BITS Pilani
K K Birla Goa Campus

Applied Environmental Biotechnology Laboratory

Environmental Surveillance Laboratory

GLOBAL SANITATION GRADUATE SCHOOL

Water Sanitation and Hygiene Laboratory

Faecal Sludge Management Laboratory

Prof. Srikanth Mutnuri
Email ID: srikanth@goa.bits-pilani.ac.in

ABOUT US

BITS Pilani
K K Birla Goa Campus

"Water, water everywhere, Nor any drop to drink"

(Lines from "The Rime of the Ancient Mariner" by Samuel Taylor Coleridge)

World Water Day, held on 22 March every year since 1993, celebrates water and raises awareness of the 2 billion people living without access to safe water (https://www.worldwaterday.org/). This year the theme of the World Water Day is on "Accelerating Change". World Water Day 2023 (UN) asks people to "Be the change you want to see in the world". Using an ancient story from the Quechua people in Peru, of a hummingbird who carries drops of water to put out a great forest fire, the United Nations campaign encourages people to do what they can to help solve the water and sanitation crisis. In the ancient tale, the hummingbird is faced with a great fire and, rather than stand and stare, decides to act - trying to put the fire out one drop at a time. The other animals laugh, but she replies, "I'm doing what I can."

Below are some of the facts to know from the United Nations on Water Crisis

- 1.4 million people die annually and 74 million will have their lives shortened by diseases related to poor water, sanitation and hygiene (WHO 2022).
- Today, 1 in 4 people – 2 billion people worldwide – lack safe drinking water (WHO/UNICEF 2021).
- Almost half of the global population – 3.6 billion people – lack safe sanitation (WHO/UNICEF 2021).
- Globally, 44 percent of household wastewater is not safely treated (UN-Water 2021).
- Global water demand (in water withdrawals) is projected to increase by 55 percent by 2050 (OECD 2012).

We present to you now the work that we carry out towards Clean water and Sanitation for all as part of Sustainable Development Goal (SDG) 6. SDG 6 is one of 17 SDGs established by the United Nations General Assembly in 2015.

We are part of Global Sanitation Graduate school offering ME in Sanitation Science Technology & Management, M.Tech in Sanitation Science Technology and Management, Minor Program in Water and Sanitation and Postgraduate Certificate in Non Sewered Sanitation for working professionals. We have four Laboratories – Applied Environmental Biotechnology Laboratory, Environmental Surveillance Laboratory, Water Sanitation & Hygiene Laboratory and Faecal Sludge Management Laboratory. Our Faecal Sludge Management Laboratory is part of Global Partnership of Laboratories for Faecal Sludge. We do Applied Research and through our research projects we established several field scale installations through our Lab to Land approach. Details of the same is in this booklet.

Global Sanitation Graduate School

BITS Pilani
K K Birla Goa Campus

Transfer of the IHE Delft M.Sc Programme in Sanitation and related Diploma Programme & Short Courses

- ME Sanitation Science Technology and Management
- M.Tech Sanitation Science Technology and Management (WILP)
- Minor in Water and Sanitation
- Postgraduate Certificate Programme in Non Sewered Sanitation (WILP)

Programme	Goa	Pilani	Hyderabad
M.E / M.Tech	59 (19 + 40)	2	2
Target to be achieved	60	20	20
OLC	60	0	0
Target to be achieved	60	0	0
Minor programme	6 (ongoing)	0	0
Target to be achieved	25	15	15

Faecal Sludge Management Laboratory -Global Partnership of Laboratories for Faecal Sludge Analysis

Support from Alumni: INR 5.5 Million (75,000 $)

Well established Environmental Technology Labs

Funding agency:

BILL & MELINDA GATES foundation

UNESCO IHE DELFT

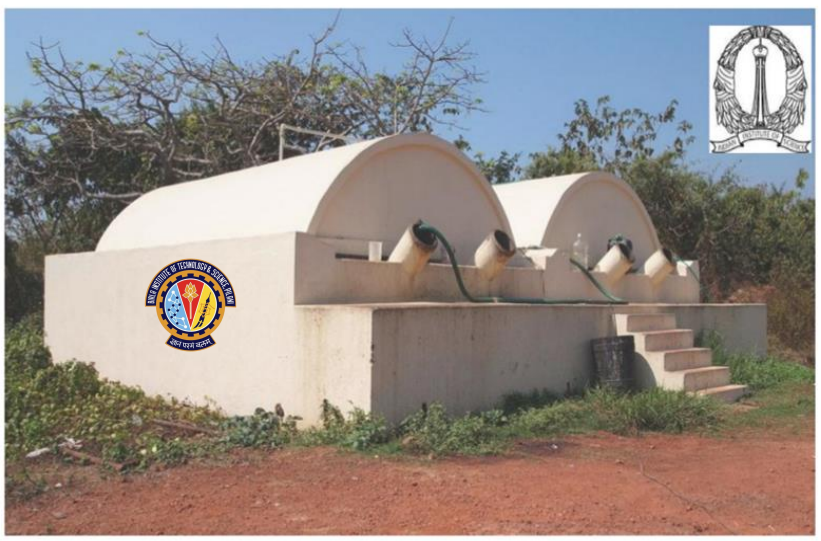
Field scale installations

Horizontal Plug Flow Anaerobic Digester for food Waste (one ton per day)

