*Proceedings of the Brainstorming Session*

# Industrial By-Products for Sustainable Development

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सत्यमेव जयते

*In collaboration with*

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TIFAC

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## EXECUTIVE SUMMARY

Rapid industrialization and urbanization has affected the environment tremendously. Several industries such as mining, mineral processing, metallurgical and metal processing, textiles, power plants, food processing, construction etc., face a major challenge in handling/management (including disposal or utilization) of their by-products or in other words, waste products. Notwithstanding the contributions of industrial establishments in India to the growth of the economy through 'good' output, they have been struggling to deal with 'bad' output or 'industrial by-products' (IBPs). When the economy emphasizes on the achievement of high growth rates in output and increased share from the manufacturing sector, efforts need to be made to help create a market for 'bad' output. It is widely known that such 'bad' output could be highly useful in sectors that may, perhaps, use them as inputs. The industrial and/or competition policies that have evolved in India over a period of time has not spelled out the methodologies to deal with the IBPs, adequately.

The so-called "outputs"/IBPs are known with different classifications and generally seen as "waste". Direct waste is a material, that is unaccounted for. This type of waste can be prevented and involves the actual loss or necessary removal and replacement of a material. Indirect waste is the result of materials being used for purposes other than those specified or in excess of measured quantities to meet the dictates of production. Construction activities generate avoidable and unavoidable waste. Identifying and categorizing the types and causes of avoidable waste help in minimization. Even this qualifies as IBPs as the Construction Industry is very large in the country and the amount of excess waste generated, etc., if considered, is significant. Industrial and agro-industrial by-products and waste can be processed to obtain new materials and high added value products. The valorization of industrial and agro-industrial waste is achieved by re-use in the production of innovative materials and components. Secondary raw materials are recycled for several applications. It is a challenge to turn this into a successful program of Waste to Wealth through Recovery and recycling of industrial by-products and waste into a well-defined policy.

In view of the above, a brainstorming session was organized by ***Prof. D. N. Singh***, *Indian Institute of Technology Bombay*, on 22nd August, 2018, with the representatives from several industries, regulatory agencies, and policy-making bodies, to delve into these aspects and concur on the way forward. The delegates shared their views on aspects ranging from current practices, state-of-the-art, technological advancements needed, role of regulators and policymakers in the handling, management, transportation, utilization and disposal of IBPs. ***Sri Suresh Prabhu***, *Hon'ble Minister for Commerce and Industry, and Civil Aviation* through his video message, highlighted the importance of balance between economic development and ecological priorities, by citing the philosophy 'cradle to grave' to be modified as 'cradle to cradle'. ***Prof. Indranil Manna***, *Vice-President, Indian National Academy of Engineering* (*INAE*), through teleconferencing welcomed the delegates and made them aware about the policies of the Govt. of India, IMPRINT in particular. ***Dr. V. K. Saraswat***, *Member, NITI Aayog*, addressed the delegates and emphasized upon various issues associated with IBPs.

Delegates present but who have expressed their views via e-mail were of the unanimous opinion that the fate of various IBPs such as those from alumina industry (red mud), slags from different metal manufacturing units, ash from thermal power plants, mined residues from municipal solid waste landfills, E-waste, used/waste rubber tyres, and refuse from leather

industry need to be addressed immediately. The bottlenecks in addressing these issues exist either due to lack of implementable and/or scalable technological solutions, or regulatory and policy issues that are causing impediments in adopting the recent innovative technologies. There is a huge potential for bulk utilization of these materials to be used in various projects such as *SagarMala*, *BharatMala*, road and rail constructions across the country, and manufacturing of materials of construction such as cement, fine and coarse aggregates as replacement materials (of sand, cement, etc.), sub-grade materials, ballast, etc. Also, the know-how regarding the technologies/solutions developed indigenously, and the pilot studies of such technologies need to be disseminated or demonstrated on a sizeable scale, in a more efficient manner, so that it would reach the audience across the country and resulting in saving huge time and cost involved in reinventing the techniques. Moreover, the incorporation of the scientifically proven advanced/innovative/emerging/new technologies in manuals/standards of agencies such as Central Public Works Department (CPWD) and state PWDs, National Highway Authority of India (NHAI), Indian Road Congress (IRC), Bureau of Indian Standards (BIS) etc. progress at a slower pace that hinder/discourage the possible utilisation of IBPs. In addition, lack of incentives from national transporters, mainly Indian Railways, has financially burdened the projects/entities aiming at utilizing some of the IBPs. Furthermore, as a nation with rapidly increasing usage of solar energy and Li-ion batteries in select applications, it is prudent to develop cost-effective, indigenous methods for recycling or tackling the spent modules of these appliances.

