Faecal challenge attracts scintillating ideas

- DBT & BIRAC with BMGF for Reinvent the Toilet Challenge-India
- Six proposals supported of which five aim at developing proof of concept
- BIRAC supported four waste management technologies
- TERI supported for installation of 100 toilets to demonstrate technology

A thousand ideas need to contend to solve the problem of poor sanitation, however ideas need financial support. There is already enormous effort going on this important front through multiple government ministries such as Urban Development, Rural Development, Water and Sanitation, Health etc. To see how science can impact on solutions, the Department of Biotechnology, BIRAC and the Bill and Melinda Gates Foundation came forward with monetary support for ideas to tackle one of the most critical problems of India—sanitation.

As per a report by WHO and UNICEF called the Progress of Drinking Water and Sanitation—2014 released in May,2015 approximately 597 million people in India defecated in the open. Millions of tonnes of faecal sludge collected from pit latrines and septic tanks are discharged untreated into the environment. All these activities create an unfortunate health hazard, resulting in a need for new bio-toilet ideas and solutions

The result—six innovative ideas triggered in the minds of people in multiple parts of the country are on the path of being tested. Ideas triggered off watching the shame of open defecation while travelling on a suburban train, or generated in the minds of entrepreneurial individuals working in a lab or in the minds of people who while working on a certain scientific topic were inspirations to apply to making clean bio-toilets.

Parag Nemade, scientist at the Institute of Chemical Technology who travelled to work by the Suburban train every day, watched people defecate on the track for lack of better options. This prompted him and his co-workers to start thinking on ideas to improve the existing toilets.

He says that he started to search for the reasons behind the present conditions of toilets. “Why don’t many people use them, if they are available? What’s the reason more toilets cannot be built? Is there a better way to build a toilet which will require less maintenance?” he thought. He found that in most places maintenance is lacking because of the unavailability of water. So they started looking at ways to isolate the faecal matter from vectors such as flies and insects without use of water. This got them thinking about the use of fluidized beds to segregate faecal matter from the bed of sand like particles in the toilet. Fluidized beds are bed of small particles that are suspended due to introduction of pressurized fluid, such as a gas or liquid, from the bottom.

“With simple valve arrangement, faecal matter can be isolated from disease vectors such as flies. Moreover, the surface of the bed is refreshed continuously, the next person to use the toilet only encounters a clean surface in the toilet, Nemade pointed out.

He added that, cutting out the water not only saves water but also reduces the volume of the waste substantially.

So what about the treatment of the waste that is generated? Nemade says that his team intends to create an integrated system of treatment and disposal of reusage, but that will come at a later stage when the proof of concept for this one is established.

Dinesh Bindiganavale of Pradin Technologies, a start up based in Bangalore proposeda new type of sludge treatment which uses ultra-sonification to effectively reduce the microbes and pathogens. This treatment will enhance the oxidation speed and quick recovery of waste water for recycling back in the system as reusable wash water.

Ultra sound techniques will also effectively reduce the adherence of the waste to the pot and accelerate sedimentation. Sonification also implodes the air cavities, compacting the solid waste and settling it down at the bottom of the tank.

Additionally, high power sonification is well known to effectively ‘declone’ microbes, making them more susceptible to conventional disinfectants. Hence this technology too facilitates minimal usage of water and would require minimal maintenance.

Pradin has also proposed a natural gravel bed to filter out the waste water. Using this combination, they are expecting a substantial reduction in microbes, spores and viruses.

They are in the process of working out the most effective ultrasound frequency for this technology and optimize the usage of power.

Dr Bipin Nair, Dr Sanjay Pal and Ajith Madhavan professors at the Amrita school of Biotechnology took up the challenge of using viral agents to target and kill pathogens and odour-producing bacteria in faecal waste and also develop a way to integrate this into the waste treatment systems. Their idea was triggered by the bacteriophage therapy against bacterial infections, a technology that has been applied and adopted by Russia and Eastern Europe over the past several decades. It is now being explored to combat the threat of ‘superbugs’ which are resistant to a wide range of antibiotics.

It is based on the principle that all living organisms undergo virus attack, eventual lysis and death by different mechanisms and that elimination of target pathogens is achievable by enriching for specific viruses against target populations in any medium.

Encouraged by the wide range of applications of this principle, the team decided to solve improper sanitation associated health risks by developing lytic agents more specifically viruses

against human enteric pathogens and parasites. Their task now is to produce high titre virus population in appropriate media which are cheap and possibly locally made from organic wastes.

The scientists are now collecting sewage samples from different eco-climatic zones and culturing them to have different broad spectrum virus stocks. After this the specific microbes will be cultured in selected media and the isolated virus stocks will be titrated against these microbes. The effective high titer viruses will be used as inoculum in a porous reactor which will be designed as an effective Virus Broadcasting System (VBS), for effective dissemination of the viruses into settling tanks to treat sludge and effluent water

Sudipta Sarkar and his team from IIT Roorkee was long been thinking that microbes are extremely slow in degrading human excreta because the complex organic materials contained in it are too difficult to be degraded easily.

“The appropriate solution lies in not ‘degrading’ them but to ‘consume’ them he thought. His hypothesis was that rather than unicellular microbes, higher forms of biological agents would be more effective in the consumption process. He along with a group of his motivated students, after hours of search and brainstorming decided that it will be worthwhile to try using larvae of black soldier fly as the agent to consume the human excreta.