BITS Pilani
K K Birla Goa Campus

MESS
(WASTE FOOD)

Food waste Macerator room



1 tpd plant at BITS Goa Campus, 2009: Mess and kitchen wastes

CAFETERIA
(COOKING FOOD)

Biogas bag and Compressor Room

A Horizontal Plug Flow Anaerobic Digester designed to handle one ton of food waste per day offers a sustainable solution for organic waste management. This system utilizes a horizontal configuration, optimizing the waste digestion process. The anaerobic environment promotes the breakdown of organic matter, producing biogas rich in methane for energy generation. Its design ensures continuous loading and unloading, minimizing downtime. By converting food waste into biogas and nutrient-rich digestate, this digester not only reduces greenhouse gas emissions and landfill burden but also generates renewable energy and valuable fertilizers. It stands as a compact, eco-friendly, and economically viable approach to address both waste disposal and energy needs.

KEY FEATURES	
Size of PFR	60 m^3
Substrate	Food waste from the campus
Biogas generation/day	600 m^3
Biogas utilization	For cooking
Treatment efficiency	82%
Are biological processes used?	Yes
Does the system require an external source of electricity?	Yes. For maceration of the substrate.
Does the system require any off-site waste processing?	No
Does the system require any waste to be dumped or infiltrated in adjacent soil?	No
End use of the Digestate?	For composting

Project executed by:
Dr. Vidhya Prabhudessai

Funding agency:

Sequencing Batch Reactor (250 cu.m)

Influent and effluent water quality

The Sequencing Batch Reactor (SBR), with a capacity of 250 cubic meter, represents a versatile and efficient wastewater treatment solution. Operating in a batch mode, it effectively removes contaminants through a series of sequential phases such as filling, aeration, settling, and decanting. This adaptable system excels in treating varying inflow rates and pollutant loads, ensuring consistent effluent quality. Its controlled processes enable the removal of nutrients like nitrogen and phosphorus, contributing to environmental compliance. The compact design and automation capabilities make it suitable for diverse applications, including municipal and industrial wastewater treatment.

KEY FEATURES	
Size of the tank	
Size of the tank	4.5 x 9.2 m diameter
Total volume	300 m^3
Working volume	250 m^3
Minimum height between the water level and the top of the tank	0.74 m
Surface of the tank	64 m^2
Loading conditions	
Volumetric loading rate	0.35 kg of $BOD_5/m^3.d$
VSS concentration	4 g/L
Quantity of BOD_5 treated in 250 m^3	87.5 kg BOD_5/d
Are biological processes used?	Yes
Does the system require an external source of electricity?	Yes. For maceration of the substrate.
Does the system require any off-site waste processing?	No
Does the system require any waste to be dumped or infiltrated in adjacent soil?	No
Digestate end use?	For composting

Funding agency:

Single Household Empowered Septic tank plant – Hybrid of Vertical Flow Constructed wetland and Electrochemical system

The Single Household Empowered Septic Tank Plant presents an innovative wastewater treatment solution, combining a Vertical Flow Constructed Wetland with an Electrochemical System. This hybrid design maximizes treatment efficiency for individual households. Wastewater first enters the septic tank for initial settling and organic decomposition. The effluent then flows into the Vertical Flow Constructed Wetland, where plants and microbial communities further purify the water through natural processes. The final step involves the Electrochemical System, which enhances disinfection and removes residual contaminants, ensuring safe water quality. This integrated approach offers a sustainable and decentralized solution that effectively treats household wastewater while minimizing environmental impact.

KEY FEATURES

Features	Single Household Integrated treatment system
Components	Septic Tank, Constructed Wetland, Electrochemical Reactor
Treatment Capacity	180 L/day
Treatment Efficiency	Average Reduction in COD, TP, Ammoniacal nitrogen, TKN and TOC are 68%, 99%, 77%, 43% and 53%. 100% reduction in coliform bacteria. Wetland passage and subsequent passage through EC causes complete removal of helminths
Life expectancy	Constructed wetlands: 15 years Electrochemical reactor: 5 years
Consumables	Ion exchange membrane (once in 3 months) Anode (once in 1.5 years)
Unit Costs	$ 1600 (Toilet + Treatment system)
Operational Costs	$ 7 per month (approx.)

Project executed by:

Dr. Guruprasad V. Talekar

Dr. Priya Sharma

Funding agency:

