plastic production has been 8.3 BN Tonnes out of which 2.6 BN Tonnes are still in use and 5.7 BN tonnes have been discarded / incinerated and recycled etc. This indicates there are doubts on the volumes of waste plastics, claimed as remaining on earth unattended. (Fig. 1)

Life span of some products like Plastic Pipes, Plastic Cables and some other infra-structure products are long to very long exceeding 100 years. Hence it is obvious that most of the long-life plastics products produced since 1970's are still in existence and would not be considered as part of waste waiting to be recycled. It is also to be noted that most of the large-scale development activities in these sectors occurred after around 1970.

Assessing the quantum of waste generation and the subsequent estimation of recycling component of the waste is a complex situation. One such approach attempted in Indian condition is given in Fig 2, which is based on estimation of life span of different products and representing the end-of-life volume cumulatively.

Est. % of Plastics Recycled 2018-19

PLASTINDIA FOUNDATION

Total Consumption & Qty enters waste stream 2018-19-KT

Commodity Plaastics	Consump 18-19 KT	Qty enters recylable stream in 1st Year KT	% enters
PE	5300	2968	56
PP	5082	1919	38
PVC inc paste grade	3308	217	7
PET + BOPET	1638	1330	81
PS + EPS	379	192	51
Total	**15707	*6626	42

Total Qty recycled in 2018-19-KT

Total Qty reaches waste stream in 2018-19		% recycled	Quantity recycled in 2018-19 KT
Frome the 2018-19 year consumption	6626	67%	4439
Two year old waste stream	1000	80%	800
5 year old waste stream	1000	80%	800
Total	8626	70%	6039
Total qty recycled in 2018-19 KT			6039

6 million tons recycled in 2018-19 which is 70% on waste stream

Source : ICPE/Industry estimate

*remaining 9 million are in long term usage
** 85% plastics consumption covered.
Rest are EP with long term usage.

Application wise consumption figure is reasonably practical, which has been calculated with the participation of major stake holders.

It is observed that in Western Europe some countries do not have any landfill at all. All waste, including plastics waste, are recycled or the energy is recovered fulfilling a proper scientific disposal system without making any negative impact on the environment. Western European countries consume most of the 60 MN Tonnes of plastics consumed in the EU. Japan, Australia and some more countries in South – East Asia are doing well in recycling of plastics.

It is thus imperative in above context that the caption statement of the UNEP report needs modification or clarification.

Having said that, there is no denying that world needs efficient plastics waste management system with the principal tool of recycling on the principle of circular economy.

"A circular economy development path in India could create annual value of 14 lakh crore (US$ 218 billion) in 2030, 40 lakh crores (US$ 624 billion) in 2050 compared with the current development scenario. This conclusion emerges from comparison of costs in the three focus areas. The analysis indicates that costs to provide the same level of utility would be significantly lower in the circular development scenario. Cost savings amount to 11% of current Indian GDP in 2030 and 30% in 2050.

A circular economy development path could significantly mitigate negative environmental externalities. For example, greenhouse gas (GHG) emissions could be 23% lower in 2030 and 44% lower in 2050 compared with the current development scenario, helping India deliver on its targets promised in the recently ratified Paris Agreement. This comparison is derived from the accumulated emissions in the three focus areas. Other negative externalities, such as those resulting from the linear use of virgin materials and water, and the consumption of synthetic fertilisers, would also decrease." (Ellen MacArthur Foundation, Circular Economy in India.)

In India, recycling of plastics is known to be in practice since the '60s. The driving force for recycling in the initial stage was mainly economics. The plastics waste was too valuable a product those days to throw away as the availability of basic raw material was limited and was expensive. Even today, almost all rigid plastics waste including plastic bottles (PET and other plastics) are recycled. No rigid plastics go to the waste stream; these are collected and recycled.

"Estimation of Global PET bottle production during 2004 to 2016 was about 485 billion and it is forecasted that in 2021, some 583.3 billion of these plastic bottles will be produced", according to M. Garside, 3, 2019.

Though all types of plastics are 100% recyclable either by mechanical recycling or feedstock recycling process or its latent energy is recoverable, a substantial quantity of plastics waste still remain abandoned due to lack of infrastructure for collection. To increase the recycling activity worldwide, large users of plastics have recently announced actions to replace virgin plastics by recycled plastics in substantial quantum. Latest commitments declared by top MNC's gives some indication of further reduction of virgin plastics in packaging by the year 2025 to 2030. **Co-Cola, PepsiCo, Nestle, Unilever, P and G and Colgate Palmolive would result** in further reduction of virgin plastics. This would result in environmental benefits by way of resource management and energy saving.

Global Petrochemicals operators also have now committed to put their efforts for collection of plastics wastes for recycling (recovery). Plastics Raw Materials manufacturers also have come forward to extend their active support in plastics waste management and recycling.

Dow Announced 100% of its Products Will Have Reusable or Recyclable Packaging by 2035.

By 2030, Dow will help "stop the waste" by enabling 1 million metric tons of plastic waste to be collected, reused, or recycled through its direct actions and partnerships. The company is investing and collaborating in key technologies and infrastructure to significantly increase global recycling. Beyond mechanical recycling, following non-conventional recycling processes have already been established in the world. Except a few, most of the options have been developed and used in India.

Feedstock / Chemical Recycling

Light Diesel Oil (LDO) from plastics waste: Waste generated out of mixed and co-mingled plastics and plastics materials made of a combination of different types of plastics, are generally difficult for conventional mechanical recycling process and are mostly abandoned in the waste stream creating an environmental issue. Pyrolysis technology helps to establish decentralised recycling process in urban localities without creating any environmental pollution.

Reducing Agent in Blast furnace for production of iron : Waste plastics are used as reducing agent in the blast furnace for the manufacture of iron from its ore. Use of coke in the blast furnace provides only one type of reducing agent – Carbon Mono-oxide - (CO). In contrast, use of plastics waste provides one additional reducing agent – Hydrogen (H) apart from Carbon Mono-oxide. The process also reduces generation of 'ash'. A steel manufacturing facility having production capacity of 3 million tons per anum, can consume 600,000 MTs of plastics waste. Japan is the leader in the world for implementing such process in various steel plants in their country. The chemical reactions involved is described below:

WITH ONLY COKE

$C + O2 = CO2$

$C + CO2 =$

$Fe2O3 + 3 CO = 2 Fe + 3 CO2$

WITH COKE + PLASTICS WASTE

$\frac{1}{2}$ $C2H4 + CO2 = Fe2O3 + 2 CO + H2 = 2 Fe + 2CO2 + H2O$

H2 is an additional reducing agent hence demand for COKE is less

About 20% Coke is replaced with Plastics Waste

Energy Recovery

1. **Co-Processing of plastics waste in Cement Kilns**
2. **Incineration for energy recovery / power generation**

Co-Processing in Cement Kilns: One of the most effective methods of recovery of energy from plastics waste is its use as an alternative fuel in cement kilns in partial replacement of coal. Around 60% coal has been substituted by plastics waste in the cement kilns in Germany. Coal requirement in a cement kiln is around 15% of the clinker capacity. Clinker Capacity in India in 2019 was around 300 Mn Tons. At the rate of 20% replacement of coal, plastics waste requirement would be 9 MN Tonnes. It is possible to co-process all abandoned and difficult to recycle plastics waste including thermosets, in cement kiln. The issue is collection of waste and transporting the same to the cement kilns. Generally, one tone of coal can be replaced by 600 kg of plastics waste due to higher calorific values of plastics compared to coal. Manufacturers and users of plastics should take the responsibility of this aspect so that all types of plastics wastes could be co-processed in the cement kilns. Cement companies have already started taking initiatives in bearing the transportation cost of the plastics waste from the nearby areas.

6 Bn tonnes of cement kiln capacity in the world can handle more than 300 Mn Tonnes of plastics waste in a year ending the global plastics waste recycling crisis.

Incineration for Energy Recovery / Power Generation: After the selection of various types of plastic waste for mechanical recycling, there may still remain some types of plastic waste, heavily contaminated with various types of contaminants including different toxic chemicals or hazardous products. When considering incineration as an option, it is to be remembered that waste incineration plants are to be operated with the aim of producing energy and curbing air pollution. The main purpose is and remains to reduce the volume of waste to a considerable degree by means of incineration in an environment friendly manner. Energy generation and utilisation of the same is an added value.

Use of plastics waste in the construction of asphalt road

Use of plastics waste in the construction of asphalt road has been demonstrated widely in India. Key properties of asphalt roads like Marshal Stability, stripping value of bitumen layer on the aggregates, penetration value on the road etc., are improved resulting in extending the life of the road by several years without any maintenance. Not only the cost of road construction is reduced (due to lower cost of plastics waste compared to that of bitumen) bitumen is also reduced, thus reducing dependence on petroleum-based products. About one million ton of mixed plastics waste can be consumed in this sector in India in about next five years.

Conclusion:

Plastics are most environment friendly products. Alternatives will have negative impact on the environment. Plastics waste, if it remains unattended, would cause environmental issues. As plastics are 100% recyclable, it is the responsibility of the manufacturers and users (packers) to arrange proper management of the plastics waste jointly with the respective government authorities. It is important for world today to address the waste management issues by adopting appropriate recycling process to reap the benefits of the safe and environment friendly material – Plastics.

★★★

BIO-MEDICAL WASTE

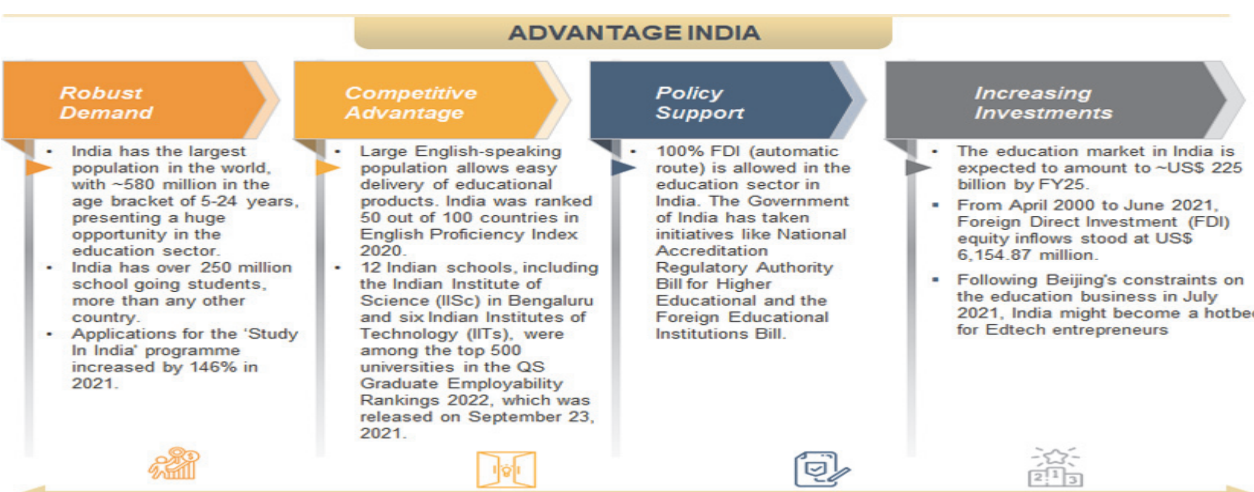
Challenges In Management Of Bio-medical Waste On The Backdrop Of Covid-19 Pandemic

Dr. Sanjay Joshi
Vice President, Paryavaran Dakshata Mandal,
Founder And Director,
Enviro-vigil's Common Biomedical
Waste Treatment And Disposal Facility,
Member, Technical Advisory Committee, NSWAI
sanjay.joshi1958@gmail.com

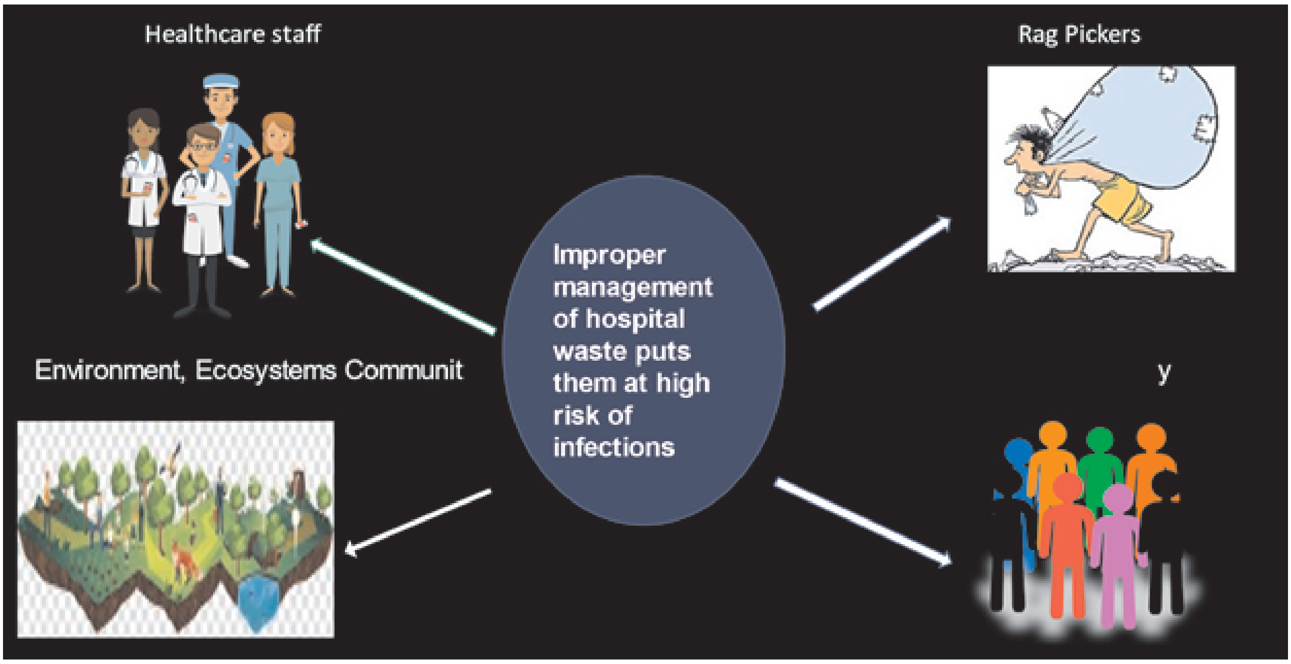
Introduction :

In India, the Healthcare has become one of largest sectors both in terms of revenue and employment. The industry is growing at a tremendous pace owing to its strengthening coverage, services and increasing expenditure by public as well private players. During 2008-20, the market is expected to record a CAGR (Compound Annual Growth Rate) of 17 per cent. India is expected to rank amongst the top three healthcare markets in terms of incremental growth by 2020.

The following infographic highlights the factors responsible for growth in health care sector in India.