“The larvae would act as tiny reactors who would convert the waste into fat, protein and chitin as they mature into pupae. Engineered processes in place would help extract valuable products such as essential oils, biodiesels, chitin, fish and animal feeds, etc. can be recovered and purified to produce commercial end products for value,” he said.

The team intends to develop a single household container that will cultivate black soldier fly larvae, using human faeces, which can be processed into valuable products. The study will involve designing facilities for using black soldier fly larvae (BSFL) to consume the solid waste under different environmental conditions.

With the funding from the Grand Challenges award, the scientists will check extent of growth and kinetics of development of BSF larvae on different types of substrates (mixed with human faeces) and under different environmental conditions to find out their effect on its life-cycle in and out of the substrates and also on their waste conversion rate. They will also find out the extent of artificial mating and mass hatching of eggs under different controlled conditions.

They will also research on the potential market for the valuable by-products that can be produced from the harvested larvae.

A few unique collaborative efforts were also awarded.

A team of scientists from Eram Scientific Solutions Pvt. Ltd., Kerela in collaboration with University of South Florida has developed a toilet that is suitable for Indian slums. It is an off-

grid, self-sustained, modular, electronic toilet for houses and communities and can be run with the help of solar energy. It is suitable for the Indian weather and has been integrated with mixed waste processing unit. The grant from the reinvent the toilet challenge-India will help the scientists to field trial this innovative urban sanitation and resource recovery solution that involves designing and implementing a novel public sanitation platform capable of meeting the specific needs of an Indian slum. The tests of the standalone unit that will be field tested in a suburban slum will lead to demonstration of a closed-loop resource recovery by integrating the toilet with a novel onsite wastewater treatment and recovery solution.

BITS Pilani K K Birla Goa Campus in collaboration with Ghent University and Sustainable Biosolutions LLP was awarded for a “septic tank” that integrates electrochemistry to reduce organic pollutants and improve the quality of effluent discharged. The effluent of the septic tank will have a lower load in COD and odour. The proposed facility will be for decentralized treatment at a single household and society or a small community. With the help of this grant they will demonstrate a proof of concept.

“Effective solutions emerge from a barrage of ideas. They will also have to be scalable and they need to be designed, prototyped and field-tested. Finally, they must be attractive to entrepreneurs and industry and attractive to users,” said K VijayRaghavan, Secretary Department of Biotechnology.

He added that though effective and comprehensive sanitation seems an impossible dream for India, today we see a congruence of new and applicable science and technology, its affordability, and sustainable implementation. This he said a great opportunity, which we cannot afford to let slip, for by implementing effective solutions in each kind of social context, big problems can be dealt with in small units and be catalysts for scaling up.

“Through the Awards under Grand Challenges, we hope to have some innovative prototypes and Proof of Concept demonstrated. These solutions would then offer scalable options for meeting our Urban and Rural Challenges. This challenge offers Science & Technology solutions for a National problem to have a Clean and Healthy nation, said Renu Swarup, Managing Director of BIRAC.

The Gates Foundation also has announced a partnership with South Africa's Department of Science and Technology to field test technologies developed as part of the global Reinvent the Toilet Challenge.

“By applying creative thinking and new approaches to sanitation challenges, we can improve people's lives. And we have no doubt that these new partnerships with India and South Africa Water Sanitation and Hygiene Team will help us achieve this," said Brian Arbogast, director of the team at the Gates Foundation. "We believe that with governmental leadership, new business models, and innovation, we can dramatically increase the progress made in tackling this global sanitation crisis.”

Open defecation and poor sanitation are India's shame. Both these problems are as critical in rural as in urban areas. Though sanitation is commonly perceived as a problem of the poor, piling up of and problems in handling the huge amount of waste is also a problem of the rich. With the diversity of people and cultures that defines India, a "one size fits all" solution is not attainable. We need a huge basket of innovative solutions that will suit the people, be affordable, environment friendly, sustainable, water saving and manageable so that we can pick and choose the right one for a particular context.

We need technologies to empty toilets before they pile up to a level that can affect people's health, life and property, technologies to save water and power and land area necessary for managing the waste. In order to solve a problem of this scale, the Reinvent the Toilet Grand Challenges can play a massive role in setting the young, fertile minds across the sub-continent thinking and generating the barrage of ideas that are required to address the problem.

Technologies on solid & liquid waste management

BIRAC has also been instrumental in supporting technologies on waste management in its other funding schemes. An anaerobic membrane bioreactor (AnMBR) has been made for conversion of wastewater to energy. The prototype for the AnMBR has been developed at a scale of 2000 L with expected performance parameters and is ready for commercialization.

A proof of concept for the fermentation based process is being developed for the conversion of municipal solid waste to chemicals

A technology has been formulated for removal of hydrogen sulphide from biogas by recovering sulphur from it. The proof of concept for this technology will be ready by January 2018.

A prototype of a high rate bio-methanation reactor which does not require additional water and has two times higher energy productivity has been developed. A proof of concept for advancement in the efficiency of the developed prototype is underway.

Initiatives for technology demonstration

In another initiative, BIRAC is supporting The Energy Resources Institute for installation of 100 toilets in schools in north eastern region of India. The aim of the program is to adopt an integrated approach for interlinking school toilets with anaerobic digester for maintaining hygiene and resource recovery.