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Technology and Design, IIT BOMBAY

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TURNING POINT

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Inside

Interactions at the MIT-Tata Center symposium

The Tata Centre team from IIT Bombay attended the annual symposium in MIT-Tata Center, in full force

The Dean Alumni & Corporate Relations, some faculty members and a project manager from Tata Centre for Technology and Design, IIT Bombay, had an eventful visit to the 3rd Annual MIT-Tata Center Symposium in Boston, USA. Scheduled in September, the week comprised a two-day symposium and conference. But the agenda primarily was to strengthen project collaborations between both sister institutes.

With eminent speakers and panelists invited, Day 1 began with IIT Bombay alumnus, Nandan Nilekani, delivering a keynote address. The mandate for the rest of the day included panel discussions where the speakers brainstormed on whether the developing world needed a different model for social entrepreneurship. Day 2 had Ashok Khosla, Chairman, Development Alternatives, speaking about his social enterprise, followed by MIT-Tata Center faculty members who showcased their projects, with the Tata Fellows taking

centre-stage for a few presentations. There was also a posters exhibition put up by the Tata Fellows there.

The team from TCTD, IIT Bombay, comprising Prof Ravi Sinha, Dean ACR, Prof Sanjay Mahajani, Professor-in-charge, Prof Narendra Shah, Prof Soumyo Mukherji, Prof Jayesh Bellare, Prof Shireesh Kedare, and Gayathri Thakoor, met with the various faculty members, NGOs and members from the Tata Trusts attending the event. Separate meetings were held to chalk out plans for further interactions with the two Centres. Water and Healthcare were identified as the domains wherein big challenge problems would be researched on by both the Tata Centres, to work in collaboration in the near future.

- Gayathri Thakoor, Project Manager

Tata Fellows visiting MIT-Tata Center

The IIT Bombay Tata Fellows are visiting MIT-Tata Center, as part of the joint orientation between both Tata Centres. Planned as a week-long trip, the objective is to help understand their work culture and research methods. Also on the agenda is meeting the MIT-Tata Fellows, participating in discussions with the various domains, visiting the local waste water treatment plant, and adding a dash of celebration to the Diwali week in Boston.

- Gayathri Thakoor, Project Manager

A cost-effective water-based scrubber

Conventional techniques utilize compressors to increase the efficiency of scrubbing. But the compressor is not only expensive, it also demands large power consumption and maintenance costs

ENERGY

Biogas scrubbing is normally carried out to improve its calorific value by removing the incombustibles and also to make the gas more equipment friendly by removing CO_2, H_2S and other gases. Conventional techniques rely on increasing the scrubbing efficiency by using higher pressures - compressing the gas to 10 bars or higher to eliminate these undesirable components. Since these processes involve compressing higher volumes of gas at input and obtaining lesser volume at output, compressors are generally oversized. This in turn, increases the various costs- capital, maintenance, power consumption- associated with the compressors.

A project team led by Prof Milind Rane, Department of Mechanical Engineering and PI of the project - Compact efficient modular water based biogas scrubber - aimed to remove CO_2 and H_2S before the gas was compressed, to minimize the costs. The solution has been to proceed with a water-based scrubber that operates at atmospheric or near atmospheric pressure. Since the feed going into the scrubber has not been compressed, the compressor sizing for the gas can be significantly reduced.

The scrubber uses rotating contacting devices that enable high surface densities, thereby ensuring good contact between gas and water. This technique also enables the gas to pass through the scrubbing section without any pressure drop. All these features mean that initial costs can be reduced by a factor of at least 5 times compared to conventional technologies.