The advent of disposables in the hospitals has brought in its wake, many illegal practices also. These include inappropriate recycling, unauthorized and illegal re-use and increase in the quantum of waste etc. All round technological progress has led to increased availability of health-related consumer goods, which have the propensity for production of increased wastes. The issue of improper hospital waste management in India was first highlighted in a writ petition in the Hon'ble Supreme Court; and subsequently, pursuant to the directives of the court, the Ministry of Environment and Forests, (Now MoEF andCC) Govt. of India notified the Bio-Medical Waste (Management and Handlings) Rules on 27th July 98; under the provisions of Environmental Protection Act 1986. According to these rules "Bio-Medical waste is any type of waste generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining to the production of drugs in pharmaceutical companies, animal waste generated in the veterinary hospitals and also in the animal houses etc." Bio-Medical waste is extremely hazardous, and if not managed properly, can lead to serious health and environment problems. The group of people that are a high risk of getting infection include doctors, nurses, technicians, sweepers, hospital visitors, patients, rag pickers and their relatives etc.



Apart from this category of waste that is highly infectious and is generally biodegradable, the other types of waste such ampoules, chemicals, radioactive wastes, pharmaceutical wastes, pressurized containers, batteries, plastics, low level radioactive wastes, food wastes, and other miscellaneous wastes also form a part of the hospital waste. Other types of waste include toxic chemicals, cytotoxic drugs, flammable and radioactive wastes. However, over the past nineteen years after the notification of BMW rules, with subsequent amendments, management of biomedical waste in India has become a topic of important concern.

Ironically, the Government response to BMW management issues has been slow to develop and largely unsuccessful in its attempts to govern and enforce the existing BMW management rules. According to a study conducted by the Indian Institute of Management (IIM) in Lucknow, "Presently 50 to 55 per cent of bio-medical wastes is collected, segregated and treated as per Bio-medical Waste Management Rules." So where is the rest of this waste going? It is dumped in hospital's backyards, thrown on the side of roads and mixed with municipal garbage.

Current Status of Bio-medical Waste Management in India.

As per the annual report information received from the State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs) and Director General of Armed Forces Medical Services (DGAFMS) for the year 2013, the bio-medical waste management scenario in the Country is given in Table 1.

As per the details given in Table 4, total number of Health Care Facilities (HCFs) in India have been reported as 1,68,869 (this may also contain number of HCFs which do not come under the purview of Authorization as required under BMW Rules) and 1,06,805 number of healthcare facilities applied for authorization.

Approximately 92.3% i.e., 447 out of 484 Tons per day bio-medical waste generated is being treated and disposed of either through 198 no. of Common Bio-medical Waste Treatment Facilities or captive treatment equipment installed by the HCFs. 548 no. of incinerators, 3112 autoclaves, 250 microwaves, 15 hydro-claves and 5179 shredders are installed by the HCFs as captive treatment equipment in the country. 198 no. of incinerators are operated by the CBWTFs. 331 (60.4%) out of 548 captive biomedical waste Incinerators operated by HCFs are provided with air pollution control devices. (ENVIS Newsletter, 2014).

An overview of the Bio-Medical Waste (Management and Handling) Rules, 1998 and subsequent amendments

The original Bio-medical Waste (Management and Handling) Rules of 1998 were comprehensive and stipulated that 'it shall be the duty of every occupier of an institution generating bio-medical waste which includes a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank as well as operator of a Common Bio-medical Waste Treatment Facility (CBWTF) to take adequate steps for environmentally sound management of such waste". Also "Every occupier of an institution generating, collecting, receiving, storing, transporting, treating, disposing and/or handling bio-medical waste in any other manner [except such occupier of clinics, dispensaries, pathological laboratories, blood banks providing treatment/service less than 1000 (one thousand) patients per month] shall obtain authorization". (ENVIS Newsletter, 2014). These rules were further amended in the year 2000 and 2003 so as to fill the gaps experienced while implementing the BMW Rules.

Through the first amendment in the year 2000, the provisions for prescribed authority i.e. State Pollution Control Board (SPCB)/ Pollution Control Committee (PCC) were stipulated for enforcement of the provisions of these Rules in the respective State/UT. Municipal Corporations, Municipalities or Urban and Local Bodies, as the case may be, made responsible for providing suitable common disposal/ incineration sites for the biomedical wastes generated in the area under their jurisdiction and in areas outside the jurisdiction of any municipal body, it shall be the responsibility of the occupier generating bio-medical waste/ operator of a bio-medical waste treatment facility (CBWTF) to arrange for suitable sites individually or in association, so as to comply with the provisions of these rules. The Municipal body of the area shall continue to pick up and transport segregated non-bio-medical solid waste as well as duly treated bio-medical wastes for disposal at municipal sanitary landfills. The BMW Rules were further amended in the year 2003, whereby Director General, Armed Forces Medical Services (DGAFMS) notified as Prescribed Authority for enforcement of the BMW Rules by the Health Care Establishments (HCEs) under the Ministry of Defense. Advisory Committee for implementation of the BMW Rules by the HCEs under the Ministry of Defense is also required to be constituted under the Chairmanship of Additional Director General of Armed Force Medical Services and other members from Ministry of Defense, MoEF, Indian Society of Hospitals Waste Management, Pune. CPCB has a limited role and is required to monitor the implementation of the BMW Rules by the Armed Forces Health Care Establishments under the Ministry of Defense.

Bio-Medical Waste Management Rules, 2016.

In the latest amendment in 2016 some new provisions have been incorporated thus increasing the responsibilities of the operators of CBTWF. These new rules are amended in exercise of the powers conferred by section 6, 8 and 25 of the Environmental (Protection) Act, 1986 (29 of 1986) and in suppression of the Biomedical Waste (Handling and Management) Rules,1998 except as respects things done or omitted to be done before such suppression, the Central Government, Ministry of Environment, Forests and Climate Change have made these rules which bear short title as the **Bio-Medical Waste Management Rules, 2016.**

In these rules, in addition to various sources of generation of BMW as mentioned in the original rules of 1998, some new establishments have been added as the sources of generation of the same. These are, Ayush hospitals, research or educational institutions, health camps, medical or surgical camps, vaccination and blood donation camps, first aid rooms of the schools and the forensic laboratories.

Following are the important provisions incorporated into this new amendment of 2016:

1. In the original definition of the “Occupier”, there is an addendum, “irrespective of their system of medicine”. It means the family physician of every pathy is covered and also, the Duties of occupier are described in details.
2. Laboratory waste, microbiological waste, blood samples and blood bags must be pretreated through disinfection or sterilization on-site in the manner as

prescribed by the World Health Organization (WHO) or National AIDs Control Organization (NACO) guidelines and then sent to the common bio-medical waste treatment facility for final disposal.

3. Establishing the Bar-Coding system with GPS to monitor movement of every storage bag from distribution to disposal. Thus, it is mandatory for the occupiers to use only those storage bags, that are imprinted with Bar Codes.
4. Chlorinated plastic bags to be used for collection, treatment and disposal should be phased out within 2 years.
5. Duties of the operator of a common biomedical waste treatment and disposal facility are newly introduced.
6. Record of Recyclable BMW should be maintained and should be made available to SPCB.
7. If application of Authorization remains as pending with the authorities for more than 90 days, applicant should presume that the facility has got the authorization (conditions apply).
8. Local self-government is liable to provide adequate land for common BMW facility.
9. Cytotoxic drugs should be returned back to the manufacturer or send for incineration at temperature >1200°C.
10. Glassware and Metallic Body Implants, broken or discarded glass should be stored in Cardboard Boxes with Blue Colored marking instead of Plastic Bag.
11. Dead Fetus should be considered as Anatomical waste.
12. Bio-medical waste generated in households during healthcare activities shall be segregated and should be handed over to CBMWTSDF.
13. Secondary chamber gas residence time shall be at least 2 seconds.

Summary of special guidelines issued by Central Pollution Control Board for managing biomedical waste from COVID-19 patients

To deal with COVID-19 pandemic, State and Central Governments have initiated various steps, which include setting up of quarantine centers/camps, Isolation wards, sample collection centers and laboratories. Specific guidelines for management of waste generated during diagnostics and treatment of COVID-19 suspected / confirmed patients, have been released by CPCB and are required to be followed by all the stakeholders including isolation wards, quarantine centers, sample collection centers, laboratories, ULBs and common biomedical waste treatment and disposal facilities, in addition to existing practices under BMW Management Rules, 2016. Guidelines for handling, treatment and disposal of COVID-19 waste at Healthcare Facilities, Quarantine Camps/ Quarantine-homes/ Home-care, Sample Collection Centers, Laboratories, SPCBs/PCCs, ULBs and CBWTFs are summarized as follows:

a. COVID-19 Isolation wards: (isolation wards are those where COVID-19 positive patients are being kept for treatment / diagnosis

Healthcare Facilities having isolation wards including temporary Healthcare Facilities like rail coach wards, COVID Care Centers etc. for COVID-19 patients need to follow these steps to ensure safe handling and disposal of biomedical waste generated during treatment.

- Keep separate color-coded bins in wards and maintain proper segregation of waste as per BMWM Rules, 2016 as amended and CPCB guidelines for implementation of BMW Management Rules.

- As precaution double layered bags (using 2 bags) should be used for collection of waste from COVID-19 isolation wards so as to ensure adequate strength and no-leaks;

- Collect and store biomedical waste separately prior to handing over the same CBWTF. Use a dedicated collection bin labelled as "COVID-19" to store COVID-19 waste and keep separately in temporary storage room prior to handing over to authorized staff of CBWTF. Biomedical waste collected in such isolation wards can also be lifted directly from ward into CBWTF collection van.

- In addition to mandatory labelling, bags/containers used for collecting biomedical waste from COVID-19 wards, should be labelled as "COVID-19 Waste". This marking would enable CBWTFs to identify the waste easily for priority treatment and disposal immediately upon the receipt.

- General solid waste comprising wrappers of medicines/syringes, fruit peel offs, empty juice bottles or tetra packs, used water bottles, discarded papers, carton boxes of medicines, empty bottles of disinfectants, left-over food, disposable food plates etc., should be collected separately as per SWM Rules, 2016.

- To minimize waste generation, as far as possible, non-disposable items must be used for serving food, which are to be handle with appropriate precautions and cleaned and disinfected as per hospital guidelines.

- If use of disposable items is inevitable, use bio-degradable cutlery. The wet and dry solid waste bags to be tied securely in leak-proof bags, sprayed with sodium hypo-chlorite solution and hand over to authorized waste collector of ULB's on daily basis. Yellow colored bags should not be used for collecting general solid waste. Compostable bags should be used for collecting wet-waste.

- Collect used PPEs such as goggles, face-shield, splash proof apron, Plastic Coverall, Hazmet suit, nitrile gloves into Red bag;

- Collect used mask (including Triple layer mask, N95 mask etc.), head cover/cap, shoe-cover, disposable linen Gown, non-plastic or semi-plastic coverall in Yellow bags.

- Used masks, tissues and toiletries, of COVID-19 patient shall become biomedical waste and shall be segregated in yellow bag.

- Segregation of biomedical waste and general solid waste should be done at the point of generation in wards / isolation rooms. There should be no segregation of biomedical waste and solid waste at temporary waste collection / storage area of Healthcare Facility to ensure occupational safety.

(b) Sample Collection Centers and Laboratories for COVID-19 suspected patients

Report opening or operation of COVID-19

sample collection centers and laboratories to concerned SPCB/PCC. Guidelines given at section (a) for isolation wards should be applied suitably in in case of test centers and laboratories. Pre-treat viral transport media, plastic vials, vacutainers, Eppendorf tubes, plastic cryovials, pipette tips as per BMWM Rules, 2016 and collect in Red bags.

(C) Responsibilities of persons operating Quarantine Centers/Camps/Home Quarantine or Homecare facilities

Less quantity of biomedical waste is expected from quarantine Camps / Quarantine Home/ Homecare facilities. However, the persons responsible for operating quarantine camps/centers/home-care for suspected COVID-19 persons need to follow proper steps to ensure safe handling and disposal of waste;

-General solid waste should comprise of waste generated from kitchen, packaging material, waste food material, waste papers, waste plastics, floor cleaning dust, etc. including left-over food, disposable utensils, water bottles, tetra packs, used by suspected quarantined persons and COVID-19 patient at homecare or home quarantine.

- Only the used masks, gloves and tissues or swabs contaminated with blood / body fluids of COVID-19 patients, including used syringes, medicines, etc., if any generated should be treated as biomedical waste.

- Biomedical waste if any generated from quarantine centers/camps should be collected separately in yellow bags (suitable for biomedical waste collection) provided by ULBs. These bags can be placed in separate and dedicated dust-bins of appropriate size. General waste should not be stored in yellow bags.

(d) Duties of Common Biomedical Waste Treatment Facility (CBWTF):

- Report to SPCBs/PCCs about receiving of waste from COVID-19 isolation wards / Quarantine Camps / Quarantined homes / COVID-19 Testing Centers;

- Operator of CBWTF shall ensure regular sanitization of workers involved in handling and collection of biomedical waste;

- Workers shall be provided with adequate PPEs including three-layer masks, splash proof aprons/gowns, nitrile gloves, gum boots and safety goggles;

- Use dedicated vehicle to collect COVID-19 ward waste. It is not necessary to place separate label on such vehicles;

- Vehicle should be sanitized with sodium hypochlorite or any appropriate chemical disinfectant after every trip.

- COVID-19 waste should be disposed-off immediately upon receipt at facility. In case it is required to treat and dispose more quantity of biomedical waste generated from COVID-19 treatment, CBWTF may operate their facilities for extra hours, by giving information to SPCBs/PCCs.

- Operator of CBWTF shall maintain separate record for collection, treatment and disposal of COVID-19 waste.

- Do not allow any worker showing symptoms of illness to work at the facility. May provide adequate leave to such workers and by protecting their salary.

- CBWTF operator shall register on 'COVID19BWM' Tracking App developed by CPCB and also ensure registration of Waste Handler (with vehicle) for entering the data of COVID-19 biomedical waste received and disposed.

e) Disposal of used PPEs

- Waste masks and gloves in general households should be kept in paper bag for a minimum of 72 hours prior to disposal of the same as dry general solid waste after cutting the same to prevent reuse.

- Discarded PPEs from general public at commercial establishments, shopping malls, institutions, offices, etc. should be stored in separate bin for 3 days, thereafter disposed of as dry general solid waste after cutting/shredding.

- At Material Recovery Facilities (MRFs), discarded PPEs containing plastic should be shredded and sent to SPCB authorised plastic waste recyclers, or may be converted into refuse derived fuel (RDF) for co-processing or energy recovery (in Waste to Energy Plants) or for road making. Shredded PPEs may be disposed at landfill only in case the requisite infrastructure as required under SWM Rules is not available in the State.