Department of Biotechnology, Government of India

UNIVERSITEIT GENT

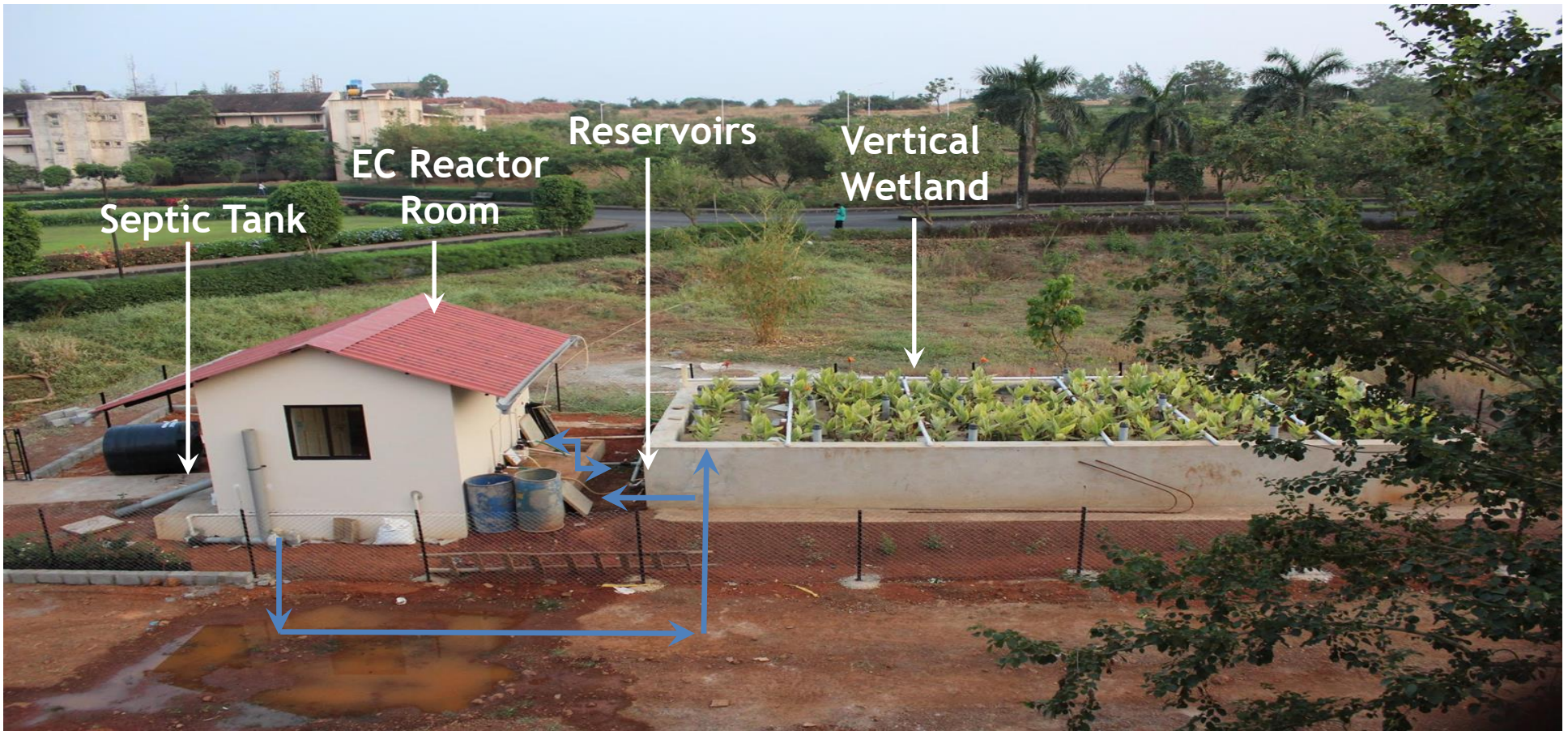
BIRAC Biotechnology Industry Research Assistance Council (A Government of India Enterprise)

BILL & MELINDA GATES foundation

BITS Pilani K K Birla Goa Campus

100 people equivalent Empowered septic tank plant - Hybrid of Vertical Flow Constructed wetland and Electrochemical system

BITS Pilani
K K Birla Goa Campus



The hybrid system combines a vertical flow constructed wetland and an electrochemical system to treat septic tank effluent**.** The removal efficiencies of the organics and phosphorus were steady in the hybrid systems, but the removal efficiency of total nitrogen was not steady due to high total nitrogen concentration in the septic tank effluent**.** The capability of purification was the worst in winter, but cultivating with plants could improve the treated effluent quality from the hybrid systems**.** A high-rate-wetland coupled with an electrochemical system was developed and demonstrated to treat septage at full scale**.** The septage was distributed evenly over the wetland surface, and the electrochemical system was used to disinfect the effluent**.** The results of the study showed that the EC by itself, as deployed here, cannot achieve treatment and disinfection**.** Recirculating vertical flow constructed wetlands are recommended for treating residential wastewater, and they should be placed after the septic tank and before final soil treatment and dispersal.

KEY FEATURES	
Components	Two Stage Constructed Wetland, collection tank (may not be required if the system designed to work on gravity)
Treatment Capacity	600 L/day
Expected life	20 years
Total capital investment	$ 500
Does the system use any other “consumable” materials?	No
How much water will be generated for reuse	0.6 KLD
Compost or Fertilizer recovery?	NA
Are biological processes used?	Yes
Does the system require an external source of electricity?	Yes. Pumping wastewater from storage tank to system. 0.5-0.75 hp pump (0.5 units/day electricity requirement)
Does the system use any other consumable” materials?	No
Does the system require any off-site waste processing?	No
Does the system require any waste to be dumped or infiltrated in adjacent soil?	No

Project executed by:

Dr. Guruprasad V. Talekar

Dr. Priya Sharma

Funding agency:

Department of Biotechnology, Government of India

UNIVERSITEIT GENT

birac Biotechnology Industry Research Assistance Council (A Government of India Enterprise)

BILL & MELINDA GATES foundation

BITS Pilani K K Birla Goa Campus

Vertical Flow Constructed Wetland (French system) for single household (6-8 people)

The Vertical Flow Constructed Wetland (French system) tailored for a single household of 6-8 people provides a nature-based wastewater treatment solution. Wastewater from the household is directed into a vertical bed filled with specially selected plants and porous media. As the water percolates through the bed, natural processes facilitated by the plants and microorganisms break down pollutants and filter contaminants. This system effectively removes organic matter, nutrients, and pathogens, resulting in treated water that is safe for discharge or reuse. Its compact design and reliance on ecological processes make it an eco-friendly choice for decentralized wastewater management.