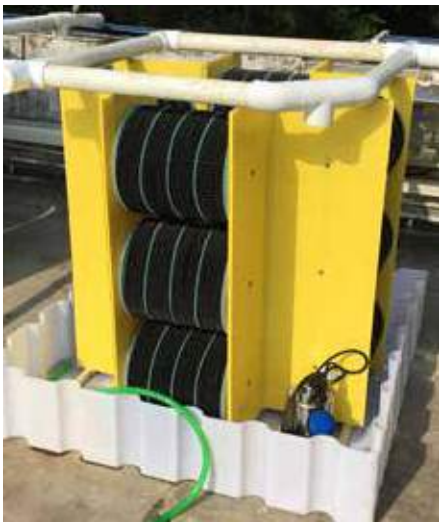


Photo credit – Project team

A field demonstration of about 12m³/hr processing capacity is anticipated within a year and a half. A unit is also being setup at the IIT Bombay Biogas plant. The biogas thus purified would be used in one of the hostel kitchens.

The team has already identified an industry partner - Muni Seva Ashram, Vadodara – at whose site the first field prototype is being demonstrated. A branch of Muni Seva, MSA Bioenergy, is into building and deploying biogas plants in the country and has shown commercial interest in this technology. Moreover, the PI has also partnered the project idea with a consultancy to transfer this technology. Upon successful demonstration, IIT Bombay could license this technology to them.

- Jasleen Chhabra, Tata Fellow 2016

Making organic jaggery efficiently

ENERGY

This project aims to bring down the drudgery in the jaggery-making process and make it energy-efficient

Initial lab prototype of mobile jaggery maker

Better quality jaggery is always good for consumers, and getting it organically and economically produced would be ideal. Various energy conservation methods have been used to produce jaggery. But the process has involved several hardships giving only heat stress to the workers.

To reduce drudgery, a project team led by Prof Milind Rane, Department of Mechanical Engineering, and PI of the project – Energy Efficient Jaggery Maker - used the Heat pump concept to get the vapours generated out of the jaggery cane juice boiling process, use it, recompress it and then use it to boil the further juice. By using a patented long stroke reciprocating mechanism-based compressor, the efficiency was improved upon. "This is a near isothermal compressor which makes it very efficient and also reduces the energy consumed to boil the juice and concentrate it," explains Prof Rane.

With the burning of bagasse avoided completely, the saved bagasse can be sent to farms for composting. In effect, the organic jaggery produced using the compost after recycling the bagasse onto the same field can easily double the output from that production field. Normally if 30-60 tonnes of jaggery are produced per acre, one can now aim to produce more than 100 tonnes per acre, thus increasing the farmers' incomes. The drudgery involved in sitting in and firing the bagasse will also be reduced significantly.

The overall efficiency of the jaggery making process has improved because of the patented near isothermal compressor. By bringing in a non-lubricated compressor, the vapour which gets recompressed, condenses and gives distilled water. All the water vaporising from the juice is now available to the farmer again as distilled water. Distilled water has various applications and can be a potable by-product, with the addition of salts and nutrients.

Additionally, the team is also making a mobile jaggery making unit. Instead of cutting the cane and bringing it to the jaggery making unit, this unit is compact enough to be placed on the tractor troller. This can be transported to the site wherever the cane is ready for harvesting, and they can cut and crush it right there on the troller. The juice will be fed into this and converted to jaggery next to the cane growing area on the field. On the next day, it can move to the same part in the field and then cover the whole field in maybe a day or two. Ultimately, it works as a modular system which can be scaled up.

The current capacity of the unit of vapour recompression is 0.5 kg/hr and this is expected to be operated for 20 hours in 2 shifts, bringing the concentration of juice from 20 brix to 43 brix. Another unit of standard size is being planned for the field which will process 10 tonnes/day. This 10 tonne/day crushing is going to produce around 1.5 tonne of jaggery per day. The energy required for the unit is predominantly electrical, but can be replaced by the cheaper solar photovoltaics.

Empowering individual farmers with such units would render them capable of processing their own produce. This unit is capable of processing milk, juices, Ayurvedic products and other applications, beyond just jaggery making. The cost of each portable machine is expected to be around Rs 10-14 lakh per unit, and is to be revised in time and with the relevant subsidies. The project team is hoping that in another year a prototype of at least 5 kg/hr capacity will be field-tested and the modules be multiplied.