- Used PPEs taken off by healthcare workers accompanying diseased body of COVID-19 patient to crematorium / graveyards should be treated as biomedical waste and disposed as per provisions under SWM Rules, 2016 and BMW Management Rules, 2016.

***

Covid Waste And Its Consequences On Waste Management Sector In India

Dr. K. Balachandra Kurup
Governance And Social Development Specialist
balan_kurup@yahoo.com

1. Introduction :

Waste management is becoming increasingly challenging and complicated due to diverse categories of materials coming in the waste stream, especially due to COVID- 19. This situation is evident in all urban, peri-urban and rural areas due to improper sanitation and drainage problems and degraded environmental issues. It was reported that the total solid waste generated in India is around 42 million tons annually. Waste generation varies from 200-600 kg/capita/day and collection efficiency ranges from 50-90%.

The outbreak of COVID-19 has created health crisis across the nation along with diverse impacts on economy, society and environment. COVID waste has emerged as a critical component in the waste stream and severally affected the hospitals, nursing homes, quarantine centres, the environment and humanity.

Covid waste generation and disposal is a significant factor, especially in countries with poor infrastructure, hygiene and high population growth. Medical centres including hospitals, clinics, and places where diagnosis and treatment are conducted generate wastes that are highly hazardous and put people under risk of fatal diseases.

2. Evolution of COVID-19 waste and trends

The first case of COVID-19 was reported in India were reported in the towns of Thrissur, Alapuzha and Kasargod (Kerala) among three Indian medical students who had returned from Wuhan in January/February 2020. Little information was provided regarding the initial COVID-19 cases, and thus, it is unknown whether they were contacts of the first case or whether they had travel history. On 30 January 2020, government of India initiated awareness of proper hygiene and sanitation steps to protect from the spread of diseases.

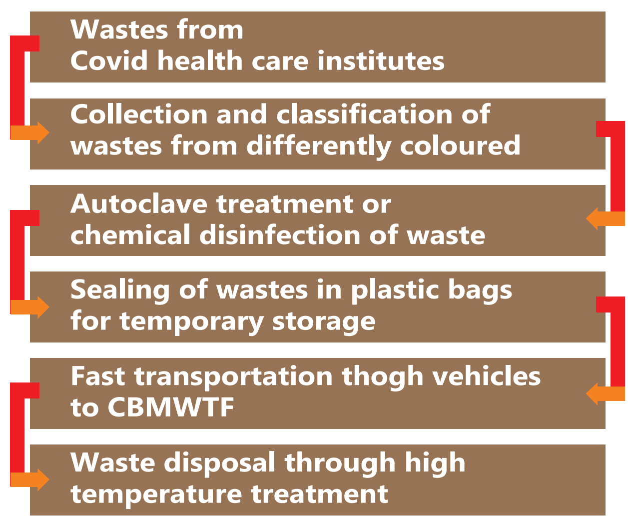
The pandemic has shown increased use of sanitary goods, PPE, and other healthcare products which has triggered to an increase of the generation of different hazardous and contagious wastes. The population has been falsely convinced that there have been environmental benefits with decreased environmental pollution. This has resulted in the production of excessive solid/plastic wastes and Covid wastes.

The containment of the spread of COVID-19 pandemic and limitations on commercial activities, mobility and manufacturing sector have significantly affected waste management scenario. The invaluable service provided by the waste management sector ensures that the unusual heaps of waste that poses health risks and escalate the spread of COVID-19 is avoided.

A second wave beginning in March 2021 was much larger than the first, with shortages of vaccines, hospital beds, oxygen cylinders and other medicines in parts of the country.[15] By late April, India led the world in new and active cases. On 30 April 2021, it became the first country to report over 400,000 new cases in a 24-hour period. Highly dense population stays in these regions generates a heterogeneous type of solid waste daily which consist about 70% to 80% of the total waste generated per day in India. As per the MNRE report 2018, overcrowded states such as Maharashtra, Tamil Nadu, Uttar Pradesh, National capital Region, Gujarat, Karnataka and West Bengal generates a tremendous amount of waste in the country.

The waste burden correlates with spread of diseases and infections. In one year, India generated 56,898 tonnes of COVID-19 bio-medical waste between June 2020 to June 2021, data from the Union Ministry of Environment, Forest and Climate Change.

In India we have around 198 Biomedical Waste Treatment Centers (BMWTC) along with around 225 medical centers with well-developed waste management facilities. Simple arithmetic revealed that such infrastructure is very poor to handle such large amount of COVID wastes. Therefore, development of several mobile incinerators, several campaigning regarding awareness of waste segregation may be an alternative to address this crisis. The chart given below give an Overview of COVID waste management, the information of which collected from different health care institutes practiced in India (Hindustan Times 2020.



Overview of COVID waste management, the information of which collected from different health care institutes practiced in India.

Maharashtra is the worst affected state due to the current pandemic, and in non-COVID-19 situation, it is among the top BMW generating states in India and with comparatively better management facilities. The state has 60,414 healthcare facilities, where 50, 440 kg/day of BMW is generated from bedded hospitals, 11,793 kg/day is generated from non-bedded hospitals and 185 kg/day is generated from other sources. states that the state has 60,414 healthcare facilities, where 50,440 kg/day of BMW is generated from bedded hospitals, 11,793 kg/day is generated from non-bedded hospitals and 185 kg/day is generated from other sources. Of the total hospital waste generated, approximately 10% is hazardous, 85% is general (non-risk) waste while a small percentage (5%) is labelled as highly hazardous. Pollution Control

The tremendous increase in the use of PPE — like gloves, face masks, and gowns, by healthcare workers, fuelled by the outbreak are disposable after single use generating an enormous amount of plastic waste (WHO, 2016). Besides, the protective equipment used by the healthcare staff and infected patients inside an ambulance including hoods, masks, gloves, gowns, during their transfer to healthcare facilities, are generally disposed of post transport. Moreover, the increased biomedical waste generation from laboratory studies and testing which includes a considerable proportion of plastics also contributes to the problem. It is understood that the infectious plastic waste generated from hospitals and at homecare facilities are not being fully collected, treated, and disposed of as per the biomedical waste management rules.

3. BMW/Covid waste Policies and regulations

The National Solid Waste Association of India (NSWAI) is the only leading professional non-profit organization in the field of Solid Waste Management and also Biomedical Waste and Hazardous waste in India. It was formed on January 25, 1996 under the dynamic leadership of Dr. Amiya Kumar Sahu. Founder, NSWAI helps the Ministry of Environment and Forest (MoEF), New Delhi in various fields of solid waste management makes policies and action plans. The other regulatory framework for waste management is related to Indian government initiatives for waste management under Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT), "Recycled Plastics Manufacture and Usage Rules (1999) amended and now known as The Plastics Manufacture and Usage (Amendment) Rules (2003), "Draft Guidelines for Sanitation in Slaughter Houses (1998)" by Central Pollution Control Board (CPCB), Non-biodegradable Garbage (Control) Ordinance, 2006, Municipal Solid Wastes (Management and Handling) Rules, 2000, etc. At the national policy level, the ministry of environment and forests has legislated the Municipal Waste Management and Handling Rules 2000.

The first standard on the subject to be brought out in India was by the Bureau of Indian Standards (BIS), IS 12625: 1989, entitled 'Solid Wastes- Hospitals-Guidelines for Management' (Annexure 7.1) but it was unable to bring any improvement in the situation. In this scenario, the notification of the 'Biomedical waste

(Management and Handling) Rules, 1998' assumes great significance. The Ministry of Environment and Forests of the Government of India has enacted the Biomedical Waste (Management and Handling) Rules, which came into effect on 20th July, 1998.These rules are applicable to every hospital and nursing home, veterinary institution, animal house or slaughterhouse that generates biomedical waste. According to Biomedical Waste (Management and Handling) Rules, 1998 of India "Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals".

The World Health Organization (WHO) reports revealed that 85% of hospital wastes are actually non-hazardous, whereas 10% are infectious and 5% are non-infectious.

The Government of India was quick to recognize the threat of COVID-19 and introduced a series of steps expeditiously to contain the transmission. Protective measures such as thermal screening, travel history, securing symptoms of the disease, and airport screening began at the end of January. The Government also started dedicated and aggressive public awareness campaigns through multiple media channels. The innovative messages and mode of communication were effective in convincing the public to react enthusiastically and in a spirited manner to the Government's directive, including a countrywide lockdown, which began on 24 March. Physical distancing, personal hygiene, and use of face masks were emphasized and are widely practised, with remarkable compliance. After the completion of 3 weeks of the first lockdown, it was further extended by an additional 5 weeks. The Government has introduced and implemented a series of innovations including a novel smartphone application called Aarogya Setu for contact tracing and aiding in quarantine and related containment measures.

Considering the magnitude of problem associated with BMW management during pandemic, Central Pollution Control Board (CPCB) has initially formulated guidelines (Guidelines for Handling, Treatment and Disposal of Waste Generated during Treatment/Diagnosis/Quarantine of COVID-19 Patients) based on current knowledge on COVID-19 and from other contagious diseases. CPCB has been issuing specific guidelines on segregation, collection, storage, transportation and disposal of COVID-19 wastes generating from the treatment facilities. It is encouraging to note that the Central Pollution Control Board (CPCB) has been in the forefront to come up with timely guidelines towards BMW-COVID-19.

The guidelines further stipulated that the Common Bio-Medical Waste Treatment Facilities (CBWTF) operators "shall ensure regular sanitisation of workers involved in handling and collection of biomedical waste and that they should be provided with adequate personal protective equipment". PPE has been suggested as mandatory for all medical personnel with probable exposure to the virus including staff, persons involved in handling of any material exposed to COVID-19 care facilities. The National Green Tribunal, India, expressed the need for further revision of the guidelines so that all aspects of scientific disposal of liquid and solid waste management are taken care of not only at institution level but also at individual levels, such as manner of disposal of used Personal Protection Equipment (PPE), without the same getting mixed with other municipal solid waste causing contamination. Administrations and the management of the service providers are required to provide adequate PPEs for the human resources handling BMW as prescribed in the guidelines.

4. Plastics and Covid wastes :

Plastics are one of the significant components of medical equipment and allied products. However, mixed plastics like that of single use masks with layers of plastics combined with other materials also pose a great threat to the environment due to their low recyclability The inadequacies and discrepancies in the existing waste management systems like shortage of staff, capacity constraints, capability of handling of treatment facilities, disruptions in recycling facilities due to the pandemic, could lead to improper disposal of wastes polluting the environment.

The waste collection and transportation workers in the hospital segregate the recyclable material for sale. In a similar way, all disposable plastic items are segregated by the waste pickers, from where the waste is deposited either inside the hospital grounds, or outside in the community bin for further transportation and disposal along with municipal solid waste. Since the infectious waste gets mixed with municipal solid waste, it has potential to make the whole lot infectious in adverse environmental conditions. It is reported that in some places/localities biomedical waste generated from health care facilities are collected without segregation into infectious and non-infectious categories and are disposed in municipal bins located either inside or outside the facility premises.

Despite the progress made in plastic sustainability and waste management, there have been widespread drawbacks in the use and management of plastics during COVID-19 pandemic. Alarming cases of infection have exerted personal protective equipment (PPE) (containing a substantial proportion of plastic) as the most reliable and affordable defence system against infection and transmission of the virus.

The demand for plastic in other sectors (automobiles, aviation, construction) has, however, drastically reduced during the economic crisis. The public perception and fear about hygiene and health safety has altered their mind set of reusable cups, bags, etc. has reduced the plastic waste generation. The loss of people's faith in products without packaging could risk the return of the throw-away culture and cause the resurgence of usage of single-use plastics. Also, the consumer behavioral changes also affected the increased use and disposal of single-use plastics contributing to the plastic waste problem.

5. Covid 19 and environmental monitoring

With limited available solutions, there is a substantial need for innovations which should address key challenges in covid waste/plastic waste collection and integrating new technologies in segregation and treatment into the existing waste management system. Scientific sterilization of infectious waste at on-site treatment facilities of healthcare centers like steam-sterilization (autoclaving), energy-based treatments (microwave, radiowave), incineration, chemical disinfection would guarantee the reduced risk of viral transmission from contaminated PPE and other plastic waste

6. Conclusion

The COVID-19 pandemic has developed an increased awareness and usage of sanitary goods, PPE, and other healthcare products which has resulted into generation of different hazardous and contagious wastes. The isolation wards/hospitals/quarantine centers/home-quarantines should follow careful collection of all used and non-used health related items in double-sealed bags/bins for their disposal based on Government guidelines. The roles of local civil bodies are also very significant for the timely collection and disposal, although many waste management facilities face the manpower shortage during the lockdown period. The health workers as well as sanitization workers should use sanitizer after proper removal of PPE and facemasks.

The challenge before us is to scientifically manage growing quantities of biomedical/Covid waste that go beyond past practices. If we want to protect our environment and health of community, we must sensitize ourselves to this important issue not only in the interest of health managers but also in the interest of community. To deal with the current situation, there is a need to prepare infrastructure and operation modalities for fastest disposal and aggressive disinfestation during the holding period. This calls for setting up additional incineration facilities in short time frame near Covid-19 hotspots.

Higher degree of protection should be rendered to waste handlers as they may be prone to infection in view of their health security and to contain further possibilities of secondary infection. The central government and the state governments need to be stricter and more attentive while considering government and none should go without treatment following these procedures and guidelines issued by the government. Public awareness for the segregation of waste should also be promoted that might help to segregate the waste like masks and gloves which are used in homes as well to be treated before it can harm any other human beings.

To overhaul the covid waste management sector we need to induce appropriate personal behavioural and social institutional changes. An integrated approach of environmental processes and governance is required for effective solid waste management. Effective institutional framework needs to be established along with policy-level directions which will facilitate the required change. Specific colored bags might be provided by the local authority to households to dispose of PPE kits (mask, gloves) in sealed bags, which makes them easy for separation and treatment along with biomedical wastes. Besides, appropriate policies should be framed to avoid spread of infections by providing specification for handling waste for generation, segregation, collection, storage, transportation, and treatment. Awareness should be created at all levels of society through various means of communication and education, so that the risks of spreading the health hazards could be minimized.

References :

1. CPCB-Central Pollution Control Board, Government of India- Guidelines for Handling Treatment and Disposal Waste Generated during Treatment, Diagnosis and Quarantine of COVID-19 Patients, Revision 2, Ministry of Environment, forest and climate change (2020)

2. Hem Chandra, Hospital Waste an Environmental Hazard and Its Management, (1999).

3. B.N. Kulkarni, V. Anantharama- Repercussions of COVID-19 pandemic on municipal solid waste management: challenges and opportunities, Sci. Total Environ., 743 (2020), p. 140693

4. Kumar Raja Vanapalli et.al, Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic, Science of the Total Environment 750 (2021).

