PAVITRA GANGA

WORKSHOP

Innovative technologies for wastewater treatment, reuse and resource recovery

27 & 28 September 2023

WORKSHOP SCHEDULE AND TECHNOLOGIES

भारतीय प्रौद्योगिकी संस्थान दिल्ली
Indian Institute of Technology Delhi

IIT Kanpur

vito

IHE DELFT Institute for Water Education under the auspices of UNESCO

pavitra-ganga.eu

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SCHEDULE OF THE WORKSHOP

Title of the workshop: Innovative technologies for wastewater treatment, reuse and resource recovery **Dates and venue:** September 27-28, IIT Delhi, India	
DAY 1, September 27 | Wednesday (HYBRID)	
9:00 h - 10:30 h	**Inauguration and opening ceremony**
9:00 h - 9:05 h	Welcome and opening note about the workshop - Eldon R. Rene (IHE Delft)
9:05 h - 9:15 h	Welcoming the delegates and participants - Prof. T. R. Sreekrishnan (IIT Delhi)
9:15 h - 9:30 h	The Pavitra Ganga Project: An Overview - Dr. Anshuman (TERI)
9:30 h - 10:00 h	Guest of honour: Dr. D. P. Mathuria [Executive Director (Technical), NMCG, Govt. of India]
10:00 h - 10:30 h	Group photo and coffee break
10:30 h - 12:30 h	**Workshop session 1 (Moderators: Eldon R. Rene and Sofie Van Ermen)**
10:30 h - 11:10 h	**Keynote lecture 1:** Ecotechnologies for the removal of heavy metals from wastewater - Prof. Purnendu Bose (IIT Kanpur)
11:10 h - 11:50 h	**Keynote lecture 2:** Current trends in monitoring water and wastewater quality - Prof. Shaikh Ziauddin Ahammad (IIT Delhi)
11:50 h - 12:30 h	**Keynote lecture 3:** A novel approach to achieving compliance: The methodology of CETP Vatva – Mr. Deepak Davda [Executive Director & CEO, GESCSL – Vatva]
12:30 h - 14:00 h	**Lunch break**
14:00 h - 17:30 h	**Workshop session 2 (HYBRID) (Moderators: Shaikh Ziauddin Ahammad and Saroj K. Sharma)**
14:00 h - 14:30 h ++	Technology 1 - Self-forming dynamic - MBR (Alfieri Pollice and Aditya Sharma)
14:30 h - 15:00 h ++	Technology 2 - Constructed wetland plus (Luca Ofiera and Auchitya Verma)
15:00 h - 15:30 h ++	Technology 3 - Structured adsorbents (Elena Mihaela Seftel and Henna Shaji)
15:30 h - 15:45 h	**Coffee break**
15:45 h - 16:15 h ++	Technology 4 - Clean blocks (Antonella Piaggio and Merle de Kreuk)
16:15 h - 16:45 h	Technology 5 - Andicos (Aditya Sharma and Sofie van Ermen)
16:45 h - 17:15 h	Technology 6 - Aerobic MBR (Anil Kumar Dahiya and Hector Garcia)
17:15 h - 17:30 h	**Feedback and discussions**