- Vipul Ahuja, Tata Fellow 2016

Talking Social Innovation

At a conference in Seoul, Tata Centre's objective of bringing social innovation to the market was discussed

In a recent visit in September, Gayathri Thakoor - one of Tata Centre's project managers - was invited as a speaker to a conference on entrepreneurship, Artificial Intelligence and technology in South Korea. This was at the K-Global Connect Pangyo Festival, hosted by the Korean ministry of science and ICT, to encourage local start-ups to go global.

Ms Thakoor's role was to deliver an introductory talk on innovation and entrepreneurship, conduct an interactive workshop with the local start-ups about Tata Centre's mandate on social innovation, participate in a panel discussion and judge a start-up competition.

While the 10 start-up teams that competed had a variety of technological solutions to offer, a few solutions in healthcare showed a lot of promise. The Korean entrepreneurs were eager to know about Tata Centre's role in taking innovation from the lab to the market, in the interactive workshop.

- Gayathri Thakoor, Project Manager

One small step…

Toward transfer of process of content creation (and book design) to school environments

EDUCATION

Photo credit – Project team

In Autonomy in Learning (TCTD Newsletter, February 2017), we spoke of our collaboration with the children of Grammangal School, Village Aine (Dahanu), and the focus of the LETS project on creating opportunities within formal institutions for learners to also be *creators* of content. Critical to the generation of such opportunity is the transfer of the process of content creation to schools that otherwise practice only (or, for the most part) formal, structured learning. Such transfer of process will at the very least slacken the strings of formality, and shift the locus of responsibility for content from specialists to learners--this last utterly necessary for any independent creative endeavor. It will also enable students (and teachers) to heighten interest in old subjects through new forms.

The educator Maria Montessori (1870-1952) spoke early and strongly about how we are driven genetically to learn the culture around us (an assertion corroborated by subsequent research in both evolutionary biology and anthropology), and that if we wish to have children learn anything new at all, offering it within or as culture would trump any learning driven purely by particular interest/s. Now, hewing culture is not something one can do easily or from the outside. So, one of the things that we have tried to grapple with in our situation, working alongside children who live in contexts devoid of English language, both sounds and speech, is to find ways to bridge this distance between taking a class in something they may be interested in to living immersed in that something. The activity of creating content allows learners to plunge more fully into the material that aids such learning on the one hand and, on the other, makes them complicit in the outcome of such endeavor for the stake they then have in it.

Photo credit – Project team

We have witnessed extraordinary engagement with such exercise, and have an early appreciation of its impact, though we await further understanding. The first of our art and writing workshops to help consign process—of generating stories, selecting those most amenable to visual retelling, creating artwork, designing pages, printing them in color, then pasting and binding books—was held at the Agastya International Foundation (AIF) in Kuppam, Andhra Pradesh, with students (all girls) of Standard 8 of the KGVP School, Gudupalli, for four days in April earlier this year. Thirty students were divided into three groups of ten each, given a bagful of words (we brought ours in English, which were translated into Telugu by the teachers there) to create stories in an interactive exercise of sentence and story building. Each sentence after the first had not only to use a given word listed in a sequence,

offering its own challenge and constraint, but also had to speak to the earlier sentences to create a story with cogent plot and action and credible characters. The three groups of girls wrote three stories, completed storyboarding and illustrations, then colored and painted them before penning the story on the frames. All the finished frames that told the story were scanned and printed in 30 colored copies, which were finally pasted and bound together to create 3 books for each student to carry home with her. Both art and language teachers at AIF were involved in a similar workshop, attempting to create storybooks in like fashion. They did not complete their work in the days allotted to the workshop, which offers us a new challenge in the next phase of the transfer of process. Our strength is that both teachers and students have been on board with the process and its intent in this collaborative effort. We expect to conduct two, perhaps three, more workshops of this kind before the teachers at AIF—who engage with children from nearly 300 rural schools within a tri-state area—will take charge of story making and book creation on their own terms, and innovate both process and product with school children as they (all) accept ownership of and agency over content and pedagogy.