The quantum of red mud generation from alumina industry, slags from steel and copper industry, and construction and demolition (C&D) debris needs to be addressed in mission mode, similar to the one adopted in the case of fly ash, by the Govt. of India. Academic institutions such as IITs could be the nodal agencies for implementation and monitoring of such missions. In order to bring some realistic & time bound touch to these efforts, representatives from Industries/ Chambers of Commerce could be invited to contribute. Further, technological solutions for novel utilizations schemes for various IBPs should be developed at IITs and other leading research centers at industries. Such activities could be realized by an open-to-all funding scheme for successful development and pilot scale implementation of techno-economic feasible processes for utilization/disposal/management of IBPs. An umbrella body (similar to the existing trade bodies such as CII and FICCI) consisting of IITs, other educational institutions, autonomous bodies under each nodal ministries, and industries that would facilitate in disseminating the knowledge regarding the latest innovations and practices across the country needs to be established. Such a body would also help in self-regulation of the industries with regard to monitoring the generation, handling, utilization, management and disposal of IBPs. In order to encourage co-processing of IBPs, the regulators could also explore the option of dis-incentivising the landfilling practices and promoting circular economy. More proactive measures by agencies such as BIS, IRC, NHAI, and various PWDs would instantly help in reducing, to a certain extent, the burden of storage of a few IBPs. Industries need to come forward and invest in development of novel technologies with or without the help of leading research institutes. Further, the economics associated with utilization of IBPs needs to be seen from the perspective of environment and not just a financial one. Thus, envisioning sustainable and zero-discharge industrial processes, will lead to a better environment for the coming generations.

The IBPs listed above need to be exploited to augment economic growth and employment generation. A clear policy to deal with the situation can provide a win-win situation from environment as well as economic opportunities perspective. Academic institutions like IITs can help formulate a clear pathway for fostering sustainable development as required by the international obligations.

On the other hand, we need to exploit this opportunity to engineer/develop processes to produce sustainable materials of construction out of the IBP wastes. These comments of the delegates are summed up at the end of this report with future plan of action that creates a logical way forward.

## VIEWS OF DELEGATES

## A. BAUXITE RESIDUES

***Dr. Gautam Goswami, TIFAC***

"Mission required for utilization of Red Mud in a sustainable way i.e., extraction of Rare earths, Titanium and other important components".

***Dr. P. K. Banerjee, Hindalco Industries Ltd.***

"At National level a comprehensive strategy needs to be made on utilization of Red Mud mainly in following four areas a) Cement making b) Bulk construction – road, embankment, marine clay reclamation and mine backfilling c) man-made soil for green belt development d) metal / non-metal value recovery. On each of these areas a National level Mission Projects need to be launched and these projects to be executed in parallel. Participating organizations in these missions will be from industry, academia, research labs and Govt. agencies and preferably, to be led by industry sector. The projects should focus on complete solution including commercial scale technology development, demonstration & implementation, preparation of policy guidelines and standards.

Initiative on Bulk construction application is already being led by IIT Bombay along with Hindalco Industries Ltd. The same may be extended to other partnering organizations including Govt Agencies to make it the Mission Project and expedite demonstration and implementation of the technology.

NITI Aayog initiative to extract Rare Earth Element (REE) from Red Mud (and Fly Ash) to be expanded to complete Value Recovery (Fe, Ti, Al, REE & Non-metals). The committee recommendation on the potential process/technology route, expected by Dec, 2018, to be taken as the basis for launching the National Mission Project for technology demonstration on Value Recovery from Red Mud".