Note: ++ - The presentation will be made online

Title of the workshop: Innovative technologies for wastewater treatment, reuse and resource recovery **Dates and venue:** September 27-28, IIT Delhi, India	
DAY 2, September 28 | Thursday (at IITD only)	
9:00 h - 12:30 h	**Field trip**
9:00 h - 12:30 h	Visit to the IITD WWTP and the Pavitra Ganga project demonstration site at Barapullah drain
12:30 h - 14:00 h	**Lunch break**
14:00 h - 15:30 h	**Workshop session 3** **(Moderators: Eldon R. Rene and Paul Campling)**
14:00 h - 14:25 h	**Keynote lecture 4:** Soil aquifer treatment (SAT): A managed aquifer recharge approach for wastewater treatment and reuse - Dr. Saroj K. Sharma (IHE Delft)
14:25 h - 14:50 h	**Keynote lecture 5:** Recent innovations in the use of membranes to treat and reuse wastewater - Ir. Sofie Van Ermen (VITO)
14:50 h - 15:10 h	Technology 7 - Photo activated sludge - Eldon R. Rene and Ashish K. Lohar
15:10 h - 15:15 h	Technology 8 - AQUATRACK® - Sudhir Chowdhury and Ulla Chowdhury (Presented by Eldon R. Rene)
15:15 h - 15:30 h	**Coffee break**
15:30 h - 17:45 h	**Group work activity and closure of the workshop**
15:30 h - 17:30 h	**Group work topic:** Technological and management options to complement conventional STP approaches in India* **Group presentation will be made by the participants, followed by discussions* **Group activity facilitators:** Eldon R. Rene, Saroj K. Sharma, Shaikh Ziauddin Ahammad, Sofie Van Ermen and Paul Campling
17:30 h - 17:45 h	**Closure of the workshop and certificate to the participants**

PILOTED TECHNOLOGIES IN THE PAVITRA GANGA PROJECT (NEW DELHI AND KANPUR)

Technology 1: Self Forming Dynamic Membrane BioReactor Technology

Description

CNR-IRSA is working with IIT Kanpur to pilot the Self Forming Dynamic Membrane BioReactor Technology at the Kanpur demonstration site to evaluate how it performs in Indian conditions to remove bulk organics and nutrients.

The Self Forming Dynamic Membrane BioReactor (SFD-MBR) is an improvement of an ultrafiltration-based MBR where solid liquid separation is done through a self-forming cake layer that develops on a carrying surface (Figure 1).

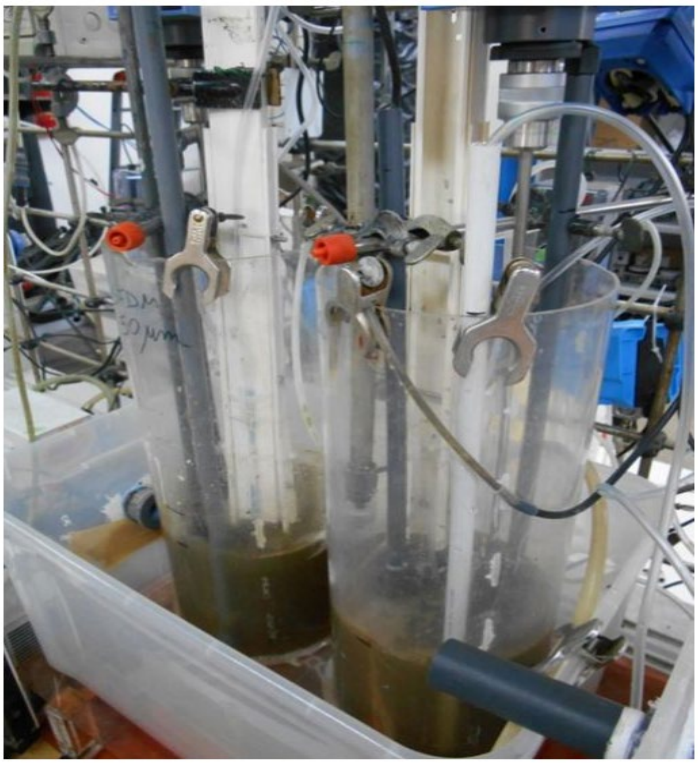

Figure 1. Photograph of the Self Forming Dynamic Membrane BioReactor

The idea is to adopt the same scheme of out-in submerged MBR and replace the filtering membranes with materials having pore sizes larger by two or three orders of magnitude (i.e. 50-100 μm instead of the usual 0.5-0.05 μm of commercial UF-MBR). The main advantages of this technology are the robustness, resilience and cost-effectiveness of the filtering materials when compared to ultrafiltration membranes.