KEY FEATURES	
Components	Two Stage Constructed Wetland, collection tank (may not be required if the system designed to work on gravity)
Treatment Capacity	600 L/day
Expected life	20 years
Total capital investment	$ 500
Does the system use any other “consumable” materials?	No
How much water will be generated for reuse	0.6 KLD
Compost or Fertilizer recovery?	NA
Are biological processes used?	Yes
Does the system require an external source of electricity?	Yes. Pumping wastewater from storage tank to system. 0.5-0.75 hp pump (0.5 units/day electricity requirement)
Does the system use any other consumable” materials?	No
Does the system require any off-site waste processing?	No
Does the system require any waste to be dumped or infiltrated in adjacent soil?	No

Project executed by:

Dr. Anant Yadav

Ms. Rajashree Yaragal

Funding agency:

Open raceway pond for microalgae cultivation

BITS Pilani
K K Birla Goa Campus

200 Litre capacity microalgae cultivation

100 cu.m capacity

Open raceway pond is one of the oldest and simplest ways to cultivate microalgae in large scale**.** The open pond system is widely used in the industry due to its relatively cheaper construction, maintenance, and operation cost**.** The raceway pond consists of a series of closed loop channels around 30-cm deep and a paddlewheel that enables the recirculation of microalgae biomass to ensure equal distribution of nutrients and prevent sedimentation of microalgae biomass**.** The raceway pond has been perceived as one of the best open pond cultivation designs available due to its energy efficiency, as a single paddlewheel is sufficient enough to properly agitate a 5-hectare raceway pond**..**

Project executed by:
Dr. Ram Chavan

Biogas Plant at Madgaon Fish Market

Waste to Energy project - Anaerobic Co-Digestion of food Waste and Septage

BITS Pilani
K K Birla Goa Campus

This Waste to Energy project employs anaerobic co-digestion of food waste and septage, efficiently processing 10 to 15 metric tons of food waste daily from 1350 hotels, along with 10 to 20 m^3 of black water from 200 community toilets. The 1300 m^3 digester, featuring a 35-day retention time, facilitates biogas generation of approximately 2,100 m^3 daily. The system incorporates a 60 kW Combined Heat and Power Unit (CHP) running 24/7 for the Anaerobic Digester-Plant and an additional 200 kW (15 hours per day) for external use, producing up to 3,000 kWh daily. This integrated approach not only converts organic waste into renewable energy but also provides a sustainable waste management solution for both hospitality and community sectors.

Input material

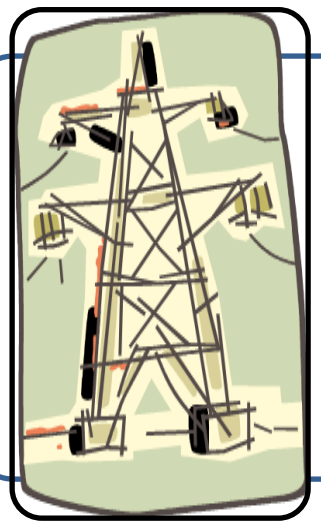
Food waste : 10 to 15 metric ton per day (from 1350 Hotels)

Blackwater : 10 to 20 m^3 per day (from 200 community toilets)

Volumes

Digester : 1300 m^3 including storage capacity (retention time is 35 days)

Biogas-generation: approx. 2,100 m^3/per day



Combined Heat and Power Unit (CHP)

60 kW (24 hours per day) for Anaerobic Digester-Plant

200 kW (15 hours per day) for external use (up to 3,000 kWh per day)

Project executed by:
Dr. Megnath Prabhu

Funding agency:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

TERRA PRETA & PROM for improving agricultural productivity

BITS Pilani
K K Birla Goa Campus

Terra Preta, the fertile Amazonian soil enriched with charcoal and organic matter, combines with PROM (Phosphate Rich Organic Manure) to revolutionize agricultural productivity. Terra Preta's ancient wisdom boosts soil structure and nutrient retention, while PROM delivers essential phosphate nutrients. Together, they form a powerful synergy, enhancing soil fertility, water holding capacity, and nutrient availability. This approach revitalizes depleted soils, promoting healthier plant growth and increased crop yields. By harnessing the benefits of Terra Preta and PROM, farmers can cultivate sustainably, ensure food security, and contribute to ecologically balanced agricultural systems.

KEY FEATURES

Location	Nashik, Maharastra, India
Raw meterials	Septage sludge and spent biogas digestate
Nutrient Content	High levels of essential nutrients, including nitrogen, phosphorus, potassium, calcium, and trace elements.
Unit Costs	<2.8$ per ton
Water Retention	Improved water-holding capacity, reducing the risk of both drought stress and waterlogging.
Carbon Sequestration	Acts as a carbon sink, storing carbon in the soil and mitigating the effects of climate change.