***Mr. Anjan Das, Confederation of Indian Industry***

"Confederation of Indian Industry spearheaded by its National Committee on Environment, which has members from varied sectors of Indian Industry, works extensively on key policy issues in the areas of Plastic Waste Management, E-waste management, and Environment and Forests Clearances. In addition, the committee has a specific focus on key challenges associated with environmental compliance, and hazardous waste management is one of them. With an objective to facilitate increased utilization of hazardous waste in the country, especially in the cement kiln, CII has been advocating streamlining of waste co-processing trials, through extensive interaction with regulatory authorities. Hazardous waste can be utilized in cement kilns, leading to lesser GHG emissions. However, on account of a few challenges, we are losing a large opportunity to reduce GHG emissions and conservation of coal. These challenges are: business is getting impacted because industries are not able to comply to the green supply chain principles; some of the SPCBs are advising industries to approach CPCB for obtaining approval for co-processing; a large amount of hazardous and non-hazardous wastes is getting disposed in an unsustainable manner causing environmental hazard; at locations, where landfill and incineration option are not feasible, the industries are facing huge waste disposal issues such as in Tirupur, Goa, etc. CII made a presentation on the requirement of modifying the CPCB guidelines, based on the data analysis from the results of

co-processing trials that are already approved by CPCB. All these trials had demonstrated that the baseline emissions of the kiln were not impacted considerably due to co-processing of wastes. Although the CPCB guidelines were amended, however, varied interpretations at SPCB level need to be addressed and removed.

CII's Green Business Centre (GBC) at Hyderabad, has been working in the industrial waste since many years. CII's GreenCo Rating Program promotes Waste Management in industrial facilities by inventorizing all waste generated and establishing specific waste generation; encouraging industries to *Commit & Reduce* specific waste generation year-on-year; encouraging adoption of waste management practices in line with waste treatment hierarchy; facilitating 'Waste Exchange' through unique online platform www.ciiwasteexchange.org; substitute & reduce waste generation by promoting tools like Lifecycle Analysis (LCA), Environment Product Declaration (EPD). CII promotes Co-processing of Alternate Fuels & Raw materials (AFR) in cement plants by creating a platform to bring all stakeholders like cement plants, generators, policy makers (PCBs & ULBs) and technology suppliers; creating awareness, capacity building and enabling conducive policy framework; support implementation, scaling-up success stories, develop implementation models and forecast generation and utilization; technical feasibility, developing business models, waste fuel mapping, etc. are also carried out to help industries pursue AFR utilization further. CII-GBC also works on phytoremediation with applications in the agricultural waste. industrial waste, sanitary and urban waste, landfills and lake & river rehabilitations".

***Mr. Ulhas Parlikar, ACC Ltd.***

"Cement kilns can manage reasonable quantum of red mud in plants when petcoke is utilized as fuel. We would be happy to utilize it in workable proportions".

***Mr. Vinod Sood, IBAAS***

"Several Government agencies and Institutions are carrying out research work on bulk utilization of Red Mud and Ash on behalf of Aluminium industries. Since a lot of progress has been made by IIT, it is not necessary for producers to initiate and progress individually on this. ***It would be advisable to make a single central agency and all producers be asked by NITI Aayog or similar such agency to direct their activities through IIT.*** This will not only save funds but it will also allow the producers to present a united front to the agencies involved in granting clearance.

The need of the hour is to find a fast solution for safe disposal of Red Mud by backfilling in Mines. The Central/State Government agencies are to be educated accordingly.

While recovery of precious metals is definitely an excellent idea but the generation of waste from such processing needs to be studied in greater detail. So far only RUSAL has come to a pilot scale plant for recovery of Scandium".

***Mr. Tapan Mappat, Vedanta Alumina Ltd.***

"Regarding the possibilities of the red mud utilization, it is suggested that the respective stakeholders work together on projects pooling in expertise, funds, experience etc. to bring a sustainable solution to the society as a whole.

To reduce the freight expenses related to the railway transport of the red mud by relooking into the freight classification.

To look in to option of making a mission red mud similar in the lines of Fly Ash mission.

Suggested that all the 3 stakeholders of red mud to work in coordination while representing the case to the Central government bringing the technical studies to the table.

Suggested that Central Government help in setting up a model plant for utilization of the red mud which could be replicated at different locations. The academia has to bring the research papers on table to identify the right solution to the problem".

***Dr. P S R Babu, Alcon Pvt. Ltd.***

"Study utilization economics at resource-limited condition (now regional and in future the whole world) before by-product disposal. Example- recovery of iron from red mud is not viable in India but it is processed in other part of the world.

Design processes towards atomic level recovery- in aluminum manufacturing, more than 5% alumina is wasted through red mud. Today, technologies are available for safe utilization and disposal of all industrial/social IBPs, the willingness for implementation is the only need of this hours".

***Mr. K. Venkatesh, Hindalco Industries Ltd.***

"Govt. Policy, Protocol by MoEF&CC/CPCB should be made so as to obtain necessary approval from Statutory bodies easily".