The process itself is run under very limited pressure gaps (normally below 50 mbar), therefore it is suitable for gravity operation, which reduces the energy needs substantially. Bench scale tests performed at CNR-IRSA (Italy) revealed the capability of this technology to produce effluents having similar quality of that normally observed in MBR permeate, except for the microbial indicators that can be easily abated through post-disinfection (low turbidity below 5 NTU allows for the adoption of UV disinfection).

Optimization of the operating conditions with a pilot scale prototype is being done at the Jajmau STP, Kanpur to assess the potential of this technology under real conditions and compare it with a conventional MBR.

Main goals

- The effluent quality should be suitable for unrestricted irrigation (post UV disinfection)
- Test the long-term operation at the pilot scale
- Monitor the operations and maintenance (O&M) requirements

Technology 2: Constructed Wetland Plus (CWplus)

Description

HBO is working with IIT Kanpur for the demonstration of the modified Constructed Wetland technology (CWplus) that combines vertical flow constructed wetlands (VFCW) with adsorptive elements and specific sorbents for the removal of heavy metals.

The granular activated carbon serves as a sorbent particularly of recalcitrant compounds such as trace organic compounds and supports growth of specialised bacteria to improve their biodegradation. Sorbents particularly suitable for heavy metal removal (HM) are e.g. zeolites.

$CaCO_3$ will further be added to control the pH and minimize remobilization of HMs. The vertical flow constructed wetland will be composed of several layers consisting of gravel, sand, and sorbents planted with local vegetation such as *Cana indica* (Figure 2).

The removal rates of modified wetlands and soil filters in polishing applications are particularly high for micro pollutants ranging e.g. around 65% for diclofenac and 80% for ibuprofen. Heavy metal removal ranges between 70 to 80%. Residual ammonia can be oxidised and reduces the oxygen depletion potential of the final effluent.

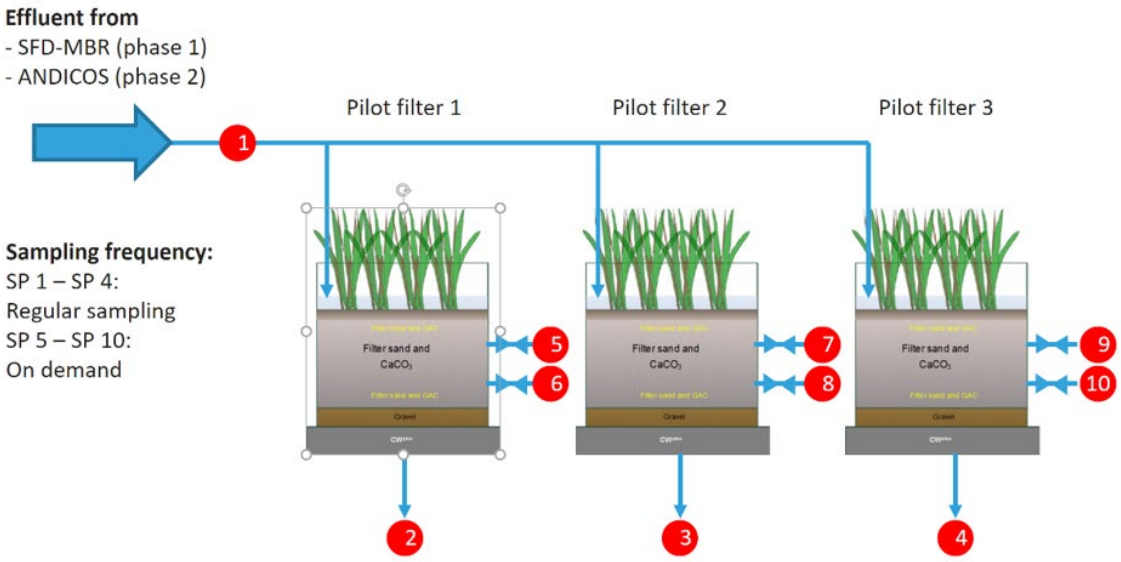

Figure 2. Schematic of the Pilot-Scale Constructed Wetland Plus (CWplus)

Technology 3: Structured Adsorbents

Description

VITO is working with IIT Kanpur to optimize the design of the structured sorbents for the removing of chromium (Cr) from the effluents of the Jajmau municipal wastewater treatment plant (STP) and the industrial wastewater plant (CETP) to ensure that wastewater loaded with Cr can be re-used for irrigation after the treatment.