5. Hindustan Times, 2020.

6. Patil G.V., Pokhrel K., "Biomedical solid waste management in an Indian hospital: a case study.", Waste Management 25(6) p 592-599, 2005

7. Dr. K. Balachandra Kurup- Need of the hour is Integrated Thinking and Action, EPC World, Mumbai, December 2014, pp 116-120;

8. Dr. K. Balachandra Kurup, Biomedical Waste management in India, Challenges and Constraints, 6th National Conference on Urban, Biomedical and Industrial Waste Management at Ahmedabad Management Association (AMA), Ahmedabad, 21-22, August 2015

9. Dr Sunil Kumar's presentation on "Science and Technology: Municipal Solid Waste Management in India" on 7 November 2017

10. P. Duarte, V.T. Santana- Disinfection measures and control of SARS-COV-2 transmission, Global Biosecurity, 1 (3) (2020)

11. Sharma et.al 2020, Challenges, opportunities, and innovations for effective solid waste management during and post COVID-9 pandemic. Resources, Conservation and Recycling 2020. https://doi.org/ 10.1016/j.resconrec.2020.105052.

12. WHO-World Health Organization - Water, Sanitation, Hygiene, and Waste Management for the COVID-19 Virus: Interim Guidance, (2020)

***

WASTE TO ENERGY

Energy From Waste – Challenges And Opportunities

Dr Lakshmi Raghupathy
Former Director, Ministry Of Environment Forests And Climate Change
Visiting Faculty TERI School Of Advanced Studies
lakshmi.raghupathy23@gmail.com

1.0 Introduction

Waste management has become a major global issue with the exponential increase in the waste generated in every human activity. According to the recent reports the world generates about 2.01 billion tons of municipal solid waste annually which is not managed in an environmentally safe manner. In Climate Change COP 26 waste management was discussed on priority along with concepts of Circular Economy, Zero Pollution, and Climate Neutrality. Role of Waste-to-Energy in reducing the requirement of non-renewable fuel resources was debated.

According to the recent World Bank Report, 2019 municipal waste comprises of 44% is green and food waste; 17% paper; 12% plastic; 5% glass; 4% metal; and 18% others [1,2]. The waste management practice includes composting, recycling, incineration and mostly landfilling either controlled or uncontrolled dumping. Although municipal solid waste is the major waste stream there are other waste streams such as the industrial wastes, biomass waste, plastic waste, biomedical waste, electronic waste etc.

2.0 Waste to Energy – Global Scenario

The concept of waste-to-energy (WTE) has developed since 1970 and has been implemented in the developed countries for waste management and energy security. Today waste to energy techniques have attained modernization as well as importance, facilitating waste management and energy security. The world over waste management hierarchy is used for integrated solid waste management systems. 3R principle is incorporated into waste management plans for resource recovery which includes energy recovery options using thermal

WTE technology [1,2].

There are about 2,450 WTE plants worldwide and 330 million tons of wastes are processed to produce energy every year. Europe has the largest number of WTE plants, with 598 plants in operation to achieve the target of 65% reduction landfill by 2030, the WTE plants convert 20% of the MSW. In the Sweden Denmark and Norway, about 60-80 WTE plants have been set up in 2020. In Asia Pacific region there are 1162 WTE plants are located in, China has 299 WTE plants, Japan has and Taiwan has 25 WTE plants. China has highest number in the Asian region. USA has 87 WTE plants producing 2,700 megawatts electricity as a solution for preventing landfills that takes care of 7% of the MSW. According to the recent reports 80% of thermal waste to energy plants are located in developed countries such as Japan, France, Germany and the United States.

In developing countries, the major issues are low calorific value and high moisture content of waste that remain a critical technical challenge for thermal WTE plants. The calorific value of waste should average at least 7 MJ/kg at the lowest. A large scale modern thermal WTE plant requires at least 100,000 MT/yr. of MSW. Thermal WTE have the potential to reduce the waste destined to landfill at the same time provides alternate source of energy to reduce the use of nonrenewable energy.

3.0 Waste to Energy – India

In India, the waste generated is mostly dumped outside urban living area of every township or village. It has become a major national issue. These landfills or dumpsites poses huge threat to environment producing green-house-gases (GHG) (methane and carbon-di-oxide) and generates leachates, contaminating the air, water and soil. Waste to Energy units can reduce dump size, but also produce energy from the same, thus achieving our goal of waste management as well as energy security.

The waste generation in India is estimated to be 36.5 million tonnes of solid waste annually. According to Ministry of Environment Forests and Climate Change 75-80% of the municipal solid waste gets collected but only 22-28% is processed or treated. It is estimated that the amount of waste generated in India will increase at a per capita rate of approximately 1-1.33% annually.

3.1 Waste Management Regulations

The Waste Management Regulations notified under the Environment (Protection) Act 1986 include:

1. Solid Waste Management Rules, 2016 [2000]
2. Hazardous and Other Waste (Management and Transboundary) Rules 2016 [1989]
3. Construction and Demolition Waste, 2016
4. Plastic Waste Management Rules, 2016 [1999]
5. Bio-Medical Waste Management Rules, 2016 [1998]
6. E-waste Management Rules 2016 [2011]

The waste management regulations are framed on the principle of Waste Management Hierarchy (WMH) depicted in the Fig. 1.

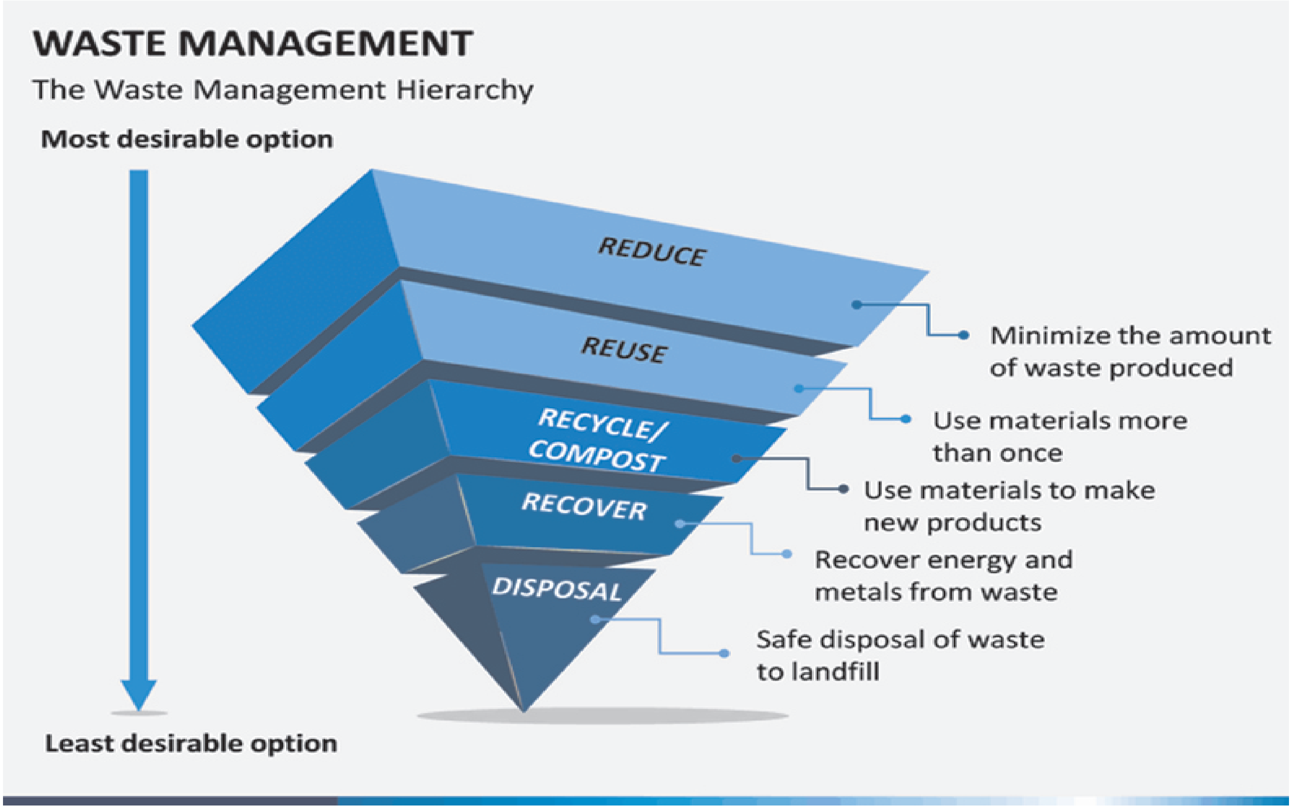


Fig - 1 Waste Management Hierarchy

4.0 Energy Potential from Waste

MSW contains organic waste up to 56% but yields a low calorific value due to high moisture content. The WTE plant requires wastes with minimal average calorific value of 1500kcal/kg, and needs significantly high investment, operation and maintenance costs.

The types of waste suitable for energy production are urban waste, industrial waste or agriculture biomass waste that comprises of different types of organics. The organic waste essentially contains carbon-based compounds and has significant portion in overall waste generation in industrial/urban/ agricultural sector and it can be used for energy generation.

1. **Urban Waste**
   - **Municipal Solid Waste (Biodegradable/ Non-Biodegradable organic waste)**
   - **Sewage and fecal sludge**
2. **Industrial Waste (Hazardous organic or Non-Hazardous organic)**
3. **Biomass Waste (agricultural and forest wastes, aquatic biomass).**

4.1 Waste-to-Energy (WTE) Technologies

The municipal solid waste, the industrial waste and the biomass waste have all the potential to produce energy that can be converted into heat, fuel or electricity. The technologies used for energy recovery essentially comprises of biochemical, thermal, thermo-chemical and electrochemical methods. Fig. 2 illustrates how MSW is used to produce energy using various technologies.

1. **Bio-chemical conversion:** This process

is based on enzymatic decomposition of organic matter by microbial action in the absence of oxygen to produce biogas, a combustible mixture of methane (60%) and carbon-di-oxide (40%) and the residue that can be used as manure. The biogas can also be cleaned to remove the carbon dioxide to produce Bio CNG to be used as natural gas or as a vehicle fuel.

2. Thermal Conversion: The process involves degradation of waste under high temperature also known as incineration. This is complete combustion of the waste under controlled conditions with the recovery of heat to produce steam that can be used to produce power through steam turbines. The incinerators require extensive air pollution control systems to treat the flue gases produced and ash produced can be used as construction material This technology is well established and has been used in many WTE plants globally Incineration efficiency is improved by converting the combustible fraction of the waste into Refuse Derived Fuel (RDF) to enhance the calorific value of the waste.

3. Thermo-chemical conversion: This process uses high temperature decomposition of organic matter in absence of oxygen to produce either heat energy or fuel oil or gas or its combination. The technological options include Gasification and Pyrolysis which are less polluting than incineration. Gasification is a thermal conversion process carried out at high temperature 500-1800°C in the presence limited amount of oxygen or air producing a mixture of carbon monoxide and hydrogen gas also known as 'synthesis gas' (syngas) or 'producer gas'. Pyrolysis is process that uses heat energy to break down combustible polymeric materials in the absence of oxygen producing combustible gases such as methane, hydrogen, carbon monoxide and complex hydrocarbons, liquids and solid residue.

4. Electrochemical conversion: Electrochemical conversion in the context of waste to energy refers typically to microbial fuel cells (MFC). These systems are developed to trap the energy from wastes, where the reduction-oxidation machinery of immobilized microbial cells is catalytically exploited, for the accelerated transfer of electrons from organic wastes, to generate electricity and bio-hydrogen gas. This method is being experimented for use in mass transport systems.

5. Refuse Derived Fuels: Refuse Derived Fuel (RDF) is produced after drying the waste to remove moisture and removal of non-combustible material. RDF is a renewable energy source that can be burned to produce electricity. The calorific value of RDF ranges between 2000 – 4000 Kcal/Kg and 1ton of coal can be substituted by 1.3 tons of RDF. RDF is used in Cement kilns, power plants, blast furnaces, industrial boilers etc.

6. Co-generation: Cogeneration is also known as combined heat and power (CHP), generation. In India cogeneration is often associated with sugar industries, as the sugar mills use their own bagasse which is a waste by-product, to run their mills and generate steam to run the boilers and turbines that produce heat and electricity.

7. Co-processing: Co-processing means the use of suitable waste materials in manufacturing processes for the purpose of energy and /or resource recovery and the resultant reduction in the use of conventional fuels and/or raw materials through substitution of the virgin material. Alternate Fuels and Raw Materials (AFR) use in cement plant adds to both fuel and raw material intake. The materials used AFR include Used tires, Meat and bone meal, animal fat, Plastics, Packaging waste, Waste wood, impregnated saw dust. Co-processing in cement plants is the best option for hazardous wastes as the operations are carried out at temperatures above 1450˚C.

Fig - 2 Technology Options for MSW-ENERGY

5.0 India's Waste to Energy Potential

According to the Ministry of New and Renewable Energy (MNRE), India has a potential of about 1700 MW from urban waste including sewage sludge and 1300 MW industrial organic waste. MNRE is also actively promoting the generation of energy from waste, by providing subsidies and incentives for the projects. As of December 2019, about 26 waste to electricity plants were functional across India.

5.1 Indian Government Support for Waste to Energy

The Indian Government has recognized waste to energy as a renewable technology and supports it through various subsidies and incentives. The Ministry of Environment Forests and Climate Change (MoEFCC) has provided the legal provisions to enable waste to energy plants and the Ministry of New and Renewable Energy (MNRE) is actively promoting all the technology options available for energy recovery from urban and industrial wastes.

The NITI Aayog has proposed setting up an authority for the installation of ' waste to energy ' plants under the public-private partnership (PPP) mode to clean up municipal solid waste that poses a serious threat to the public health.

5.2 Financial Support for projects

1. **GEF-MNRE-UNIDO Project:** A Financial Support Scheme to Promote Innovative Industrial Organic Waste-to-Energy (IOWtE) Announced on 10 August 2021 on the occasion of World Biofuel Day (10 August 2021)

2. **New Guidelines:** Notified for "Programme on Energy from Urban, Industrial, Agricultural Wastes/Residues and Municipal Solid Waste" and "Scheme to Support Promotion of Biomass Based Cogeneration in Sugar Mills and Other Industries in The Country"- Notification of new guidelines-reg. (13 May 2021)

3. **Applications** were invited under the current Biomass Cogeneration and Waste to Energy Schemes. (Deadline for submission 25 Mar, 2021).

4. **Concessional Custom Duty Certificates (CCDCs)** were issued for setting up projects for generation of Compressed bio-gas (Bio-CNG) using Urban and Industrial Wastes of Renewable Nature. (Reg. Dated: 25 Jan, 2021.