***Mr. Ganaraj K., IIT Bombay***

"Application of alkaline IBPs for treatment of Acid Mine Drainage, mine backfilling, embankment construction etc.".

## B. FLYASH

***Dr. Gautam Goswami, TIFAC***

"Mission to Convert Fly Ash into a resource material."

***Dr. P. K. Banerjee, Hindalco Industries Ltd.***

"Use of Fly ash in Cement and Construction applications is well established. However, policy guidelines should be relooked so that its use in the construction applications is maximized. Large-scale application potential of this material in mine backfilling to be explored and practiced".

***Mr. Sydney Lobo, Tata Power Ltd.***

"Significant policy changes to enhance the utilization of ash in the construction industry and inclusion of these materials in the various PWD tenders etc.

Utilities are pressurized to keep the tariffs low for the end customer. Adding additional cost for ash handling and disposal, does not gel well on the tariff. Thus the policy needs to be comprehensive by taking into confidence all the concerned Ministries so that the overall objective of sustainable reuse of ash (fly ash & bottom ash) is met".

***Dr. Shambhu Jha, Mahanadi Coal Ltd.***

"Mine void requires to be reclaimed, for which overburden material is not sufficient to fill up the void completely as the coal content is used up for electricity production. ***The fly ash which is normally acidic in nature may be mixed with the red mud and this neutral or slightly alkaline material may be used for filling up the mine void.*** However, this is possible if the fly ash and red mud are available locally. Also, the ratio of mixing fly ash with red mud requires to be defined for its proper utilization.

The bottom ash of the Blast Furnace can also be utilized for construction of mine roads especially during the monsoon period where the mine roads become muddy and slippery. For this purpose, the industry generating bottom ash can supply the bottom ash to a designated place at the mine site. This will resolve their issue".

***Mr. Partha Chattopadhyay, TATA Sponge Iron Ltd.***

"Coal-based rotary kilns are of relevance for DRI production and then steel production through Induction/Arc furnaces in Indian context as we have abundance of high ash coal available here.

NHAI to consume Fly Ash. NHAI has come out with a stringent specification for all parameters of fly ash. Relevance of those parameters are to be critically examined, then prioritized. General tendency is to avoid use of fly ash. As per fly ash notification, we are supposed to give fly ash free of cost which is agreeable.

***Incentivise those who are using fly ash through various fiscal measures (like GST exemption etc.)***".

***Mr. Santosh Pattajoshi, Bhushan Steel Ltd.***

"We are ready to ***provide transport subsidy @ Rs.150 per ton of ash*** but not many parties show interest to lift.

We are in the process for cenosphere extraction from fly ash".

***Dr. P S R Babu, Alcon Pvt. Ltd.***

"Preservation is better than disposal, if alternatives are available. Today cement from C class fly ash and LD slag is not viable due to cheap availability of limestone, but considering the alarming limestone depletion rate, relook at the same before disposal/utilization of these products towards non-cementitious applications."

***Mr. Tushar Chauhan, IIT Bombay***

"Green Paver Blocks can be a good step in the bulk utilization of fly-ash and slag. Economics of the IBPs can be a major challenge here".

***Dr. K. Rajkumar, IRMRA***

"Modified Fly ash can be used as filler in various rubber products replacing petrochemical-based carbon black which will be a good green initiative. IRMRA conducted preliminary research on such research project and the results was encouraging. An extended research needs to be conducted to make it commercially viable".

## C. SLAGS

***Dr. Gautam Goswami, TIFAC***

"Mission required for Gainful utilization of Slag (Blast Furnace and Steel Industry)".

***Mr. D. Satish Kumar, JSW Steel Ltd.***

"Speedy amendments in IRC codes (for both Orange and Red book) for usage of slag aggregates in road construction.

***Usage of steel slag in cement making also need to be studied and a new cement code for steel slag based cement needs to be drafted"***.

***Dr. S. Majumdar, JSW Steel Ltd.***

"Policy changes to promote greater use of industrial material (*e.g., IS 383: 2016 allows the use of steel slag as aggregates in concrete making, but Indian Road Congress is slow in updating the Codes for road construction*), and also explore the option of considering geographically proximal applications (*e.g.,* ***NHAI to take slags and fly-ash from companies located within a radius of 100 km***).

Bring together all stakeholders to decide how to enhance the potential to utilize materials such as slags, fly-ash, and other industrial wastes in various applications (*e.g., agriculture as soil conditioner, in constructing breakwater structures [e.g., tetrapods] on the coast to prevent damage due to waves, etc.*)".