Photo credit – Project team

The team of book illustrators, language specialists, and designers at IDC continue to be involved in translating the stories into English, and producing their finished versions for libraries and the general market—versions that also return to the storytellers and their schools.

To know more about the project or offer suggestions, please write to us at edutctd.iitb@gmail.com

- LETS team:
  Prof. Alka Hingorani (PI), Ms. Aarti Latkar (Research Associate), Mr. Sanket Pethkar (Design Associate), Ms. Shruti Chauhan and Ms. Safiya, Shaikh (Project Staff)

Optimizing the energy harvester

This project takes on harnessing wind energy using the phenomenon of a TEG

ENERGY

A team headed by Prof Dipti Gupta, Dept of Metallurgical Engineering and Materials Science, has taken on the project - Triboelectric generators (TEG) for wind energy harvesting. Using wind energy and a TEG, the project team has conceptualised two specially designed surfaces, preferably polymer. Here, the two surfaces will come in contact in each other because of wind energy harvesting and produce energy. These surfaces with reasonably small dimensions – say, 10 cm in height and 2-3 cm in width - are expected to move in a certain way so that the charges of different voltages can then be separated. The output voltage of 10 volts, in this case, will be less compared to that produced by the wind turbines, but it does reflect high peak to peak voltage.

Selection of the polymer material, placing the material together in the right way and putting together simple designs is currently on, so that a maximum of wind energy is generated and separated through these surfaces, in course of time. The team is also doing some nano-structuring to increase the surface area of the materials to the maximum and thus generate energy, in the process.

To scale up would mean to design a mat of these surfaces for wind energy to be generated, for small homes. The idea of a mat that is 6x6 feet in scale, can give enough power supply to a simple home with one TV, two fans, a few tubes, and a fridge. Apart from supplying power to the bottom of the pyramid segment, the idea can work in remote locations and at high altitudes as an independent, portable power source.

The project team is aiming to establish the proof of concept in the next six months, and a simple prototype in a year, to show that it can produce a specific amount of voltage with such simple designs.

- Gayathri Thakoor, Project Manager

Growing Bone, Naturally

The project team has been working on bone grafts that will substitute bone and assist bone to heal itself by providing a 3D scaffold which will get fully resorbed

HEALTHCARE

This is an interview with Prof Jayesh Bellare, Department of Chemical Engineering, and PI of the project - Translation to Pre-clinical and Clinical Trials of Low Cost Bone and Near Net Shape Graft for Dental and Orthopaedic Bone Reconstruction. His team currently includes students Kunal Khanna and Deepak Gupta, and maxillofacial surgeon, Dr. Vivek Soni.

Q.1. What is the project about?

A. Our project has to do with regenerative and reconstructive medicine, particularly in the area of bone tissue engineering. We have begun with making bone grafts, where we have had good success, and then we plan to move on to other organs which also need replacement and regeneration. In this project we have been working on developing a 3D scaffold which will substitute bone, and having the unique ability of helping the human body to help itself grow and heal bones quickly.

Q.2. What was the motivation behind this project?