The developed sorbent materials are shaped into granulates enabling their application in column set-ups with high hydraulic conductivity, easily replaceable and safe (Figure 3). Granular sorbents will be produced at VITO and sent for application testing at the Indian demonstration site. The composition of the designed sorbents will be adapted to the specific conditions of the Indian test-cases (considering relevant concentrations and possible competitive ions).

However, the high sorption capacity, low cost production and regeneration abilities will be present as well. In such a configuration the proposed technology follows the removal-recovery-reuse approach in which the wastewater purification (by sorption onto the granulated material), metal (Cr) and/or nutrient (P) recovery or removal (by desorption) is concomitant with a sorbent regeneration step allowing its reuse in a new wastewater purification step and the recovery of the valuable metals and nutrients.

Figure 3. Photograph of the prepared adsorbent materials and its application to treat contaminated effluents

Main goals

- Remove heavy metals (Cr) from the polluted wastewater (in Kanpur)
- Chromium (Cr) recovery
- Nutrient recovery

Technology 4: Clean Blocks

Description

TU Delft is working with IIT Delhi to demonstrate the use of clean blocks as a filter to remove particles, organics and nutrient from the drain water of the Barapullah Drain.

Clean blocks are specially produced drain blocks, consisting of mineral wool cubes that are used to filter sewage and to treat the water by the biological activity within the filters. This technology focusses specifically on removing turbidity, COD, NH_4-N and PO_4-P and doesn't require energy to operate (Figure 4). The filters will be tested as a passive in situ treatment step in the drain when the hydraulic capacity of the drain is sufficient during dry season, and as a pre-treatment of the PAS system on site. The clean blocks consist of cotton candy made from molten rock with densities 120 - 80 - 45 kg/m^3.

- High porosity > 98%
- High hydraulic conductivity ≤ 1 m/min
- High filtration rate
- Large internal surface area
- Biofilm formation

Figure 4. Photograph of the clean block installation

Main goals

- In-situ drain treatment for overall water quality improvement
- Operated with cascades and biofilters
- TSS and nutrient removal

Technology 5: Andicos™ Technology

Description

VITO is working with Ion Exchange and IIT Kanpur to demonstrate the full Andicos™ (Anaerobic Digestion by Combining Organic Waste and Sewage) at the Kanpur demonstration site.

The Andicos™ (Anaerobic Digestion by Combining Organic Waste and Sewage) technology is a modular treatment step that can be added to existing treatment plants. Andicos™ consists of two main steps: filtration through membranes and membrane concentrate processing through a digester with biogas and organic fertilizer production. The full Andicos™ concept, including both systems, has only been demonstrated at lab scale (TRL 4). In PAVITRA GANGA the full Andicos™ is taken to TRL 6/7 (Figure 5).

The Andicos™ technology was selected in this project because of the robust functioning and the modular concept that allows it to be easily added to existing installations. The specific construction of IPC™ membranes allows for rigorous backwashing, up to 2 bar(g) of the membrane. These membranes use 50% less energy and are more compact than other commercially available flat sheet membranes. The ability to regularly backwash membranes makes the process more stable under challenging conditions.