***Mr. Prabhat Kumar, Tata Steel***

"There are multiple forums where utilization and promotion of Steel Slag have been discussed but there is no significant progress made so far in its utilization.

Use of Steel Slag largely depends on the volume expansion of Steel Slag being used for construction. There is some limiting value of volume expansion (2%) beyond which it cannot be used as road aggregates. Hence, it is mandatory to define the process of weathering to attain that limiting value of volume expansion. This would largely prevent the manufacturers adopting shortcuts.

It must be documented as to how the processing of the slag shall be done and what all parameters (like volume expansion, free lime, iron unsoundness etc.) are to be checked critically.

Mandate the use of Processed Steel Slag in Road making in the vicinity of 150-200 kilo meters of all integrated Steel Plants.

The rail freight charged by railways is dependent on the class of material. Lower the class, lower is the freight charged for that material. Currently, Steel slag has been classified under class 140. We, therefore, strongly advocate to reduce the class of Steel Slag from 140 to 120 which will reduce the freight. This would promote the usage of Steel Slag across India.

Develop Standards for use of Steel Slag in manufacturing of Portland Slag Cement (PSC), Tata Steel has engaged NCCBM to carry out some trials for its suitability in PSC making.

As of now, IS 383 suggests to use Steel Slag as a replacement of natural aggregates, but the extent of utilization is meager. Hence, in order to increase the utilization of Steel Slag significantly, BIS should explore in enhancing the extent of utilization of Steel Slag in PCC & RCC.

RDSO is the agency who makes guidelines for any usage of Steel Slag as a replacement of rail ballast. NITI Aayog may instruct RDSO to initiate the process of developing codes & specifications for Steel Slag as rail ballast. Pilot section laid with Steel Slag in Gamharia railway station.

In addition, we should set up (a) forum represented by Steel Ministry, Niti Aayog, Indian Road Congress, NHAI and steel industry representatives to fast forward the initiatives, (b) A Govt. sponsored web page where success stories, pilot scale trials and developments, case studies, proposals for scale-up, test results of slag quality etc can be made available to all stake holders. This will facilitate wider communication to larger audience, (c) We need to separate forum wherein municipal bodies can come together for deeper understanding of new technologies of waste management and probable applications in their domain under prestigious institute like IIT Mumbai or any govt nominated forum and (d) Creation of standards by BIS with detailed spec for all sub-items for any application of steel slag. This should be the basis of inclusion of such materials in govt contracts at State and Central level".

***Prof. P. V. Divya, IIT Palakkad***

"Bulk utilization of fly ash, copper slag, steel slag: Coal ash and slag can be bulk utilized in highway embankments, Backfill of Reinforced Earth (RE) wall and for incremental raising of ash dykes etc. Also, some of the IBPs such as fly ash, ground granulated blast furnace slag etc. can be utilized in Sustainable ground improvement techniques.

One of the prime concerns with the utilization of these IBPs in various geotechnical application is that they must be carefully engineered with the provision of adequate drainage system. There is a need to revise the existing selection criteria, design and drainage guidelines when IBPs are in contact with the filters and drainage systems in geotechnical structures".

***Mr. Santosh Pattajoshi, Bhushan Steel Ltd.***

"Railway has to come forward to utilize Dry pit slag of blast furnace in place of stone chips".

***Prof. Prakash Nanthagopalan, IIT Bombay***

"The latest revisions of IS codes (for eg: IS 383) included the use of different manufactured aggregates (like copper slag, steel slag, iron slag, recycled concrete aggregates) for plain and reinforced concrete as well.

The supplementary cementitious materials (eg: slag) shall be understood properly for its reactive potential and use in applications as deemed appropriate, rather than just using as landfilling materials".

***Mr. Anil Counto, Alcon Pvt. Ltd***

"Sustainable materials to remain sustainable – After a value is found for a particular waste stream/industrial by-product the cost of the same to the end user is increased to an alarming level so that the continuous use of the particular waste stream/industrial by-product becomes increasingly difficult. Government should initiate some action to protect the interest of entrepreneurs in this regard.

Modification of Existing standards to allow maximum utilization of waste- Need for introduction of performance-based standards in areas of cement and building materials so that maximum amount of IBPs can be utilized".