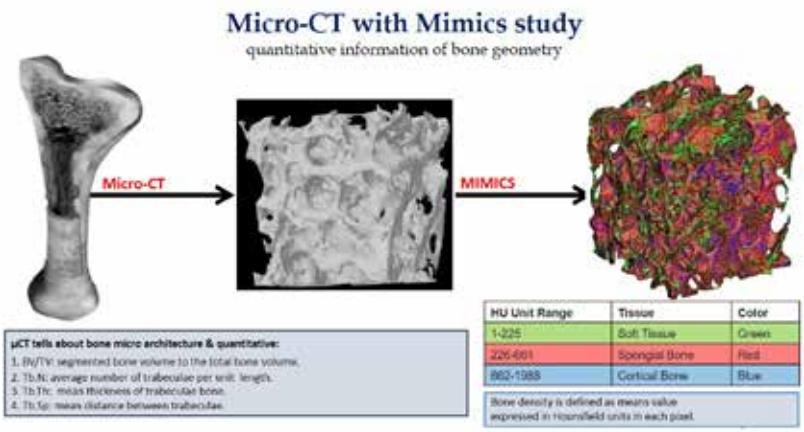
A. Bone injuries are numerous, they arise from accidents, traumas and sometimes from infection. In all these cases, it is necessary to repair the bone. Fortunately for us, bone heals on its own, but there are a few cases where the gap is so big that the bone can't heal by itself. It is in these instances that our research products could help. We got into this, thanks to our interest in nanostructured materials, and interaction with doctors, particularly dental, maxillofacial and orthopaedic surgeons.

Q.3. Can you elaborate on how your intervention will work?

A. The materials that we have developed and are continuing to develop further, assist the body in regenerating natural bone. We do this by mimicking the milieu in which the bone cells grow: this is the so-called extra cellular matrix or ECM. In this process of regeneration, the graft we put in gets completely absorbed and is transformed into a new bone by the body. Although this material is foreign, it has very natural constituents because of which it assists the osteoblasts, osteoclasts and the other cells associated with bone growth to form new bone. To illustrate, a sponge-like sample that we have developed provides the doctor with a material that can be filled into a narrow-necked cavity of a large underlying bone defect. The defect gets healed rapidly with such material.

Q.4. How is your solution different from the existing ones?

A. Such growth-facilitating sponge-like materials aren't widely available or used, while the existing ones are extremely expensive and based on bio-degradable synthetic polymers. In this project, we have used and developed economical yet better-performing materials. These use natural polymers like gelatine, making it effective in the kind of bone growth that it provides. We have had superb results of the bone growth tests done in several animal groups. These tests have been done by us in collaboration with leading national institutions like those of CSIR (Indian Institute of Toxicological Research and Central Drug Research Institute) and ICMR (NIRRH). When maxillofacial and orthopaedic surgeons see these results, they should be enthusiastic to try this on humans. This translation to humans is one of the foci of our ongoing work with the TCTD.



Q.5. How effective has testing been for this product?

A. The products have been extensively tested as there is a great deal of regulatory tests required in the approvals process, as mandated by the Drug Controller General of India (DCGI). These tests need to be documented in great detail, and done for several batches. The necessary testing has already been done by us and it has been done not just in our labs, but also in approved and renowned national labs such as GLP-compliant and GMP-certified labs (Good Laboratory Practices). We have also collaborated with some of the leading national labs like the Indian Institute of Toxicology, Drug development lab of CSIR, Lucknow, and ICMR labs in Parel, Mumbai, where we have worked closely with their experts to demonstrate that the products are safe and effective. We have also tested them with small animals like rats and rabbits, and ensured the safety and efficacy of the product shown that they can heal very effectively.

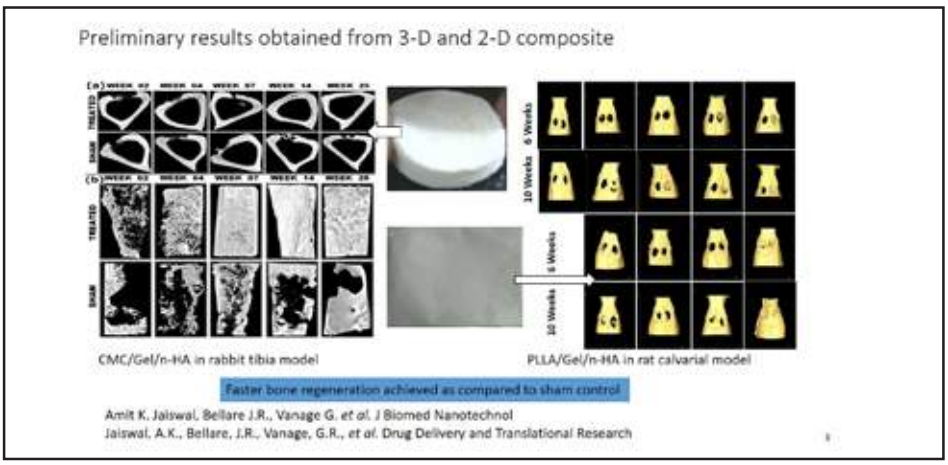


Photo credit – Project team

Q.6. How will the project translate to humans?