Positive results were obtained in comparison with chemical fertilizers for different crop parameters

Project executed by:
Dr. Ravikiran Shet

Funding agency:

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

IWMI International Water Management Institute

TUHH Technische Universität Hamburg-Harburg

Vertical Flow Constructed wetland based Wastewater treatment (10 cu.m per day) for Hegdewar School, Cujira

BITS Pilani
K K Birla Goa Campus

The Vertical Flow Constructed Wetland system, tailored for Hegdewar School in Cujira, offers efficient wastewater treatment at a capacity of 10 cubic meters per day. Wastewater from the school premises undergoes natural purification as it percolates through the wetland's plant-filled beds and porous media. This eco-friendly process removes contaminants, organic matter, and pollutants, resulting in clean and safe effluent. The system not only promotes sustainable water management but also serves as an educational tool, showcasing the benefits of ecological wastewater treatment to the school community. The Vertical Flow Constructed Wetland stands as a practical and environmentally conscious solution for ensuring hygienic water disposal within the school premises.

KEY FEATURES	
Location	Goa, India.
Components	Septic Tank, Constructed Wetland
Treatment Capacity	180L/day
Treatment Efficiency	Average Reduction in COD, TP, Ammoniacal nitrogen, TKN and TOC are 68%, 99%, 77%, 43% and 53%. 100% reduction in coliform bacteria.
Life expectancy	Constructed wetlands: 15 years
Consumables	Ion exchange membrane (once in 3 months) Anode (once in 1.5 years)
Unit Costs	$ 1600 (Toilet + Treatment system)
Operational Costs	$ 7 per month (approx.)

Project executed by:
Dr. Anant Yadav

Anaerobic digestion of food waste (5 tons) and Septage solids (1 ton) - @ Sada, Goa

BITS Pilani
K K Birla Goa Campus

In Sada, Goa, an anaerobic digestion system efficiently processes 5 tons of food waste and 1 ton of septage solids daily. With a total capacity of 360 m^3, including storage, and a 43-day retention time, this system transforms organic waste into valuable resources. The process generates approximately 200 m^3 of biogas daily, contributing to renewable energy production. Additionally, 6 cu.m of water are reused daily for plant operations, showcasing a sustainable water management approach. This initiative not only addresses waste management challenges in the local municpalities but also exemplifies how anaerobic digestion can play a pivotal role in promoting eco-friendly practices and energy self-sufficiency.

KEY FEATURES

Location	SADA Waste treatment plant, Goa, India.
Input material	Food waste : 5 tons per day (organic fraction of municiple solid waste) and 1 ton of septage solids
Digester Volumes	360 m^3 including storage capacity (retention time is 43 days)
Biogas-generation	approx. 200 m^3/per day Biogas per day
Approximate Power generated	250 kW per day
No of septic tankers	Treated 4 tankers per day
Water reuse	6 cu.m of water was reused for plant operations every day.
Total waste treated	350 ton of organic waste and 50 ton of septage was treated during the period of operation
Digestate end uses	For composting

Project executed by:
Dr. Ravikiran Shet

Funding agency:

Department of Biotechnology, Government of India

Vertical wetlands for Whole sale Fish Market wastewater and river water, Madgaon, Goa India (500 sq.m)

BITS Pilani
K K Birla Goa Campus

A 500 sq.m vertical wetland system in Madgaon, Goa, ingeniously treats wastewater from the wholesale fish market and river water. This eco-friendly solution employs natural processes as water flows through plant-filled vertical beds and porous media. The wetland efficiently filters out pollutants, organic matter, and contaminants, rejuvenating the water's quality. By harnessing the power of wetland ecosystems, this system promotes sustainable water management and revitalizes both wastewater and river water. It stands as a testament to innovative environmental practices, offering a dual benefit of wastewater treatment and enhancing the health of local water resources in Madgaon, Goa, India.

KEY FEATURES	
Location of the work	
Area	Stage 1- 150 m^2 and Stage 2- 350 m^2
Plant type	*Canna Indica*
No. of Plants/sq. m	4-6
Treatment capacity	35-40 m^3 /day
Expected life	20 years
Total capital investment	$ 30,000
Does the system use any other “consumable” materials?	No.
How much water will be generated for reuse?	35-40 m^3
Compost or Fertilizer recovery?	Yes, After 15-20 years the upper layer of organics can be taken out and used as fertilizer
Are biological processes used?	Yes
Does the system require an external source of electricity?	Yes, 70 unit/day
Does the system use any other “consumable” materials?	No.
Does the system require any off-site waste processing?	No.
Does the system require any waste to be dumped or infiltrated in adjacent soil?	No.