## D. OTHER IBPs

### Municipal Solid Waste

***Mr. Nagesh Prabhu, Zigma Global Environ Solutions Pvt. Ltd.***

"Difficulty in transporting combustibles from our plant to cement companies if the Landfill Mining sites are away from the cement companies.

It was suggested not to transport combustibles to cement companies but rather to look for solutions like pyrolysis or plasma gasification to add value to the preposition.

Difficulty in using aggregates and inert for NHAI roads due to the absence of legislation".

***Mr. Ulhas Parlikar, ACC Ltd.***

"RDF management in cement kiln is an ecologically sustaining solution and is being implemented successfully by us. We consider that unless there is win-win approach in implementation, it will not sustain. To facilitate this win-win approach, it is desired that government implements a proper negative tax on landfilling so that the sustainable solutions such as co-processing start getting desired comparative economic consideration for implementation".

***Mr. Nigam Sahoo, Antony Lara, Mumbai***

"RDF comprises 50% of the incoming MSW. Consumers (Cement/Power Plant) are located very far from the point of generation of RDF. Policy does not incentivize use of RDF therefore probable consumers are not willing to carry out modifications required in the existing plant to accept RDF as Policy does not specify quality and price of RDF ex-works as specified for organic manure (another product of waste processing plant). The processing plant is under operation and the existing balance sheet of the waste processing companies cannot support additional major financial investments".

***Mr. Somenath Malgar, Mumbai Waste Management Limited.***

"Common platform to be created to deal with the handling of IBPs in a productive way. As CHWTSDFs across the country is the leading and pioneer organizations in handling various waste in scientific and safe manner and with the help panel authority and approval they can come with a productive concept on common stage. As we those are complying with guidelines framed by CPCB and already set up various recycling projects which will turn will be boon in understanding the IBPs its reusability in concrete manner".

***Dr. P. K. Banerjee, Hindalco Industries Ltd.***

"Copper slag and Phospo-gypsum have great potential for value-added applications in Cement and Construction applications. These materials to be included while undertaking Mission projects on these two areas. Use of phospo-gypsum as a soil conditioner may also be looked into while working on man-made soil from IBPs".

***Mr. Anjan Das, Confederation of Indian Industry***

"CII has constituted Waste to Worth Task Force to develop a PPP model by which credible private sector invests in this area adopting appropriate technologies. CII has been working with Ministry of Housing and Urban Affairs for developing a model RfP for states to

adopt it for bidding. The model has key aspects like: Private sector to manage waste end-to-end, One city one bidding (by multiple bidders for multiple locations of the city) to cover total waste generated by the city; and selection criteria only on outputs".

## Leather

***Dr. Thanikaivelan Palanisamy, Central Leather Research Institute.***

"Leather industry generates 300,000 tons of hazardous Cr containing solid waste (out of the 0.6 million tons solid wastes) by processing 0.8 million tons of rawhide/skins per annum in India. Most of these solid wastes are either not appropriately utilized or securely disposed. For immediate need, widespread usage of CSIR-CLRI 'Waterless chrome tanning technology' and 'Leather Board making from Cr containing leather wastes' need to be ensured for avoiding the generation of hazardous waste and sustaining the leather industry".

## e-Waste

***Mr. Sydney Lobo, Tata Power Ltd.***

"Research needs to be initiated for a techno-economically viable reuse/recovery for spent Li-Ion Batteries and spent Solar Modules – These will come up in the next 10 years or so in large numbers".

***Mr. Sunil Singh, CEO, Surbine Recycling***

"Possible uses for Plastic powder containing polyamide and BFR.

Mechanism to source E-Waste from corporate and government, intervention required from government to only allow refiners access to the E-Waste.

More restrictions on informal sector engaged in environmentally damaging methods of recovering metals from E-Waste".

## Plastic

***Dr. Manatesh Chakraborty, ITC Ltd.***

"Use of Multilayer film & Low-value plastics to value-added molding application, we needed help in targeting applications such as from Swachh Bharat initiatives like toilets, dustbins, etc where recycled polymers can be specified

Need contacts from mines, thermal power station, cement industry for liner, conveyors, etc & also Railways. Today these recycled polymers are available at INR 5 to 7 per kg at this price & performance it can open up application that would never have been possible

Plastics incorporation in road construction, we brainstormed how a small group activities made in some corner of the country can be put up in a common website to make it big, large & impactful".