A. The translation aspect of this project is significant: it is to implant this bone graft in a human. This is a big deal for any biomedical product because a human implant product is tightly regulated by the national authorities, DCGI and its drug testing authority. In turn, this requires manufacture in a special lab, and testing in other special labs. We have made good progress towards this: we have developed for the first time at IITB a special lab in which we make these bone grafts. This lab is built to, and follows practices of good manufacturing practices (GMP) standards so that the DCGI who regulates these products, can facilitate clearance. We have a dossier ready for submission to DCGI.

Q.7. Are there any collaborations for testing this on humans?

A. Yes, we have already tied up with hospitals where their surgeons are eagerly waiting to try out our products. These surgeons have already become familiar with our product performance so they are enthusiastically waiting for their Institutional Ethics permissions, which is underway. The hospitals include leading ones such as The All India Institute of Medical Sciences, which has agreed to do clinical trials in collaboration with us, and they are waiting for DCGI clearance.

Q.8. What are the goals that would take this project further?

A. Our current focus is to go through all the hoops and loops to get DCGI permissions, and thereafter to do a first-in-human trial for the current grafts. These current grafts are of standard shapes (geometrically regular shapes like circular and rectangular) that we have developed so far. To extend this project further technically, we have extended our goals based on the feedback we have received from surgeons, who are the end-users of such products. The first goal is to make more complex shapes because bone defects come in complex shapes. Another goal relates to internal structure: natural bone has a gradation of porosity from inside to outside, and we have been able to make such gradations with the help of 3D printing. The gradation in porosity gives the necessary strength and flexibility to the bone, making it more natural. Yet another goal is to be able to make these shapes extremely soft and spongy, thus allowing the doctor to insert it in places which have large cavities with small openings.

A further objective is to make near-net shaped bone, based on customization like that from CT-scan data. This would allow us to mimic the external structure of bone by 3D printing the bone, with complex internal and external architecture, as replacements for small or large parts of bones or even whole bones. We hope to build up strength of the grafts and infiltrate these with body's natural cells. The cells will help accelerate the process by which the body "eats up" the graft and uses it as nutrition to replace it with the body's own natural bone. In time, the graft that has been implanted goes away, and it is replaced by strong natural bone that is formed by the body itself. Our bone graft material is there just to help and for only as long as needed. The goal of our ongoing and future projects is to translate these various innovations into humans, and we expect at least one first-in-human trial started by the end of this project.

Q.9. Could you elaborate on the challenges that you foresee?

A. This being a translation project with human implications, the challenges are immense. Some of the challenges are technical: getting pure and certified materials suitable for implantation purposes, or making them to these standards; ensuring batch-to-batch repeatability; and manufacturing multiple batches under good GMP facilities that we have built at IITB. A second type of challenge is to convince our collaborating

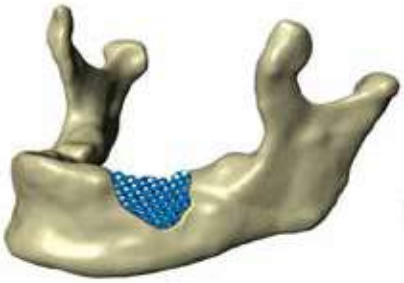
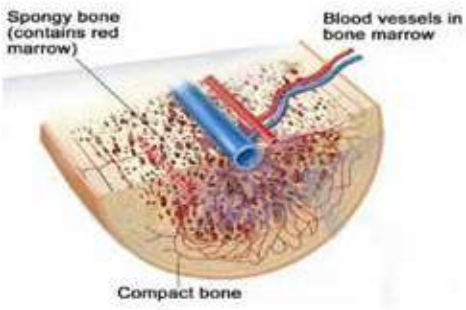