The membrane concentrate is combined with processed organic household waste (pre-treated and fractionated to remove metal, glass, wood, plastics, paper) to increase organic matter content to levels that allow efficient anaerobic digester functioning. The digester produces biogas and a nutrient-rich digestate that can be used as a fertilizer, thus upcycling organic waste and wastewater and decreasing the net costs of treatment. The resulting effluent from the IPC™ membranes is less polluted compared to current effluent, and is safer and more sustainable for water re-use (irrigation) and improving the river water quality.

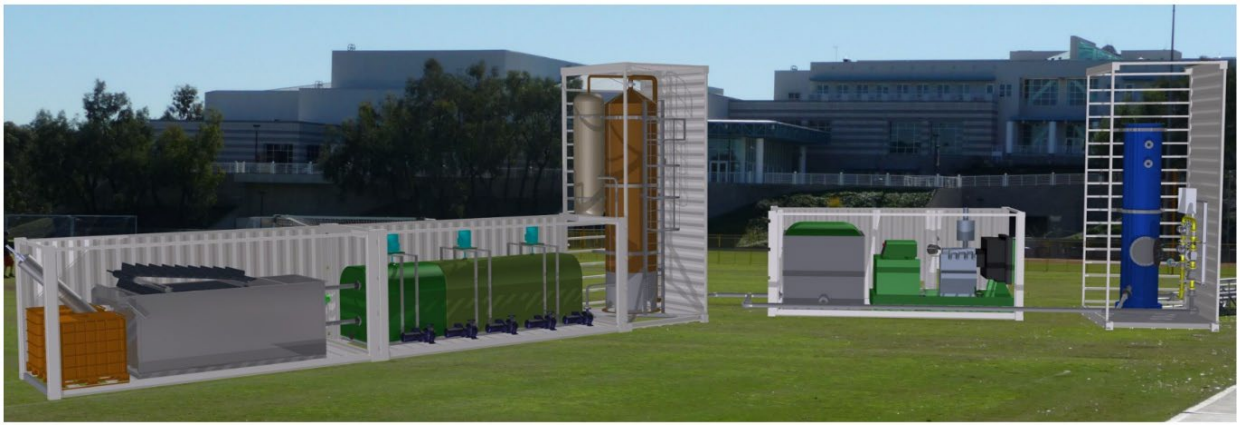

Figure 5. Schematic of the Andicos™ (Anaerobic Digestion by Combining Organic Waste and Sewage) technology

Highlights

- From energy consuming towards energy producing concepts and technologies
- Aerobic: 0.75 to 1.5 kWh/kg COD removed *vs* Anaerobic: + 3 kWh/kg COD removed
- Andicos™ deals with challenges in liquid sewage and solid (organic) waste streams
- Interesting for Indian setting due to higher temperatures and existing needs in sewage and waste treatments
- Possibility to integrate Andicos™ into existing aerobic WWT plants in order to reduce overload, high energy consumption and excess sludge production

Technology 6: Aerobic Membrane Bioreactor

Description

IHE Delft is working with IIT Delhi to assess different operational regimes for aerobic membrane bioreactors (MBR) to deal with the drain water from the Barapullah Drain in New Delhi.

This is a proven technology in a Western context. When implemented in India, new challenges need to be faced, including the operation under non-standardized and non-reliable receiving wastewaters, and excessive high temperatures. This technology also needs high appropriate maintenance. Therefore, a lab-scale movable MBR was constructed and provided with low energy, submersible membranes for the evaluation of different operational regimes (Figure 6).

Figure 6. Photograph of the lab-scale aerobic membrane bioreactor

Highlights

MBRs combine aerobic bio-treatment with membrane separation, thus:

- Clarified, mostly disinfected effluent with low turbidity, bacteria, total suspended solids (TSS) and organic content
- Small footprint - shorter hydraulic retention time (HRT)
- Bulking problems become less relevant.
- Longer solids retention time (SRT) with less sludge production
- Hydraulic and solids retention time are uncoupled
- Intensive bio-treatment provided

Technology 7: Photoactivated Sludge

Description

IHE Delft is working with IIT Delhi to pilot a photo activated sludge system to remove nutrients from the drain water of the Barapullah Drain. In Pavitra Ganga it will be tested in combination with cleaning blocks.