5. **CFA/registration of projects:** Under Waste to Energy projects Registration Submission of applications for availing program through BIOURJA portal: **https://biourja.mnre.gov.in Sep, 2020.**

6. **Continuation/Extension of Waste to Energy program:** "Programme on Energy from Urban, Industrial, Agricultural Wastes/ Residues and Municipal Solid Waste (2019-20)" dated 28.02.2020 till 31st March 2021 or till the date the recommendations of 15th FC come into effect (28 Feb, 2020)

3. Schemes for financial assistance

MNRE provides the Central Financial Assistance were announced in the form of back-ended subsidy is provided for installation of Waste to Energy projects for recovery of energy in the form of Biogas or Bio-CNG or Power from Urban, Industrial, Agricultural Waste/ Residues and Municipal Solid Waste. Some of the highlights of these schemes are given below:

1. To promote setting up of projects for recovery of energy in the form of Biogas / BioCNG / Power from Urban, Industrial and Agricultural Waste and Captive Power and Thermal use through Gasification in Industries.

2. To promote setting up of projects for recovery of energy from Municipal Solid Waste (MSW) for feeding power into the grid and for meeting captive power, thermal and vehicular fuel requirements.

3. To promote Biomass Gasifier for feeding power into the grid or meeting captive power and thermal needs of rice mills/other industries and villages

Financial assistance available under the Programme on Energy from Urban, Industrial and Agricultural Wastes/ Residues for setting up Waste to Energy plant is as given below:

- Biogas generation: 1.0 crore per 12000cum/day;
- Bio-CNG generation (including setting of Biogas plant): 4.0 Crore per 4800Kg/day;
- Power generation based on Biogas

(including setting of Biogas plant): 3.0 Crore per MW.

- Power generation based MSW: Rs 5.0 Crore per MW.
- Biomass Gasifier :

  Rs. 2,500 per kWe with duel fuel engines for electrical application

  Rs. 15,000 per kWe with 100% gas engines for electrical application

  Rs. 2 lakh per 300 kWth for thermal applications.

6.0 Energy from Ocean Plastics

The huge amounts of plastic waste is floating in the world's oceans causing harm to marine animals and seabirds. Ships that go out to clean up the ocean have huge storage of garbage on board and carry it thousands of kilometres back to port. A more efficient way to go about cleaning up the ocean at the same time converting the plastic waste into fuel onboard the ship to create a self-powered cleanup operation. A viable technology for converting plastics into usable fuel using hydrothermal liquefaction (HTL) is used for the same. A HTL reactor that fits on a ship should be able to produce enough oil to power the ship and also the reactor itself. It has been estimated that a thousand booms separated by 50 km, for instance, would clean up the entire patch in 10 years.

7.0 Conclusions

Achieving Integrated Sustainable Waste Management requires integration of appropriate collection with different technologies and waste treatment methods and governance systems in the local context. A complete and detailed legislative framework is a prerequisite for thermal WTE introduction in developing countries. The framework should include strategies for maintenance and plant decommission, a phase out plan, pollution monitoring, guidelines on safe disposal of toxic by-products, medical monitoring and health care for plant workers and the local community, and guidelines for accident management. Thermal WTE plants with advanced emission control technologies that are well-maintained have minimum public health impacts. Nevertheless, mismanaged thermal WTE plants have been shown to produce unsafe emissions, despite advanced emission control technologies so there is a need to select appropriate technologies for WTE plants.

References :

1. Kaza Silpa, Lisa Yao, Perinaz Bhada-Tata, and Frank Van Woerden (2018), What a Waste 2.0, A global Snapshot of Solid Waste Management to 2050; Trends in Solid Waste Management, World Bank.

2. Singh, R.P. V.V. Tyagi, T. Allen, M.H. Ibrahim, R. Kothari (2011) An overview for exploring the possibilities of energy generation from municipal solid waste (MSW) in Indian scenario. Renew Sustain Energy Rev, 15 (9) (2011), pp. 4797-4808 [Article Download PDF]

3. Khanjan Ajaybhai, Kalyani Krishan and K.Pandey, (2013) Waste to energy status in India : A Short Review; https://doi.org/10.1016/j.rser.2013.11.020 Get rights and content.

4. The World Bank. What A Waste—A Global Review of Solid Waste Management (2015).

5. United Nations-Habitat: Solid Waste Management in the World's Cities. United Nations Human Settlement Programme (2009).

6. Efstratios N. Kalogirou, Waste-to-Energy Technologies and Global Applications, Tailor and Francis Group,

7. Saini Samir, Prakash Rao and Yogesh Patil (2012) City based analysis of MSW to energy generation in India, calculation of state-wise potential and tariff comparison with EU Procedia - Social and Behavioral Sciences 37 (2012) 407 – 416

8. Kumar Atul and S.R.Samadder (2017) A review on technological options of waste to energy for effective management of municipal solid waste. In Waste Management Volume 69, November 2017, Pages 407-422

9. Chinwan Dipanshu and Shubhangi Pant (2014) Waste to Energy in India and its Management Journal of Basic and Applied Engineering Research Online ISSN: 2350-0255; Volume 1, Number 10; October, 2014 pp. 89-94

10. Belden, Elizabeth R. et al. Thermodynamic feasibility of shipboard conversion of marine plastics to blue diesel for self-powered ocean cleanup, Proceedings of the National Academy of Sciences, 2021.

***

Waste MONITOR Volume 4 Issue 1 Dec. 2021

Hydrogen As An Alternative To Fossil Fuels

Mr. S. Sampath
Chairman, NSWAI
samki@samkigroup.in

Impacts of global warming and climate change have triggered efforts to reduce the concentration of greenhouse gases (GHGs such as Carbon Dioxide, Methane, Nitrous Oxide and Fluorinated gases etc.) in the atmosphere around the world.

Non-renewable fossil fuels currently fulfil a major portion of the world's energy requirements. They provide electricity, heat, transportation and various other industries. When fossil fuels are burned, carbon dioxide is released. It traps the heat in the atmosphere, which leads to global warming. The climate change results from the Global Warming. Thus, a need for alternative and renewable fuels is given rise to.

Various alternative sources of energy like Solar, Wind, and Tidal have been widely evaluated and utilized. Recently, Hydrogen gas (H2) with a high calorific value of 34,000 kcal (140MJ) is an addition to the clean energy list. It has a tremendous potential for a future with a clean energy carrier with no adverse emissions. When hydrogen is used as an energy source for heat and power production, the only products are water vapor and heat.

Hydrogen gas consists of molecules of two hydrogen atoms. It is a non-toxic, colourless and odourless gas. Hydrogen is the one of the most abundant elements in the whole universe; but due to its unstable nature, it does not exist freely as hydrogen gas on Earth. It always bonds with other molecules and hence exists in the form of various compounds like hydrocarbons and water, from which it can be extracted.

Electrolysis and Steam methane reformation are the most common ways for hydrogen production. Electrolysis is the process of using electricity to split water into hydrogen and oxygen. Deriving electricity for such electrolysis from a renewable source of energy would make the above process carbon-neutral as well. Steam methane reformation is a process by which steam breaks down methane into hydrogen, carbon monoxide and dioxide. The gaseous mixture is also known as Water Gas. Hydrogen gas released in this way, can be used as hydrogen fuel. It is a promising method for carbon-free hydrogen production.

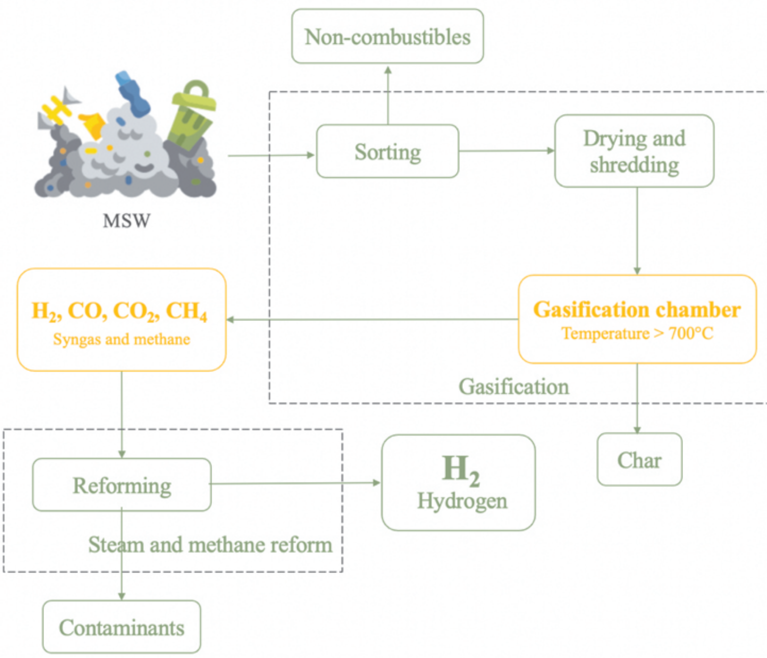
Waste to Energy:

There are other numerous ways of producing hydrogen, but hydrogen extraction from Municipal solid waste (MSW) by gasification or anaerobic digestion can be the most sustainable way. In addition to generating clean fuel, it can divert tonnes of waste from landfills. Substrates like MSW, Agricultural waste, Plastics, Organic waste, sewage sludge and hazardous medical waste thus can be converted to hydrogen.

Hydrogen from MSW:

Gasification is a process that converts carbonaceous materials into carbon monoxide, hydrogen, and carbon dioxide at high temperatures, without combustion, with a controlled amount of oxygen and/or steam.

For the production of Hydrogen from MSW, waste is first segregated and non-combustible materials like glass and metal are removed. The sorted waste feedstock undergoes pre-treatment, drying and shredding into small pieces. It is then fed into a gasification chamber, where it is heated to temperatures greater than 700°C to produce syngas, which is a mixture of Carbon monoxide, Hydrogen. It can be used as fuel or further refined. The gas mixture then undergoes steam methane reformation.



Contaminants such as chlorine and sulphur are removed in the process. Solid carbon that remains as post gasification char, is also removed. The resultant syngas is cleaned and pure hydrogen is separated.

A California-based start-up Ways2H is a joint venture between US-based Clean Energy Enterprises, and Tokyo-based Japan Blue Energy Corporation (JBEC) uses gasification technology developed by JBEC over the past 20 years.

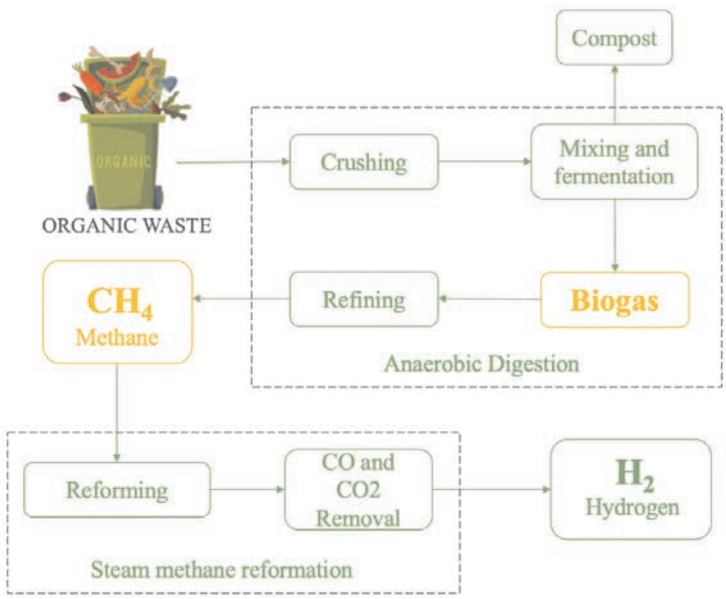
Ways2H have set up two types of plants, firstly, a mobile solution with the capacity of processing one tonne of waste per day, which fits inside three shipping containers, and secondly, a scalable stationary solution that can process between 8-50 tonnes of waste per day. Ways2H has a mobile demonstration unit in Japan that can produce 50 kg of hydrogen a day, and is in discussions to build commercial pilot projects in California, Japan and South America. Along with production of hydrogen from waste their future goal is to capture and store the carbon, making the process carbon-negative. The company is also in talks with California healthcare centres to develop projects that would convert medical waste, including all the personal protection equipment needed during the COVID-19 pandemic into hydrogen.

Hydrogen from Organic MSW:

As organic MSW is a rich source of hydrocarbons, Hydrogen can be produced from it by Anaerobic digestion. This is the process by which microorganisms break down organic matter in an oxygen-deprived environment to produce biogas and digestate.

For the production of Hydrogen from Organic MSW, firstly, the waste is crushed and blended before it undergoes anaerobic fermentation to produce biogas. Biogas is composed of methane (CH_4) at a relatively high percentage (50 to 75 percent), carbon dioxide (CO_2), water vapor, and trace amounts of other gases. The residual material left after the digestion process is called the digestate. It is a nutrient-rich substance; hence it is often used as compost. After anaerobic digestion steam methane reformation takes place to produce a mixture of hydrogen, carbon monoxide and dioxide.

Anaerobic digestion followed by steam methane reformation



A Uttar Pradesh-based renewable energy company Biezel Green Energy is working towards the conversion of biomass into renewable fuels and commercial products. They have developed a TAD (Thermally Accelerated Anaerobic Digestion) process that gives a feed to fuel conversion percentage of up to 45-50% by mass with overall output percentage exceeding 70% by mass. It can process 1.5-2 tonnes of biomass in a single operation. TAD reactors can process any kind of biomass and organic biomass wastes, and can process residues of all the crops grown in the state. Under controlled temperature and pressure, the reactor converts 1 kg of biomass into 30-40 g of hydrogen, 140-170 g of methane, 28-30 g of bio-coal, 40-42 g of carbon dioxide and a little bio tar.

Using these technologies to produce hydrogen provides many opportunities, viz. treatment of MSW, preventing the spread of infectious pathogens, decrease dependence on fossil fuels, aversion of pollution as well as GHG emissions from landfills. The by-products from the same can be used in multiple markets further increasing the sustainability and circularity of the entire process. Hydrogen fuel production from waste has the best future perspective as it achieves zero GHG emissions and hence will combat global warming.

Currently India consumes 6 million metric tonnes of grey hydrogen per year, grey hydrogen is hydrogen produced using fossil fuels, which is around 8.5 per cent of the global hydrogen demand. Increasing the share of hydrogen in the country's energy mix would take it towards greater self-reliance in its energy needs. Further, an emphasis on green hydrogen i.e. hydrogen produced using renewable energy, is completely carbon-neutral and the process does not release any carbon dioxide into the environment. It would help reduce carbon emissions and take India closer to meeting its climate change commitments.

The growth of solar energy has given a unique advantage for the growth of green hydrogen. Cheap solar tariffs mean the cost of powering the electrolysis process through surplus electricity at peak hours to generate hydrogen remains low. Setting up hydrogen generation plants near solar parks will further reduce transmission costs.

Having a clear mid-term and long-term target inspires confidence in the private sector to make their investments in a new energy source. India should increase this demand and aspire to meet at least 4 per cent of its energy demands by hydrogen by 2030. This would represent about 13 million metric tonnes of hydrogen demand by 2030. A target for 2050 of about 10-12 per cent hydrogen within the energy mix could also be recommended to ensure long-term supply-demand creation whilst further instilling confidence in the market.