Photo credit – Project team



hospitals' administration to allow their surgeons who need institutional approval, to conduct the trials. The third challenge is, of course, getting the necessary regulatory approvals for this long-term implant from the DCGI. It is a very elaborate, long and arduous procedure to get approval for a human trial. The innovators of the products – our project team, and the actual users, the surgeons, who are the medical professionals and end-users, are ready to try this, but we are limited today as far as the approvals are concerned. We would like to educate ourselves, our administration, the concerned ethical committees and the DCGI that this is a new product class developed by us that would truly help patients and their care-givers, and we hope to do this in short course of time.

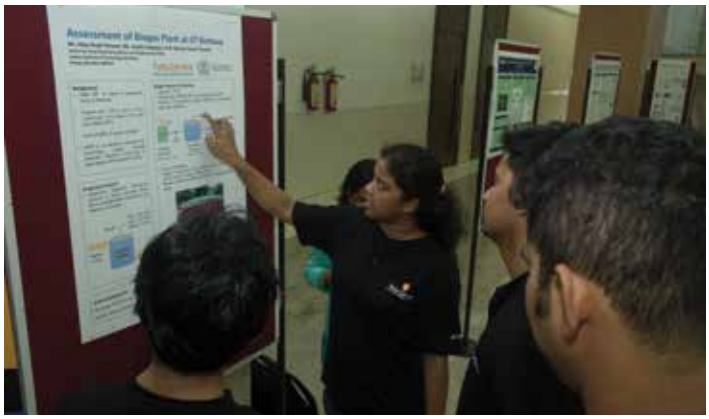
- Gayathri Thakoor with inputs from Satyajeet Santosh, Tata Fellow 2016

Finale to the Swacchta Pakhwada

The Swacchta Pakhwada organised by the PRO in IIT Bombay, culminated in an event where Tata Centre showcased its waste management technology solutions

The fortnight-long `Swachhta Pakhwada' organised by IIT Bombay as a cleanliness drive across the campus, saw its culmination in a finale event on October 15th. Presenting along with the Waste to Energy initiatives developed at IIT Bombay, the Centre's focus was on its waste management technology solutions.

Beginning with a brief introduction by Dr. Jibi Jacob, project manager, Tata Centre, on the waste management activities in campus, Prof Satish Agnihotri, CTARA, then spoke about the Swacchta Pakhwada initiative over the two weeks, in IIT Bombay. The presentation on the Centre's activities in waste management was much appreciated by the audience. Following this, the event had posters of various technology solutions exhibited by IIT Bombay faculty who had Centre-sponsored projects as well as certain independent ones. A product exhibition by organisations active in the waste management domain such as Green Communities, Stree Mukti Foundation, Enviro Vigil, Daily Dump, INORA and others, was interactive. An interesting part of the day's event was the live demonstration and detailed explanations of technologies at the testing site. This included stages and processes of composting - at Vidya Niwas, gasification - installed in Hostel 9, pelletization – in F1 shed, compaction unit to show dry waste segregation – at the Compaction Unit, and the biogas plant (which supplies biogas for cooking purposes to Hostel 3) – located behind the pipeline. This exercise ensured a lot of interaction.



Attending the event were people from the campus communities, students of IIT Bombay, representatives of NSS, and students from Campus School, whose posters on `How to Reduce Waste' were exhibited. About 15 Tata Fellows were supportive through the event in presenting posters, taking the attendees on IIT Bombay waste management tours, and volunteering in the overall coordination. Other research students working on particular waste management projects were also there on site to explain the technical queries and the technologies behind each project idea.

From the interaction between the faculty and the organisations that attended, the hope is that there will be more collaborations in the near future.

- Gayathri Thakoor, Project Manager

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