***Dr. Shambhu Jha, Mahanadi Coal Ltd.***

"Use of plastic for the construction of pavement of mine road is a good proposition. However, mining industry needs to be educated of the exact mechanism how to execute the same".

***Dr. K. Rajkumar, IRMRA***

"Use of plastics wastes in Rubber Products are one of the use which can be explored. Lots of research activities are being carried out by blending Plastics with Rubber making recyclable thermoplastic Elastomers.

Waste tyres are disposed/dumped in open landfill or open areas creates health hazards. During rainy season it becomes source for water storage on which mosquito breeding gets developed. Though reclamation process and other useful methodology for making use of waste tyres, absence of policy and guidelines leads in dumping in open areas without proper disposal system. IRMRA along with various stakeholders developed guidelines which has been forwarded to MoEF/CPCB through DIPP for further necessary/suitable action.

Further Research needs identified for using waste tyres in value-added applications which needs exploration. Suitable funding mechanism for such continued research may be envisaged".

## Agro-based By-products

***Prof. Prakash Nanthagopalan, IIT Bombay***

"The use of agro-based by-products (bagasse ash, rice husk ash) shall be encouraged to use in concrete by establishing the business model with the support of small and medium enterprises in Maharashtra".

## E. GENERAL OBSERVATIONS

***Mr. Alok Kumar Tiwari, Ministry of Railways***

"Promotion of Sustainable procurement and Green certification needs inclusion".

***Dr. Kunal Kumar Singh, Geological Survey of India***

"Several hectares of land are being mined or quarried for different mineral or metal resources and waste in the form of rock muck are in general dumped in the surrounding areas, which occupied large areas in the surface of the earth crust. In most cases, these areas were either forest/agricultural land earlier.

Therefore, mapping of such wastelands/dumping zone is urgently required to come for some solution to make such areas usable as well as make the use of dumped waste as man-made resource.

Geological Survey of India can assist in quickly identifying such zone (waste dumping site) and map or demarcate the boundary and provide the quantitative information on the wasteland/dumped zone".

***Prof. Nagesh Iyer, IIT Dharwad***

"We need legislation/code/bye-laws that will provide an opportunity to: (a) improve resource conservation and waste minimization; (b) prevent pollution, and decrease GHG emissions; (c) advance integrated resource recovery and waste management systems.

We should facilitate the Government of India, through extensive studies/investigations, develop policy framework for siting and operation for creating waste to wealth of IBPs, outlining economic parameters as tools for policy making and Policy Recommendations for following: (i) creation of dynamic database of waste generated and generator; (ii) tracking waste from cradle to the grave for transformation to "cradle to cradle"; (iii) database of all waste types; and (iv) designing management plan, guidelines for use in defined applications and required infrastructure".

***Ms. Vishakha Vartak, Tata Administrative Services***

"Use of IoT for condition monitoring of pipelines and equipment carrying/storing hazardous waste is worth considering - can help prevent seepage, leeching, leakage etc and avoid disastrous consequences.

For industrial waste which can be reused/recycled, sensors can be embedded in the products - e.g. white goods, rubber tyres etc - which will make tracking the goods easier, hence improving the pulling back of such waste into the circular economy. Dr. S. S. Gupta from DIPP has shown interest in this idea.

Owing to multiple stakeholders responsible for ensuring standards and the right governance ecosystem, there is a need to set up a council/committee/center of responsibility who can expedite regulatory processes and make the efforts for creating a sustainable circular economy successful".

***Dr. Bhushan Gabhane, Sterlite Technologies Ltd.***

"Indian Industry is suffering from the effective by-product/waste Management system. Industry should work on following three points: (1) Vision on the waste management; (2)

Technology gaps of on by-product uses; and, (3) Mission should be defined with complete pathway, goal, time Frame and budget.

Industry should work on the ideas to convert waste to product, build the ideas into scalable technology, sustainable procurement with life cycle assessment of the product as well as the waste and by-product, and manufacturing of useful raw materials to process and get the useful main product as well as useful by-product. *Green is the business*- with this philosophy, industry should build on three pillars, namely: (1) Environment, (2) Social, and (3) Economy; ignoring that sustainability comes at cost, environmental, and social factors. Economics should be at last, and the sustainability comes with price. Industry should focus on the circular economy and benefited company should bear the economics and promote the start-up companies. Distance transportation of the by-product/waste to be avoided and processer/user should be near to the industry".