The new era with Hydrogen will clean up the MSW and at the same time create value, employment and pollution free environment in India soon.

***

AAT&ANKA
DRY FERMENTATION TECHNOLOGY

Dry Digester Technology for Biogas production

AAT&ANIKA offers world-class technology of anaerobic digestion of MSW for biogas production at an affordable price.

Any of the 8 plants in Turkey can be visited anytime. This technology uses minimum water and energy.

The residue can be processed further for producing a nutrient-rich compost after separating out the plastics and cloths.

We offer modules of 400 tons per day, which can be amplified in multiples of the same depending on the quantity of the MSW.

CONTACT US

AAT Abwasser-und Abfalltechnik GmbH
Konrad-Doppelmayr-Str. 17, 6960 Wolfurt Austria

klaus.moosbrugger@aat-biogas.at

yavuz.kantur@itcturkiye.com

T: +43(0)557465190,
F: +43 (0)557465190-99

Indian contact:
SAMKITEC Resources
samki@samkigroup.in
9848045967 / 9948095967

AAT&ANKA
DRY FERMENTATION TECHNOLOGY

A Short Note On Hydrothermal Carbonization (HTC) A Quick Process To Create Value From Biodegradable Waste And Biomass

Dr. Harshvardhan Modak
Editor, NSWAI
drmodak2007@gmail.com

What is hydrothermal carbonisation (HTC)?

Hydrothermal carbonisation (HTC) is a renewable energy method where a carbon-dense solid product, hydrochar, are produced from wet biomass by heating it in a sealed container. This process is becoming attractive since it converts biomass (wet biodegradable municipal waste, sludge generated in aerobic digestion, grass, leaves, residue from anaerobic digestion or digested slurry etc.) in few hours at moderate temperature (120deg C+) and pressure. Hydrochar is a coal like substance, with good calorific value and can be used as fuel.

How HTC works?

Under these reaction conditions, the dehydration of starchy and cellulosic molecules takes place to leave behind carbonaceous substance, called hydrochar. Hydrochar, the resultant product of the pressure-cooked wet feedstock, can then be dried down and compressed into pellets which can be used as a biofuel.

What kind of feedstock can be used?

As a technology that is relatively cheap to set-up and run, HTC permits the use of 'lower-value' waste feedstock. This provides an opportunity to use waste products such as garden waste, most types of farming agricultural waste, sewage and digestate from an anaerobic digester. The feedstock used does not have to be waste, however it is most cost-efficient to use a waste product. Often wet wastes are used, but it is possible for other feedstocks to be utilised in HTC. In particular, there is an increased interest in the HTC of clothes and textile wastes.

What are the benefits of using hydrothermal carbonisation with anaerobic digestion?

Digestates, a slurry like by-product of anaerobic digestion, must meet restrictive specifications before being spread across the land as a renewable fertiliser. However, HTC can produce a more stable by-product, therefore, putting digestate through an HTC system can bypass the issues which anaerobic digesters may have.

Digestates are also extremely wet which makes them expensive to transport. Thus, for city-based plants the cost of transportation can outweigh the benefits of the AD process. A combined HTC and AD unit could offer the potential for digestate from the AD to be used as feedstock for the HTC plant, with heat being recovered from the process to warm the digester.

What can hydrochar be used for?

Currently hydrochar's primary use is as a biofuel, but research is ongoing as to alternative uses, including its benefits for carbon storage and exploring its uses as a fertiliser. A higher ash content can supplement potassium and phosphorus levels in soils thus making it beneficial as a fertiliser.

Conclusion

Looking forward, HTC can not only offer benefits as a source of renewable energy by itself; but also, in conjunction with other processes. It's an exciting prospect for sustainable energy development and it has prospects of using alongside other renewable energy technologies in the future.

The first case of COVID-19 was reported in India were reported in the towns of Thrissur, Alapuzha and Kasargod (Kerala) among three Indian medical students who had returned from Wuhan

***

RECYCLING

NEPRA's Material Recovery Facility And Innovation In The Aeon Of Sustainable Development Goals

Mr. Sandeep Patel
Founder And CEO, NEPRA
s.patel@nepra.co.in

The Sustainable Development Goals (SDG) are basically set of 17 goals inclusive of all elements of the 3 pillars (Economic, Social and Environment) essential for Sustainable Development. They were formulated in 2012 at a UN conference held at Rio De Janeiro. They were put into action in 2015, post the completion of the 15-year Millennium Development Goals (MDG). The SDG have been formulated to ensure that the nations work to achieve economic development guaranteeing social and environmental safety with 2030 targets.

Waste collection and management are amongst the fundamental services to ensure healthy well-being of the society. With present trends of consumption and escalating urban needs; waste reuse, recovery and recycling becomes indispensable to ensure that future generations have enough resources to meet their needs. SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production) define targets laying emphasis on waste management, waste reduction, recycling and reuse for a resource efficient economy. SDG 8 (Decent work and Economic Growth) and 9 (Industry Innovation and Infrastructure) guides through the importance of technological upgradation and innovation in building resilient and more productive infrastructures.

The rate of waste generation exceeds the nation's growth in waste management services. Inefficient waste collection, treatment and recycling is the reason behind present waste crisis. It can be devastating if we keep growing, consuming, producing and dumping waste without getting it sorted. Waste Management in our country is largely moved by the informal sector. Waste in the country is majorly hand sorted which is not only time consuming and labour intensive but also hazardous to health.

Moreover, looking at the pace and mixed manner at which the squander is generated such methods are highly unsustainable. Waste pickers work with daily life risks, sorting and recovering waste from poisoned environments to earn their livelihood. There is a dire need to include them and create decent jobs for them.

Material Recovery Facility (MRF) is vital infrastructural development that promotes sustainability through efficient waste management, creation of green jobs, safe and hygienic work conditions, upliftment of bottom of the economic pyramid and inclusion of waste pickers. MRF are the ones where collected waste materials are sorted into different types (e.g., plastics, paper, metal etc.) and is processed in manners to make it marketable for recycling. It maximizes waste recovery and eliminates scope of landfilling or dumping.

Fig.1 :
NEPRA's automated MRF at Indore of capacity 300MT/day in PPP with Indore Smart City Development Limited. It is equipped with technologically advanced waste sorting mechanisms under hygienic and safe conditions

NEPRA works in the sustainability space with its main role in the waste management sector. It realises the potential this sector has in creating a large positive social, economic and environmental impact. An inclusive model in all true sense, NEPRA strives to align itself with the SDGs and work in line with its targets. The company collects waste for further recovery through sorting and processing at its MRF which are of different capacities, located in several cities. Built on Public Private Partnership in 2019, the Indore MRF is one of its kind and biggest in

India. It has the capacity to process 300MT of Municipal Solid Dry Waste Daily. It is fully automated and has provided employment opportunities to several BOEPs. Women are benefitted hugely with independent earning opportunities at the MRF, improved sanitation and equal pay for equal work.

Fig. 2:
Women empowerment through equal opportunities at work with equal pay for equal work

NEPRA has innovatively process designed the MRF at Indore based on Indian waste types and has imported machineries as well. It sorts waste using magnetic belts, conveyors, ballistic separators, air classifiers and optical sorters among many others with manual intervention for quality check. The sorted waste is generated in two streams namely recyclable and Refuse Derived Fuel (RDF) which are auto baled or shredded or grinded for further recycling or co-processing.

NEPRA has kick started introduction of robotics at its MRFs to increase the efficiency. The robotic sorting solution contains state of the art elements for automated sorting of solid waste such as a robot, robotic vision guidance system and our newly developed image processing system based on machine learning and artificial intelligence. The system is targeted to retrieve designated material from the belt of mixed waste and guide it into the silos where it will get collected. The system reduces the overall operational cost of the plant and gives accuracy in collection of materials and operates 24 hours a day.

More MRFs mean efficient waste sorting, more raw material for increased recycling/ waste to energy extraction together with large amounts of CO2 Eq. emission reduction, reduced dumping, reduced open burning of waste and improved air quality and inclusion of Waste Pickers. With MRFs we take care of the health and sanitation of the most vulnerable class – the scavengers of the society and work for a Zero Waste to landfill Nation through efficient solid waste recycling. In all its dimensions MRF adds to sustainable economic growth of the nation.

While NEPRA continues to serve the society for its waste management needs and a clean, green, healthy tomorrow, it also aligns its business objectives to the Sustainable Development Goals by uplifting vulnerable groups, empowering women and addressing climate crisis. It is contributing in several ways to few of the SDGs and plans to keep innovating to address all the 5 Ps – People, Planet, Prosperity, Peace and Partnership with periodical reviews and smart, sustainable approaches.

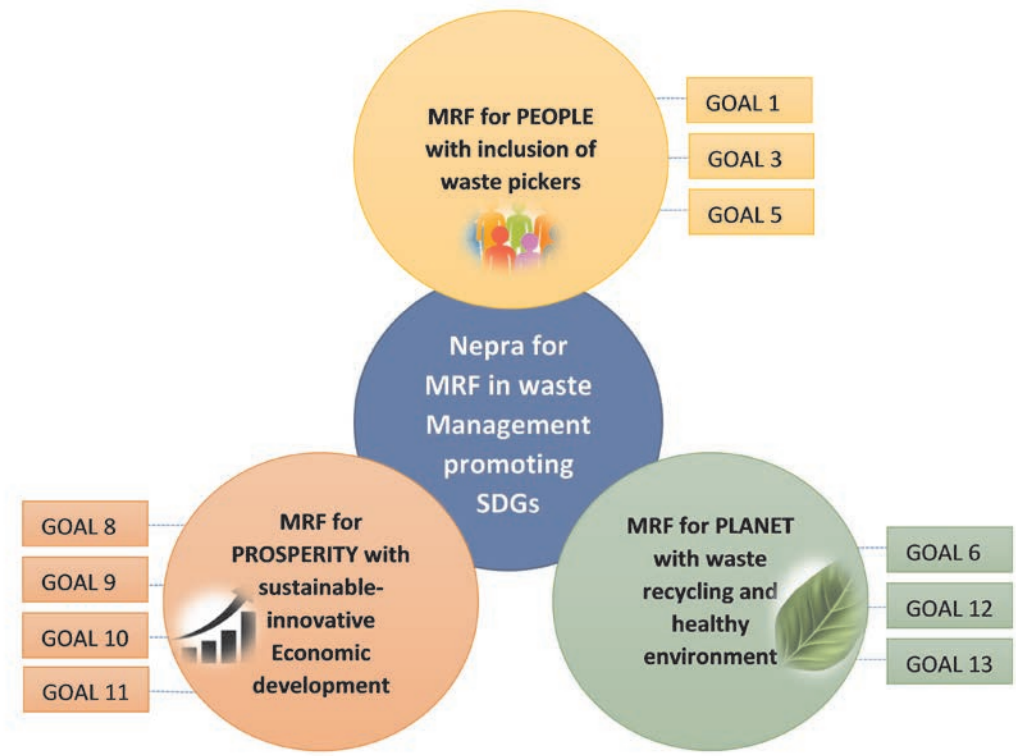


Fig.3 : Nepra's alignment with the SDGs and 3 Ps of Sustainable Development – People, Planet and Prosperity

***

C & D (Construction And Demolition) Processing Plants

Mr. Sundar.K
Head Operations Of
Project, Westart Communication India Pvt. Ltd.
Sundar.k@westartindia.com

Few Challenges and Way Forward

The Need:

The exponential industrial growth globally and subsequent accelerated depletion of natural resources has left with no other option but to adopt 4Rs concept (Reduce, Reuse, Recycle and Regenerate) to conserve fossil fuels and water to sustain not only industrial operations but to avoid depriving of very basic living needs. Continual improvements in existing processes and new technologies have to certain extent bridged the gap between consumption and demand in many domains.

The Industry:

Now, processing of C and D (Construction and Demolition) wastes has commenced across the world at different places to mitigate depletion of resources. Westart Communications India Pvt Ltd has installed two such plants at Chennai to handle about 1000 MT of C & D waste generated daily in the city and being first of its kind in Tamil Nadu State, the organization is a forerunner in not only making the city cleaner but also to foot in solid waste management. The said two units have been commissioned recently and plant capacity is 100 TPH each.

Challenges and Hurdles:

Needless to mention there are plethora of teething issues which are being addressed. Very wide fluctuations in the feed materials (various size of debris, unusable materials like plastics, metals etc) is a big challenge to ensure uninterrupted feed to the plant. However, novel methodologies are attempted for effective segregation of such unusable materials prior to using in the process.

Mix up of bricks and concrete in the debris is yet another factor that poses difficulty in achieving desired quality of aggregates. Few experiments are on the anvil to separate light density particles from the aggregates and upon successful trials, suitable commercial scale equipment will be installed at downstream.

Making of solid blocks using coarse sand and fine aggregates with different mix ratios (fly ash and cement) and after optimizing ingredients, it is proposed to install plant to make 10000 blocks per day. Simultaneously few experiments are being done to make paver blocks using the products from C & D plants.

Another area to be focused in handling of fines (less than 75 microns) generated in the process. Suitable avenues like light weight bricks, use in terracotta industry etc are being explored.

Encouraging factors:

Since good quality water is used in the process, the quality of sand after washing results in salinity levels much below general expectations / stipulated in the standards.

Since recycled products can be safely used for non-structural applications, the fine sand (75 microns to 2.36 mm size) makes it possible to use for plastering. Few users have expressed very positive feedback on the workability for plastering applications.

Conclusion:

With C & D processing plants becoming order of the day, very soon similar plants would be in place at various parts of the country which will pave way to conserve building materials in a massive scale and thus environmental improvement.

***

INDUSTRIAL WASTE

Introduction To The Concept Of Environmental Performance Indexes (EPI) And Ranking Of Various Countries In The World And States Of India By EPI

Dr. Indrani Chandrashekharan,
Former Adviser, Planning Commission, Govt. Of India
indusekh@gmail.com

A sustainable growth strategy should be based on an effective and balanced utilization of national resources, detailed short and long-term sustainable macro and micro level planning including emergency management, execution setup, process and Performance evaluation. Environmental Performance Index, Yale Index, Yale EPI Index are some prominent indices used for this purpose.

Environmental Performance Index (EPI) is being evolved at both global and national level to enable assessing progress made in achieving the targets and goals set. Criteria and indicators selected are the backbone of the assessment methodology. Identification of high Priority areas at the national level and corresponding indicators in sync with global targets and updating of policies and legislations at the national level is a challenging task.

Attempts were done to analyse the results of the EPI assessment methodology; Scores and ranking are being evolved in India (2012-2020) with Yale 2020 and compares it with 26 of the 180 countries evaluated by Yale EPI (2012 to 2020). India has been ranked at 168 by Yale in 2020. The analysis led to the need for in depth discussion, continuity of the indicators and weightage of the Categories, inclusion of Disaster management as a criteria and assessment of the implementation and progress made by a country.