The fundamental principle governing the operation of the photoactivated sludge (PAS) reactor is to cultivate a mixed consortium of algae and bacteria (e.g. activated sludge/nitrifiers) to removal pollutants of interest from the Barapullah drain (Figure 7). The latter could be heterotrophs, nitrifiers, or, even anammox bacteria. PAS technology differs from conventional pond systems in that it optimizes the growth of the mixed consortia (i.e. due to the daily light/dark cycles) and the pollutant removal rates are much higher due to higher biomass concentration and the good mixing characteristics achieved in the PAS.

Figure 7. Photograph of the photoactivated sludge reactor

The domestic sewage flowing in the Barapullah drain poses a threat to the environment due to their high pollutant load, which can lead to eutrophication of water bodies and a decline in the ecosystem quality. It is expected that the ammonium removal rates will be increased by the nitrifying bacteria, which were supplied with oxygen provided by the algae. The addition of bacteria to the microalgal culture increases the biomass retention capacity, allowing the hydraulic retention time (HRT) and solids retention time (SRT) to be decoupled.

One of the other advantages of the PAS is the fact that the microalgal-bacterial system provides the potential for a reduction in HRT, thereby reducing the large area requirements typically demanded by algal systems.

Research questions

- What is the maximum nutrient removal efficiency of the PAS system under the prevailing Indian climatic conditions, in terms of g N removed/m^2/day, per sunlight input (gN/mol photons), and the energy consumption (g N/kWh)?
- How do different operational parameters (HRT, pond depth, and biomass concentration) influence the efficiency of nutrient removal and biomass production?
- What are the possible resources that can be recovered from the algal biomass and what are their downstream recovery techniques?

Technology 8: AQUATRACK®

Description

Aqua Q, IIT Delhi and IHE Delft are working together to demonstrate the AQUATRACK® service to monitor the effluent quality of the Aerobic MBR that will be installed at the Barapullah Drain innovation site.

Currently there is no real time online monitoring and biological water sampling system for water treatment plants which can give quick information of quality variation in time to avoid dangerous pollution events. Water sampling is either random or periodic grab samples - which can often miss pollution events.

AQUATRACK® provides the real-time monitoring of micro-contaminants by using a finger-printing technique to set off alerts which trigger event-based grab sampling (Figure 8). Pavitra Ganga provides an opportunity to demonstrate the application of this technology in the Indian environment.

Figure 8: Photograph of AQUATRACK® to monitor the water quality

EMAIL CONTACT OF THE TECHNOLOGY PROVIDERS

Name of the technology and staff members	Email ID
Technology 1 - Self-forming dynamic - MBR (Alfieri Pollice and Aditya Sharma)	alfieri.pollice@ba.irsa.cnr.it shaditya@iitk.ac.in
Technology 2 - Constructed wetland plus (Luca Ofiera and Auchitya Verma)	luca.ofiera@hs-bochum.de auchitya@iitk.ac.in
Technology 3 - Structured adsorbents (Elena Mihaela Seftel)	elena.seftel@vito.be
Technology 4 - Clean blocks (Antonella Piaggio and Merle de Kreuk)	A.L.Piaggio@tudelft.nl M.K.deKreuk@tudelft.nl
Technology 5 - Andicos™ (Aditya Sharma and Sofie van Ermen)	shaditya@iitk.ac.in sofie.vanermen@vito.be
Technology 6 - Aerobic MBR (Anil Kumar Dahiya)	SRZ218427@sire.iitd.ac.in
Technology 7 - Photo activated sludge (Eldon R. Rene and Ashish K. Lohar)	e.raj@un-ihe.org ashishklohar@gmail.com
Technology 8 - AQUATRACK® (Sudhir Chowdhury and Ulla Chowdhury)	sudhir@aqua-q.se ulla@aqua-q.se

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