Project executed by:

Dr. Anant Yadav

Ms. Rajashree Yaragal

Funding agency:

Department of Biotechnology, Government of India

Grey Water Treatment by Vertical Flow Constructed wetland for single household and for Laundry

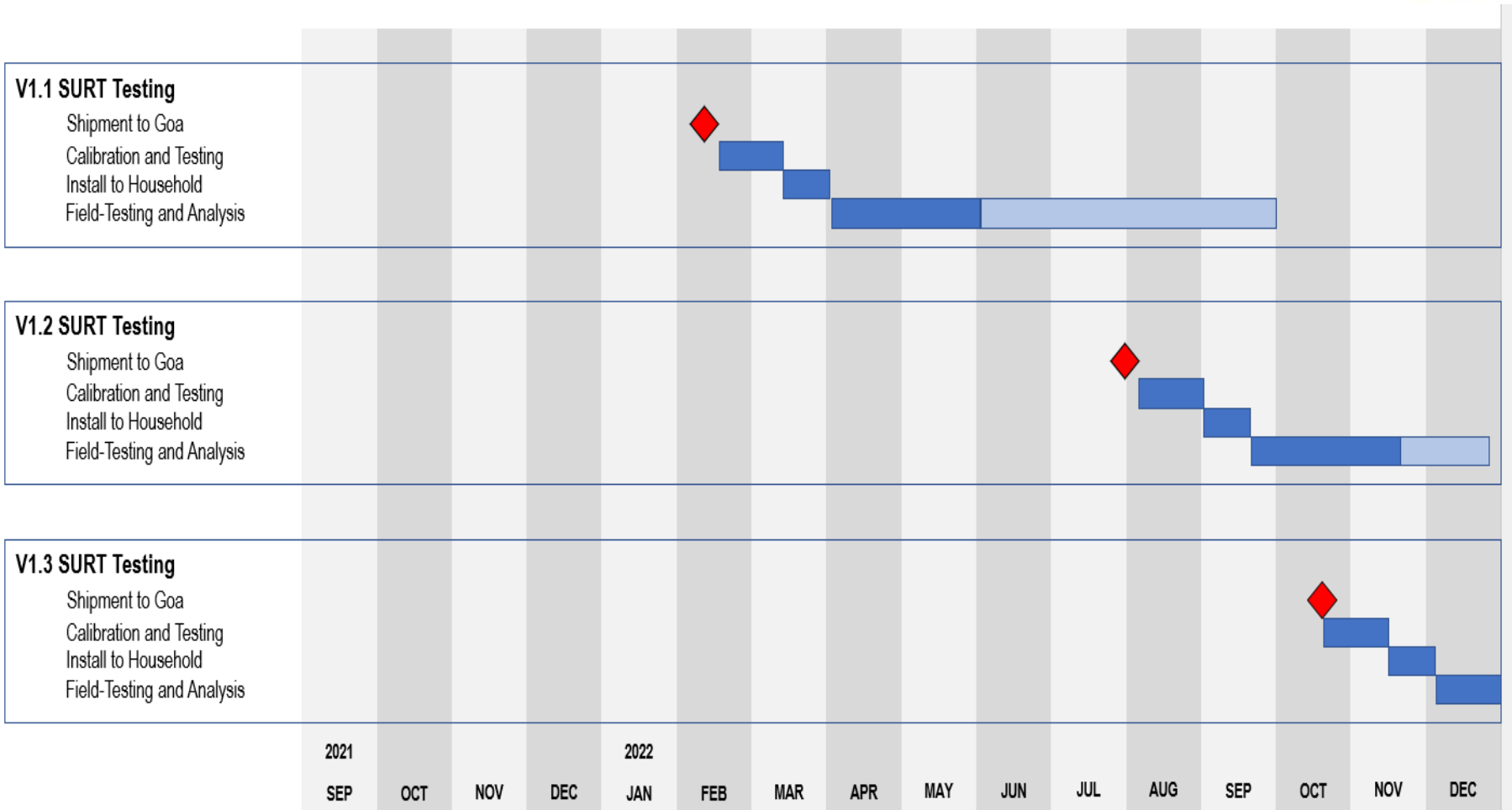
BITS Pilani
K K Birla Goa Campus

A Vertical Flow Constructed Wetland system presents an effective solution for treating grey water from a single household and laundry. This innovative approach involves guiding grey water through vertical beds filled with plants and porous media. The natural filtration and microbial processes within the wetland efficiently remove impurities, contaminants, and organic matter from the water. This system not only reduces the environmental impact of household wastewater but also offers a sustainable means of reusing treated water for irrigation or other non-potable purposes. By utilizing the power of nature, the Vertical Flow Constructed Wetland ensures responsible water management and supports a more eco-friendly lifestyle.

KEY FEATURES	
Expected life	20 years
Total capital investment	80,000 INR (1100 USD)
Nutrient / energy recovery?	NA
How much water will be generated for reuse	0.5 KLD
Compost or Fertilizer recovery?	NA
Are biological processes used?	Yes
Does the system require an external source of electricity?	Yes. Pumping water from storage tank to system. 0.5-0.75 hp pump. (0.5 units/day electricity requirement)
Does the system use any other “consumable” materials?	Yes. Starch (In specific cases only. Where Grey Water is having BOD/COD < 0.4)
Does the system require any off-site waste processing?	No
Does the system require any waste to be dumped or infiltrated in adjacent soil?	No

Project executed by:
Dr. Swapnil Punyapwar

Single user reinvented toilet (SURT)



GENERATION II
Reinvented Toilet

GLOBAL COLLABORATION

Project executed by:

Dr. Guruprasad V. Talekar

Mr. Siddhanath Shetkar

Faecal Sludge Treatment Plant and Vertical Flow constructed wetland for one septic tanker per day (8 cu.m per day)

BITS Pilani
K K Birla Goa Campus

BacTreat Environmental Solutions LLP
bactreat@gmail.com

A Faecal Sludge Treatment Plant incorporating a Vertical Flow Constructed Wetland efficiently manages the waste from one septic tanker per day, equating to 8 cubic meters daily. This innovative system employs a combination of biological and natural processes. The faecal sludge is treated within the plant, and then the treated effluent is further purified as it passes through the Vertical Flow Constructed Wetland. The wetland's plant-based filtration and microbial action significantly reduce pathogens and contaminants, resulting in safe and environmentally friendly treated water. This integrated solution not only addresses sanitation challenges but also demonstrates the potential of harnessing nature for sustainable faecal sludge management.