Environmental Performance Index

The Environmental Performance Index (EPI) identifies targets and goals for several core environmental policy categories and measures how close countries come to meet them. The main objective of the EPI is to improve the empirical data basis for long term environmental protection measures and to facilitate improved analytical assessments and adherence to policies and legislations like **PC-EPI 2013 and 2020**

The PC- EPI 2013 consists of 5 categories and 16 indicators for which standards have been notified and in respect of indicators with no standards, e.g., forests, etc. A method was evolved and these were integrated to arrive at a composite index. The criteria integrated were air pollution, water quality, forests, waste management and climate change. In 2016 PC-EPI 2013 **(Fig-1)** was modified to include Biodiversity as a criteria with 4 indicators.

To make PC-EPI-2013 more comprehensive along with Biodiversity, Agriculture, Fisheries and Disaster Management as criteria, four more indicators each were added in EPI 2020. In the existing criteria, Air Pollution, SPM has been split into PM 2.5 and PM10 as indicators, in water quality and waste management criteria one indicator each and two indicators in Climate Change have been added and **EPI-2020** evolved.

Yale Environment Performance index:

The Yale Environmental Performance Index (EPI) is a matrix which aims at establishing an international composite environment index to rank country performance on environmental issues.

The Yale 2020 Environmental Performance Index (EPI) released in June 2020, provides a data-driven summary of the state of environmental compliance using 32 performance indicators across 11 issue categories. It ranks 180 countries on environmental health and ecosystem vitality. The 2020 rankings include for the first time a waste management indicator and a pilot indicator on CO2 emissions from land cover change. Other new indicators enable analysis of air quality, biodiversity and habitat, fisheries, ecosystem services, and climate change. For disaster management both natural and manmade disasters are needed to be included as a category with indicators.

The 2018 Yale Environmental Performance Index (EPI) ranks 180 countries on 24 performance indicators across ten issue categories covering environmental health and ecosystem vitality. The 2018 EPI data and methodology have generated new rankings based on advances in environmental science and analysis. The 2010 Environmental Performance Index (EPI) ranked 163 countries on 25 performance indicators tracked across ten policy categories covering both environmental public health and ecosystem vitality

Analysis of the Yale EPI 2010-2020.

An analysis indicated that during the period 2010-2020 ,1013 assessment of countries (168-180) lead to a total of only 56 countries occupying a position among the top 30 countries in the decade. As per the EPI 2020 ranking, only 11 countries were listed in all the six years, 16 countries were ranked only once from the 56 countries ,9 countries were listed 4 years,3 countries three years, 4 countries 2 years and 1 one year. The result of the analysis raises a lot of questions regarding the, change in number of Category, incomparable scores, methodology, repetition of indicators and inclusion under 2 categories with varying weightages, inclusion of exposure, exceedance, growth rate etc. The prime objective of EPI is analysis of the effect of policy and law notified by the countries and meeting of the standards and Goals set by the country and globally.

Yale EPI Ranking of Countries and India.

The Yale EPI has calculated scores/targets for core environmental policy categories and measures how close countries come to meet them. In addition to publishing the composite index and individual country scores, a country ranking has also been released. The recent publication of the Yale EPI (2020) has placed India in the 168th position, out of 180 countries assessed and which compares it to the lowest ranked countries. Our analysis has traced the individual results for India, based on an analysis of indicators and data as well as an assessment of the underlying methodology of the index. As part of this assessment, the scientific validity of the ranking has been further investigated based on PC-EPI 2013, 2016 and 2020 which is based on data published by various departments/ ministries of the Government of India.

Regarding the relevance of the EPI for adequately assessing Indian environment policies and Laws a number of pivotal factors could be singled out. These include the selection, conceptualisation and weightage of individual indicators, the data quality and the policy scores. The selection and weightage of certain policy scores and indicators has been driven by the claim to complement the environment indicator set of the Sustainable Development Goals. However, such selection and weightage does not mirror sufficiently the specific dimensions of environmental problems typical for countries like India and therefore, reduces significantly the explanatory power of the EPI for India.

The selected indicators do not reflect the pivotal environmental problems in a number of policy areas, which are of high concern for a country such as India. This includes in particular environmental problems with a strong quality dimension (for example, access to sanitation is less of a concern compared to the quality of sanitation and sewage treatment.

Conclusion:

A sustainable growth strategy should be based on an effective and balanced utilization of national resources, detailed short and long-term sustainable macro and micro level planning including emergency management, execution setup, process and Performance evaluation. Environmental Performance Index (EPI) is being evolved at both global and national level to enable assessing progress made in achieving the targets and goals set. Criteria and indicators selected are the backbone of the assessment methodology. Identification of high Priority areas at the national level and corresponding indicators in sync with global targets and updating of policies and legislations at the national level is a challenging task.

The paper attempts to analyse the results of the EPI assessment methodology, Scores and ranking being evolved in India (2012-2020) with Yale 2020 and compares it with 26 of the 180 countries evaluated by Yale EPI (2012 to 2020). India has been ranked at 168 by yale in 2020. The analysis leads us to the need for in depth discussion, continuity of the indicators and weightage of the Categories, inclusion of Disaster management as a criteria and assessment of the implementation and progress made by a country.

★★★

Electric Vehicles - A Step Towards Sustainability But It's Waste ?

Mr. Devansh Shah
Founder, EVamp Technologies Pvt. Ltd.
devanshshah43@gmail.com

Electric Vehicles have garnered massive attention globally in recent years, owing to the sustainable transportation option it offers. It has got automobile industries and media to its attention, marking the progress it has made in the mobility sector. Domestically, EV makes for a debate considering how long will India take to get its own EV charging infrastructure? or the affordability of EVs for common man largely at present depending on fossil fuel driven transportation?

While the innovations brought by EV are exciting, not many have explored the possibility of seeing what's hidden in plain sight. The EV boom has a greater impact on the 135 Cr population of this country which needs to be noted. The article brings to you a few notes that will make you ponder India's preparation for adopting EV. A sincere hope of this short read is to make you ponder on the issues of waste management in times of EV revolution, sparking new thoughts.

To stimulate thoughts, noted below are a few challenges and suggestions that need to be answered before getting on to the bandwagon of switching to Electric Vehicles.

1. Industrial and Hazardous Waste from Refineries

Battery manufacturing of an EV is hindering the environment. Mining of lithium delivers a ton of ozone depleting substances. Greater the storage capacity of the battery, the more CO_2 it takes while underway. Batteries have in them the composition of Lithium and cobalt.

N.B.: More than half of the world's lithium supply comes from the lithium triangle-Chile, Bolivia and Argentina. Presently, these regions are facing diminished water supply to their farmlands and are likewise confronting the issues of harmful material stores.

2. E-waste

India produces 18.5 lakh MT of e-waste every year. While PCs structure a major lump i.e. 70% of absolute electronic waste, media transmission gears compensate for another 12%. Old workstations, PDAs, cameras, TVs, climate control systems and LED Lamps establish the e-waste materials. The Indian E-waste industry is blasting with a CAGR of 30%

The E-waste generated in India can easily be turned into an extraordinary donor of battery creation. With countless metals utilized in batteries, similar to nickel, cobalt, copper and lithium can be acquired from using the existing E-waste reserves.

3. Dumping or Recycling of Li-ion Batteries

Reusing metals is 2-10 times more energy-effective than metals purified from minerals. Lithium is a profoundly flammable material; thus, Li-particle batteries cannot be simply disposed of to a landfill as they are likely to burst into flames when exposed to higher temperatures.

Handling of old batteries is perilous in view of higher odds of blast and flames that may emerge because of storing of spent batteries. Thus, stressing on the need to have more battery reusing plants in our nation to be prepared to handle the mammoth test of utilized EV batteries.

4. Brake Pads (Frequently changed in ICE based vehicles. Whereas in EV it supplies energy)

The Indian Original Equipment Manufacturer (OEM) prescribe one to supplant the vehicle's brake cushions at whatever point one hears a crushing commotion, vibration or appears to be exhausted. This proposal acquires merit in view of the potential results of not having a decent stopping mechanism set up when one needs it the most. In this way, one needs to spend on another brake cushion for present vehicles.

However, there's no unmistakable information on how these brake cushions are unloaded and what befalls them after they arrive at their finish of life. Do they wind up creating more waste and falsehood some place in a landfill or a go-down far away?

On account of Electric Vehicles, regenerative slowing down broadens the lifetime of brake cushions that normally reside inside 10 years. It does so by decreasing the incessant utilization of brake cushions that are generally kept in consistent use in conventional Internal Combustion Engine based vehicles.

N.B.: Regenerative slowing down is utilized to ration energy. Energy is changed from the put away motor energy of the vehicle to electrical energy as opposed to dissipate it as warmth

5. Remote Diagnostics, Predictive Maintenance and online service scheduling

Gathering pre-owned batteries towards the finish of their life cycle is one more issue nearby. What's more, refining the materials inside the batteries is an additional issue to determine at the soonest. The base metals can be refined and recuperated to the battery grade materials so that they can be put to reuse and sold back to the business. Association models should be created among e-waste assortment organizations, reusing plants and organizational drives (Swachh Bharat Abhiyaan) that can assume a significant part on this front in light of their inescapable reach and assortment endeavors Far off Diagnostics will help in getting continuous information on vehicle related execution and quality information by the utilization of programming introduced in the vehicle. This will help in checking the battery execution and diagnosing the issues at the earliest.

While prescient support will help in cautioning the finish-of-life cycle and help in revealing the information to the proprietors and car makers with the goal that game plans can be made ahead of time. Additionally, it helps in following and checking of within hardware to ensure completion of support even before a glitch is noticed.

The Li-ion battery life for use in EVs is around 5-6 years. Indian EV makers are likewise offering battery guarantees of as long as 8 years/1.6 lakh kms. Yet, according to the states of utilization cases in India and in the event that we additionally take the various landscapes of our country, the battery life may get various cases by the makers as a result of the heap bearing limits.

6. Reusing

A pre-owned Li-ion battery from the EVs can in any case discover its utilization in applications like forklift activities, uninterrupted power supply (UPS), inverter batteries and some minor purposes that go far in saving it from being unloaded.

Nickel, cobalt and copper can be repeatedly reused. The extended development for lithium-particle batteries is fixed to develop from 44.2 Bn dollars in 2020 to 94.4 bn dollars by 2025 for the most part because of interest in electric vehicles. (Source: Markets and markets) This information focuses towards the requirement for bunches of assets.

Since we realize that batteries are a blend of metals and minerals, including nickel, cobalt, lithium, graphite and copper that come from everywhere in the world, a huge deficiency is likewise apparent ahead in view of exhaustion of these assets.

It's fitting to reuse them rather than essentially striking them off from dynamic use.

CONCLUSION

The progressions in the mobility sector are coming at an exceptionally fast speed, giving rise to genuine inquiries on the availability of a nation to battle the issues that will emerge soon. The article shared a 10,000 foot perspective of on-ground experiences that EVamp Team faces while directing examination for EV Charging Infrastructure. It might go to your notice that little advancement may have begun in addressing these issues but in any case, these are the areas that request focal core interest. We can even expect more difficulties coming up when Electric Vehicles acquire a large client base in India.

References :

How Tesla's Battery Mastermind Is Tackling EV's Biggest Problem (April 10, 2021) **https://youtu.be/xLr0GStrnwQ**

Can you recycle an old EV battery? (April 09, 2021) **https://youtu.be/PbOBmnZRpZ4**
https://youtu.be/94664TLwLqM

Breaking down EV Myths in India - EV Technology , (August 11, 2020)

https://www.theclimategroup.org/our-work/news/breaking-down-ev-myths-india-ev-technology

Bengaluru to get India's first government run E-wastE recycling plant , (28/06/2021)

https://www.thenewsminute.com/article/bengaluru-get-india-s-first-government-run-e-waste-recycling-plant-84097

Are Electric Cars Cleaner and Greener? (September, 23, 2018)

https://youmatter.world/en/are-electric-cars-eco-friendly-and-zero-emission-vehicles-26440/

Are Electric Cars really better for the Environment? (March 22, 2021)
https://www.wsj.com/graphics/are-electric-cars-really-better-for-the-environment/

Lyu, Y., Ma, J., Åström, A.H. et al. Recycling of worn out brake pads – impact on tribology and environment. (20 May 2020)

https://www.nature.com/articles/s41598-020-65265-w?utm_source=otherandutm_medium=otherandutm_ content =nullandutm_campaign= JRCN_2_LW01_CN_SCIREP_article_paid_XMOL#citeas

***

RADIOACTIVE WASTE MANAGEMENT

Radioactive Waste Management For Medical Facilities

Dr. Ramdas Bhattacharya
Former Vice Chairman, Atomic Energy Board
Former, Executive Senior Advisor,
World Association Of Nuclear Operators
dir.ipsd@gmail.com

Tertiary medical care facilities throughout the world are increasingly using radioisotopes for diagnostic and therapeutic applications. It has become a necessity over the times for diagnosis and treatment for certain patients. Therefore, radioactive waste disposal and management has become one of the vital components of the overall waste management and disposal of the medical wastes. The very important objective in any radioactive waste disposal and management is to ensure that the radiation exposure to public, radiation worker, and the environment is not exceeded at any point of time beyond the prescribed limits by the national regulatory authority, which is Atomic Energy Regulatory Board (AERB) in India. Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 under the Atomic Energy Act, 1962 gives the requirements needed for safe radioactive wastes disposal to public domain.

The main radioisotopes that are being used by hospitals/nursing homes are Technetium (Tc-99), Iodine -125 (I-125), Iodine-(I-123), Flourine-18 (F-18), Tritium (H-3) and Carbon-14 (C-14). Most of the radioactive wastes are generated in Nuclear Medicine Department of the medical facility. Most of these radioactive wastes are liquid, with lesser amount of solid and a minimum amount of gaseous.

Syringes, needles, cotton swabs, vials, absorbent materials, contaminated gloves etc. containing traces of radioactivity constitute the large part of solid wastes in addition to the utensils, clothing of patients who are administered high doses of radioisotopes such as I-131. Disposal of these radioactive solid wastes has to be taken utmost care by the medical facilities where such wastes are generated to in order to comply with the safe disposal limits prescribed by the regulatory body.

Radioactive wastes can be classified as:

- High level
- Intermediate level and
- Low level

And these can be in the form of solid, liquid and gaseous form.

Some of these are long half- life waste (half- life more than a month) and some are Short half-life waste (half- life less than a month).

The hospital wastes are generally low level waste and occasionally medium or intermediate waste.

The radioactive waste management in the medical facility involve various steps: collection, segregation, treatment, monitoring and disposal as per prescribed limits.