## F. SUMMING UP

There are number of candidates available as options for consideration as material of construction for different applications. We have a huge task ahead to make correct engineering judgment and thereby frame policy. In order to meet this and also to successfully exploit the use of IBPs in purposeful use in different applications in an effective manner, academic institutions, R&D labs and corresponding industry need to interact to develop processes to produce sustainable materials. Some of those that need extensive studies/investigations are:

i) Ceramic materials and components
ii) Development of bio-based materials from recovery and treatment of organic waste
iii) Synthesis of alternative binder and aggregate/filler/fibre from waste materials (At least three such binders/aggregates can be identified, namely, a) Fly ash (FA) +Ground granulated blast furnace slag (GGBS); b) GGBS +Silica fume(SF), & c) Portland cement and Micronized biomass silica (MBS)
iv) Manufactured Sand (M-Sand) – An urgent need to formulate the standards and regulate the use. The human consumption rate of natural resources, exceeds earth replenishment rate by 30%.
v) Construction and Demolition Waste (C&D Waste) - Precise knowledge of waste properties expands opportunities to maximize its utilization as recycled construction materials. Generally, construction and demolition waste can be classified, depending on the nature of works, into five categories, namely roadwork material, excavated soil, demolition waste, site clearance waste and renovation waste.

## WAY FORWARD

The key action points that emerge out of the brainstorming session are:

- Issue of red mud, slags, and other IBPs needs to be addressed in mission mode, similar to the one adopted for fly ash. TIFAC in partnership with IIT Bombay may take lead in preparation of DPR for such a mission on utilisation of 'red mud' and other IBPs.
- As suggested by Prof. D. N. Singh, and encouraged by Dr. V. K. Saraswat, studies needs to be taken up on utilization of geothermal energy, foundry sands, and feasibility of deep disposal of toxic waste.
- Academic institutions should play a key role in technology development, knowledge dissemination, and monitoring the generation, handling, utilization, management and disposal of IBPs.
- Establish an umbrella body (similar to the existing trade bodies such as CII and FICCI) consisting of IITs, other educational institutions, and industries to focus on various aspects of sustainable (environmental friendly) practices in industries.
- Issues regarding the slow progress in various governmental agencies needs to be addressed urgently.
- Transport of IBPs for utilization in construction activities or industrial processes needs to be incentivized.
- CII will be happy to be the Industry Partner in this initiative through its Centres of Excellence: Green Business Centre and Centre for Sustainable Development.
- Showcasing the policies towards disposal and creation of a market for IBPs as economic opportunities to all the stakeholders.

## LIST OF DELEGATES

| Sl. No. | Title | Name | Designation | Affiliation |
|---|---|---|---|---|
| 1 | Dr. | V. K. Saraswat | Member | NITI Aayog |
| 2 | Dr. | D. N. Singh | Institute Chair Professor | Indian Institute of Technology (IIT) Bombay |
| 3 | Mr. | S. S. Kohli | Scientist-G | Science and Engineering Research Board (SERB), Dept. of Science and Technology (DST), Govt. of India |
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| 5 | Dr. | Malini V. Shankar | IAS, Director General and Secretary (Shipping) | Directorate General of Shipping, Ministry of Shipping, Govt. of India |
| 6 | Mr. | Alok Tiwari | Principal Executive Director (Environment and Housekeeping) | Railway Board, Ministry of Railways, Govt. of India |
| 7 | Dr. | Gautam Goswami | Scientist-F | Technology Information, Forecasting and Assessment Council (TIFAC) |
| 8 | Dr. | K. Narayanan | Professor | IIT Bombay |
| 9 | Mr. | Satish Pai | Managing Director | Hindalco Industries Ltd. |
| 10 | Mr. | Partha Chattopadhyay | Chief Operating Officer (Sponge Business) | Tata Sponge Iron Ltd. |
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| 12 | Dr. | S. S. Gupta | Senior Development Officer | Department of Industrial Policy and Promotion, Govt. of India |
| 13 | Dr. | Vasant G. Havanagi | Professor, Sr. Pr. Scientist | Council of Scientific and Industrial Research (CSIR)-Central Road Research Institute |
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| 17 | Mr. | Anil Counto | Chairman & MD | Alcon Pvt. Ltd. |
| 18 | Mr. | B. V. B. Pai | Consultant | Alcon Pvt. Ltd. |
| 19 | Dr. | Ramkumar Natarajan | Consultant | Alcon Pvt. Ltd. |

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| 34 | Mr. | Vinod Sood | President | IBAAS |
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