Faecal Sludge Treatment Plant and Vertical Flow constructed wetland for 15 septic tankers per day (90 – 120 cu.m per day)

BITS Pilani
K K Birla Goa Campus

A Faecal Sludge Treatment Plant, combined with a Vertical Flow Constructed Wetland, efficiently handles the waste from 15 septic tankers daily, amounting to 90-120 cubic meters. This integrated system employs a two-step approach: the treatment plant initially processes the faecal sludge, followed by further purification through the Vertical Flow Constructed Wetland. The wetland's natural filtration and microbial processes effectively reduce contaminants and pathogens, ensuring safe effluent. By utilizing this combination of technologies, the solution addresses substantial faecal sludge volumes while showcasing the potential of eco-friendly and sustainable wastewater treatment for larger-scale applications.

Key Features	
Location of the work	Bicholim, Goa
Area	3000 sq.m.
Plant type	*Canna Indica*
No. of Plants/sq. m	4-6 (At installation time)
Treatment capacity	120 KLD
Expected life	20 years
Total capital investment	1.36 Cr.
Does the system use any other “consumable” materials?	Hypochlorite (For Disinfection)
How much water will be generated for reuse?	80- 120 cumec. per day
Compost or Fertilizer recovery?	Yes.
Are biological processes used?	Yes.
Total number of tankers that can be handled at a time.	15
Any consumable for composting?	Yes. Pressmud/cocopeat

Project executed by:
Mr. Keyur Namdev

BacTreat Environmental Solutions LLP
bactreat@gmail.com

Design and development of third rinse water treatment system

Project details :

- **Development of third rinse water system at 2 liter scale**
- **Scaling up of developed system to 20 liter scale and testing it at scale**

Untreated to treated water transition from left to right in 4 step process

20 litre scale treatment system lab set up

KEY FEATURES	
Location of the work	B108 Wash Lab BITS Goa
Treatment Capacity	20 litres of third rinse water
Treatment cost	1 rupee for 20 litres
Power required	80 to180 watts depending on detergent used
Type of treatment	Electrochemical
Treatment time	94 minutes
Technology readiness level	TRL 4
Consumables needed	Electrodes
COD of treated water	10 to 20 ppm
Disinfection achieved	100%
Orthophosphate concentration of treated water	Under 1 ppm
Total Nitrogen reduction	100%
Detergents that are compatible	All solid and liquid detergents
Total turbidity Reduction	95-100%

Project executed by:
Mr. Shamik Prabhu Chodnekar

Moving bed biofilm reactor for efficient treatment of domestic wastewater

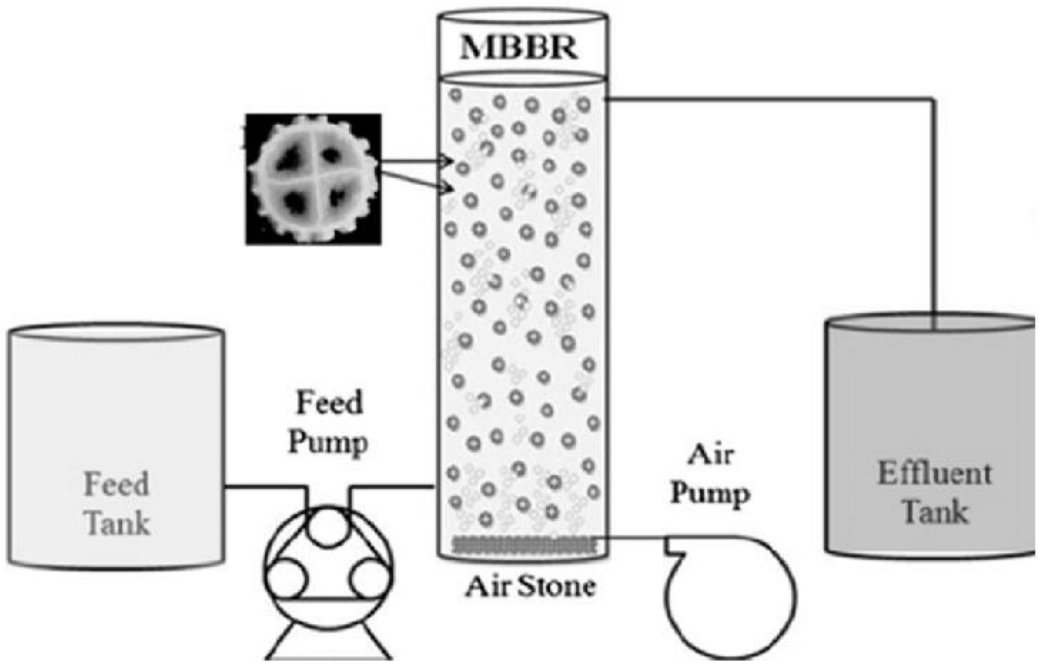


Fig. 1 Schematic diagram of MBBR reactor

Fig. 2 Picture depicting MBBR reactor and Picture depicting biofilm formation on carriers

The MBBR was successfully able to reduce cod by 80%, Bod by 70%, & total organic content by 72%.