The radioactive waste is to be identified and segregated within the work area. Foot operated waste collection bins having disposable polythene lining are used for collecting solid radioactive wastes. Polythene carboys are used for collecting liquid wastes. All packages are monitored and labelled for the activity level so that mode of safe disposal can be decided.

Medical facilities having permission to dispose combustible radioactive waste through incineration are required to segregate the combustible radioactive wastes from the non-combustible wastes.

After collection of the radioactive wastes, it can be disposed by any of the following principles:

-Dilute and Disperse
-Delay and Decay
-Incineration (limited use)
-Concentrate and Contain (if required)

Dilute and Disperse:

Generally, if the activity of the solid waste does not exceed 1.35 micro curies (50 KBq) or the overall package concentration does not exceed 135 micro curies /m3 (5 MBq/m3), such low activity solid waste can be disposed off as ordinary hospital waste. Such items include syringes, vials, cotton swabs, tissue papers, etc. Clothing and utensils of patients administered high doses of radioisotopes like Iodine -131 also constitute a radioactive solid waste. Similarly, liquid radioactive wastes with activity less than micro curie level may be disposed off into the regular sanitary sewerage system with adequate dilution with water (flushing) immediately after disposal. However, maximum limit of total discharge shall be within the limit prescribed for such disposal.

Delay and Decay

Intermediate or medium level radioactive waste and those having half- life of less than a month may be stored in a well duct ventilated room with exhaust at the rooftop. The store room should have a lead shielding of appropriate thickness to prevent any radiation leakage and exposure. The storage shall be of a minimum period of about 10 half-lives so that after decay only about 0.1% original activity remains. It can be discharged after monitoring the residual activity as low activity solid or liquid waste.

Most of the radioactive hospital waste of low and medium level activity of short half-lives radioactive components can be discharged in this way.

Concentrate and Contain

Radioactive hospital wastes having very high radioactivity and components having longer half- life (more than a month) whose disposal is not practical through Delay and Decay (because of longer storage time) can be disposed off by adopting this method.

In this case of disposal method, radioactive waste is collected in a suitably designed and labelled container and then buried in exclusive site meant for it and approved by the regulatory body.

This type of waste is rare in a day-to-day hospital work and as such this method of waste disposal is hardly needed and used in cases of hospital radioactive waste management.

Incineration

Insoluble liquid waste, as in the case of liquid scintillation system are disposed off by incineration. As in the case of other non-radioactive waste, incineration reduces the bulk of waste. However, in this case the activity gets concentrated resulting in small amount of radioactive ash, which requires further disposal. Care has to be taken in the incineration of radioactive waste as it generates gaseous radioactive waste which has to be released in atmosphere under controlled condition and in identified and permitted place. In view of the potential environmetnal cocnerns, the ashes are to be collected and disposed off as per solid radioactive waste and disposal method approved by the regulatory body.

Gaseous waste disposal

Airborne radioactive waste is generated from release of radioactive vapours from volatile radioactive sources like Iodine-131 and iodine-125. The containers radioisotopes of such volatile are always opened under fume hood chamber with exhaust at rooftop. The vapours are passed through charcoal and particulate air filters before these are dispersed in air for dilution. There are many other radioisotopes which generate radioactive gaseous waste like Hydrogen-3, Carbon-14, Technetium-99m aerosols, Xenon-133 etc.

Disposal of urine and excreta

Excreta and urine of Isolation wards' patients who are administered high therapeutic doses of radioisotopes like thyroid cancer patients are administered with Iodine-131 cannot be normally discharged directly through sewerage system without transferring to a Delay Tank through shortest route. Delay tank is located in an isolated place away from public access to avoid unnecessary exposure of radiation from the contents of the delay tank. The delay tank contents can only be discharged to sewerage system after monitoring (should not be more than 1.2 micro curies per litre) and under the supervision of the Radiological Safety Officer (RSO), authorised by the Regulatory Board.

Disposal Sealed Sources

Brachytherapy, teletherapy, blood irradiation etc. sources when become weak in activity and are not worthy for further applications are removed and replaced with a contract with the supplier of that source, who is authorised by the national regulatory body for such activities for safe removal and replacement of sealed radioactive sources. RSO of the medical facility coordinates and authorises for safe handling of the sealed radioactive sources.

Conclusion

Radioactive waste management in medical facilities is to be taken utmost care. Any disposal is to be made as per authorised limit for disposal specified by the Atomic Energy Regulatory Board. RSO has to advice and supervise for each disposal as and when required. Sealed sources when not in use shall be sent back to the supplier. It should not find a place in scrap dealers' shop, without any authorisation for same purpose.

***

RENEWABLE ENERGY

Renewable Energy : Scope For Sustainable And Vibrant Entrepreneurship

Mr. Ishan Vyas
Co-Founder, Aton Earth Pvt. Ltd.
ishan@atonearth.com

Mr. Dwij Vyas
Co-Founder, Aton Earth Pvt. Ltd.
dwij@atonearth.com

We live in a day and age where large scale energy production using solar radiation, wind, waste and water is not just a figment of an excellently crafted science fiction or wishful thinking by scientific minds limited to laboratory-based models, it is today a reality. Unlike what idealism would have had us believe, this major global push for renewable energy adoption doesn't simply stem from its efficacy, but from prescription and necessity to mitigate catastrophic impact of global warming and climate change. Global warming and climate change is no longer a hypothesis but a major continuous disaster that has been impacting millions of lives on our planet, thus making sustainable development the norm that governments and corporations aspire to work towards.

India has been one of the most proactive nations to respond with remarkable alacrity, from supporting a global effort from Rio conference which led to UNFCCC, UNCCD and CBD to setting some of the most daring and ambitious intended nationally determined contributions targets in the world at the Paris conference. This push provides a unique opportunity to budding and established entrepreneurs to contribute to a sustainable and a prosperous future for themselves and the world. Akeen to filling up a medical prescription not only to cure an illness but to emerge out of it stronger than ever before.

India and Renewable Energy:

Physical and geographical features of India;

- Approximately 300 days of sunlight, ensuring a potential of 5000 trillion KWH of energy [1].
- 7516 kms of coastline, a huge potential for onshore and offshore wind power
- Topography consisting of Deccan plateaus and Himalayan expanse making it conducive for large and small hydropower generation blessing it with a high renewable energy generation potential.

Over the years with advances made in wind turbine technology and Solar Photovoltaic (PV) cell technology, the capital cost has progressively reduced. This coupled with conducive policy incentives to the developers, investors and consumers by the government, wind power and solar power generation have been the biggest gainers. India currently ranks 4th in the world with the installed capacity of 38.7 GW of wind power while its solar power portfolio currently has an impressive 40 GW of installed capacity (roof + ground mounted) well above its intended target of 20GW by 2022[2]. Considering the monsoon climate of the subcontinent, hybrid renewable power generation set up has found a lot appeal and has been widely encouraged, where solar and wind power installations complement each other; as solar power production hits a lukewarm phase during the cloudy monsoon, the wind power generation makes up for it and generates more power benefiting from the south west monsoon winds (which is the annual peak of wind power generation). Of late solar power in India has been one of the fastest growing renewable energy segments in the world. The impressive industry size and government policy bent towards solar power combined with relatively lower capital cost makes it one of the most lucrative areas for investors and entrepreneurs. States like Andhra Pradesh, Karnataka and Gujarat have been pioneering the efforts in seeking to incentivise the private sector in solar and hybrid (wind+solar) power generation segments.

The Gujarat Experience:

Gujarat has been a power surplus state in the country for a long time, known for its robust power infrastructure and renewable power push since early days. The geographical boon of having the Tropic of Cancer passing through the state has been an added bonus for solar power generators. The Charanka solar power plant was one of the earliest and biggest projects of its time in Asia with installed capacity of over 600 MW [3]. The plant was a major push that began the solar power rush amongst private investors in the state. Charanka plant alone has attracted investment in excess of Rs.5000 Crores [4]. With the new Kutch hybrid plant with wind and solar power installations complementing each other, will have 30GW of installed capacity, making it one of the largest renewable power establishments of the world.

Gujarat has reiterated its firm commitment towards green energy. The state has had forward looking solar power policies since 2009 with the game changer being, the 2019 solar power policy addendum to the broader 2015 policy [5]. The 2019 solar power policy addendum focused on encouraging distributed grid connected power plants upto 4MW opening entry for micro small and medium entrepreneurs. This coupled with the provision of allowing 3rd party sales proved to be a very lucrative opportunity shifting the focus of the industry formerly dominated by large business houses to smaller businesses [6]. The customers of these power plants have not only gone greener but benefitted tangibly by lowering their power tariffs saving lakhs of rupees annually by claiming off sets on their electricity bills by entering into power purchase agreements. These agreements have particularly benefited the electricity intensive industries such as textiles, paper and packaging material industry to name a few. The policy further incentivised the industries to develop solar power plants for captive usage with easy financing and subsidies and revised metering rules. This has piqued the interests of private and institutional investors and entrepreneurs across the board. More importantly paving way for decentralising the energy production, which by all means is the future of the renewable energy industry. It has the potential to provide diverse areas with varied energy needs to develop energy generation capacity customised to their needs,thus,truly democratising the market.

Challenges:

For all its allure, venturing in this market is not without its set of challenges highlighted below, many of them being systemic in nature:

- Land Acquisition: One of the major challenges faced is that of land acquisition. Like anywhere in India, land acquisition process in Gujarat too remains cumbersome, riddled with unnecessary delays and cost overruns.
- Regulatory Issues: Though there is a major push towards improving ease of doing business in general and in solar power policy in particular, it is still riddled with multiple departments regulating the process with varying interpretations of the policy provisions. Oftentimes this results in a tiresome labyrinth of regulatory delays. However, with time and normalisation of processes these are expected to ease off but nevertheless a single point clearance process is definitely the need of the hour.
- Lack of easily available skilled workforce: From the time one starts constructing the power plant to reach its operations, dearth of professional skilled workforce is evident which over time with the industry maturing might smooth over. Skill development programs focussed on various technical aspects of the industry, providing vocational training would go a long way.
- Over reliance on bank loans for funds: For the industry to realise its full potential, a vibrant debt and equity market are a vital aspect. Currently, the developers have to rely heavily on bank loans to finance their projects, which is not sustainable in the long run.
- Current trends in the market heavily focus on just increasing the installed capacity, there needs to be a foresight to incentivise storage, improved efficiency and striving for innovation in the field.

Way Forward:

As impressive as incentivising the current policy is, the future iterations need to be moved away from focusing on merely increasing the installed capacity to encouraging innovation and future trends to make the industry future proof and sustainable. Several ideas and areas need to be addressed by the policy makers and the decision makers. Following are some of the many areas to to focus for driving the industry forward:

- With the Power storage technology evolving to be more efficient and cost effective, the future trend is definitely towards decentralised self-sufficient clusters rather than the central grid connected power plantsThe need for incentivising deployment of efficient storage capacities for more efficient and stable power generation needs to be considered.
- Data analytics to work out the power requirements and on demand delivery systems with pinpointed accuracy is a major field to look out for.
- Encouraging investments from the masses with innovative derivatives, debt and equity schemes for green energy finance augmentation is an interesting area that is foreseen as a game changer in the future.
- On demand need based metering and billing models using blockchain can also potentially be a major thrust area in the future.

Thus, it is quite clear that the renewable energy segment is an interesting and exciting field for ambitious entrepreneurs who operate not only for profits but with a vision of making impactful business for national and social development.

This article is written based on our personal experience of developing a new business in the field of renewable energy in Gujarat, India. The journey so far has remained exhilarating, exciting and satisfying to say the least. It is my hope that this area will appeal to a wider and newer generation of entrepreneurs who will craft their futures and chisel out the industry's new and robust form in the process.

References:

1) Muneer, T., Asif, M., and Munawwar, S. (2005). Sustainable production of solar electricity with particular reference to the Indian economy. Renewable and Sustainable Energy Reviews, 9(5), 444–473. **https://doi.org/10.1016/j.rser.2004.03.004**

2) Current Status | Ministry of New and Renewable Energy, Government of India. (2021, March 31). **Https://Mnre.Gov.in/Solar/ Current-Status/.https://mnre.gov.in/solar/ current-status/**

3) Damor, K. (2018, December 2). Gujarat riding on the sun's chariot. The Times of India. **https://timesofindia.indiatimes.com/city/ahmedabad/gujarat-riding-on-the-suns-chariot/articleshow/66900722.cms**

4) Policies for solar power and small and distributed solar power plants| Gujarat Energy Development Authority (2019, March 6) (2015) (2021). **https://geda.gujarat.gov.in/geda/2021/1/30/Policy/3157**

***

NSWAI

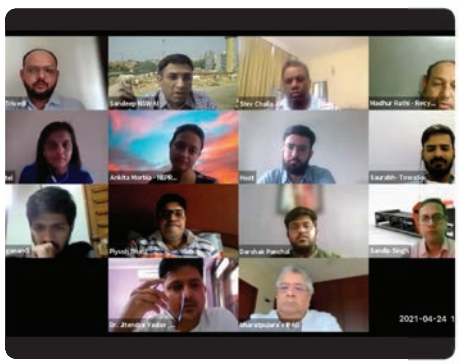
ACTIVITES 2020-2021

Dr. Sahu on Mirror News

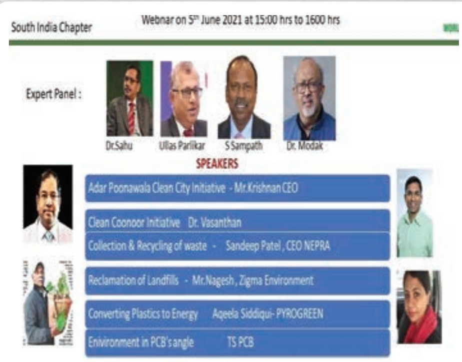
We Care Fellowship 2020

10th National Conference on Waste Management 2021

Webinar at A.J. Institute



NSWAI Entrepreneur Webinar



Webinar on World Environment Day 2021

EnvironTech Asia 2021

Webinar on Aatmanirbhar Society

Conference to be held on 23rd February 2022.

GST NO.: 27AABTN3167G1ZJ

NSWAI

EST.1996

NATIONAL SOLID WASTE ASSOCIATION OF INDIA

Join **NSWAI** and Become Professional Waste Manager

Corporate (Contributors/ Producers)

Machinery & Technology Providers

Enterpreneurs/ Innovators

Investors/ Venture Capitalists

Individuals

Waste Management Companies

Goverment Bodies (MoEFCC, PCBs, PCCs, ULBs)

Students

NPO & NGO

Educational Institute

Sector Specific association

Freelancers

Registerd Office

Bhargava House,Marol Co-op Industrial Estate Ltd, M.V.Road, Mumbai-400059

Communication Office

Noble Trade Center, 7thr Floor Nr, Bhuyangdev Cross Road Memnagar, Ahmedabad-380052

Contact:079-40050400 | Email: info@nswai.org | Website: www.nswai.org