The moving bed biofilm reactor was developed by Professor Hallvard Odegaard in the late 1980s and was further investigated and improvised in the 1990s. It is a biological treatment system that uses special carriers as biofilm media in the aeration tank of a wastewater treatment plant. MBBR treatment provides numerous advantages over conventional activated sludge treatment systems. Such as lower footprint but higher treatment capacity. As many processes involved in MBBR rely on microorganisms hence the operator has fewer controls to manage, experiencing a simpler operation.

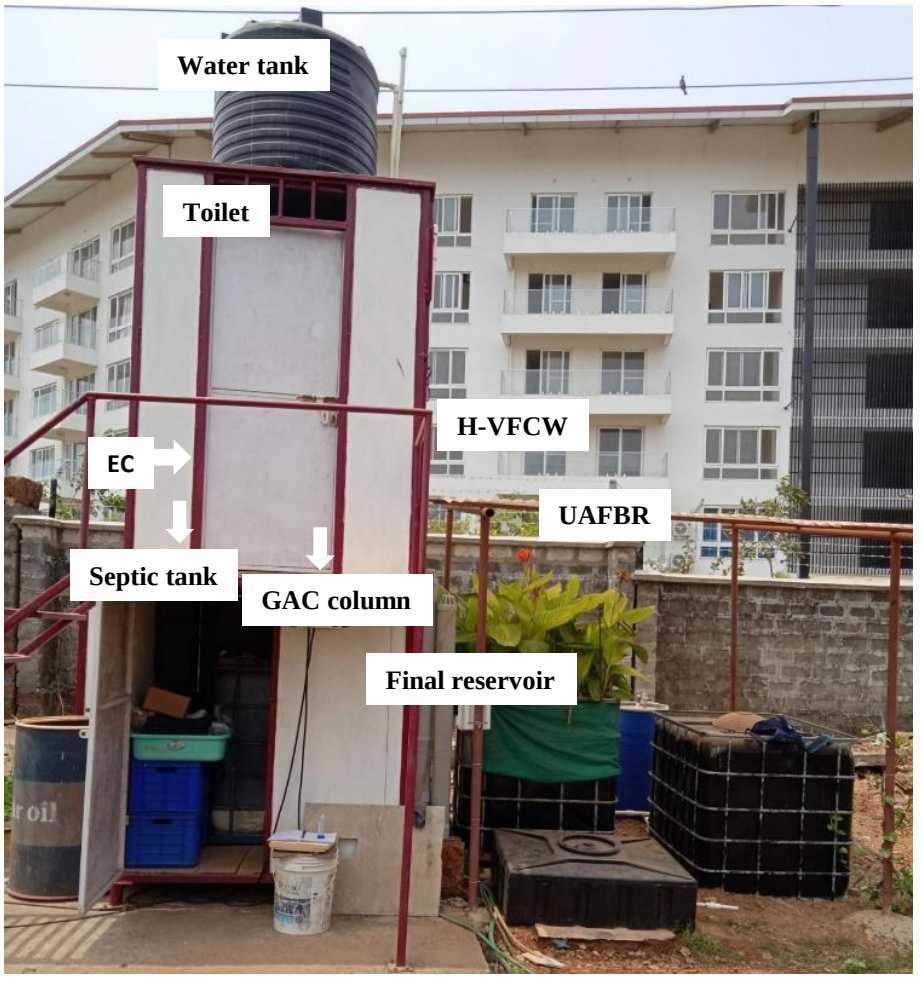
KEY FEATURES

Location of the work	BITS Goa Campus
Type of carrier used	Polypropylene
Specific surface area	400m^2/m^3
% filling in the reactor	50%
Treatment capacity	2 m^3/d
How much water will be generated for reuse?	2 m^3/d
Compost or Fertilizer recovery?	Yes, every six months
Are biological processes used?	Yes
Does the system require an external source of electricity?	Yes
Does the system use any other “consumable” materials?	No.
Does the system require any off-site waste processing?	No.
Does the system require any waste to be dumped or infiltrated in adjacent soil?	No.

Project executed by:
Mr. Sanam Prabhudessai

Demonstration of single household aqua-privies toilet with decentralized integrated treatment system: “Hybrid-Vertical flow constructed wetland, Upflow anaerobic fixed biofilm reactor and Granular activated charcoal column”, along with “in-situ electrochlorination disinfection”

BITS Pilani
K K Birla Goa Campus



H-VFCW= hybrid vertical flow constructed wetland
UAFBR= Upflow anaerobic fixed biofilm reactor
EC= electrolytic cell
GAC= granular activated charcoal

Fig 1. single household aqua-privies toilet with decentralized integrated treatment system

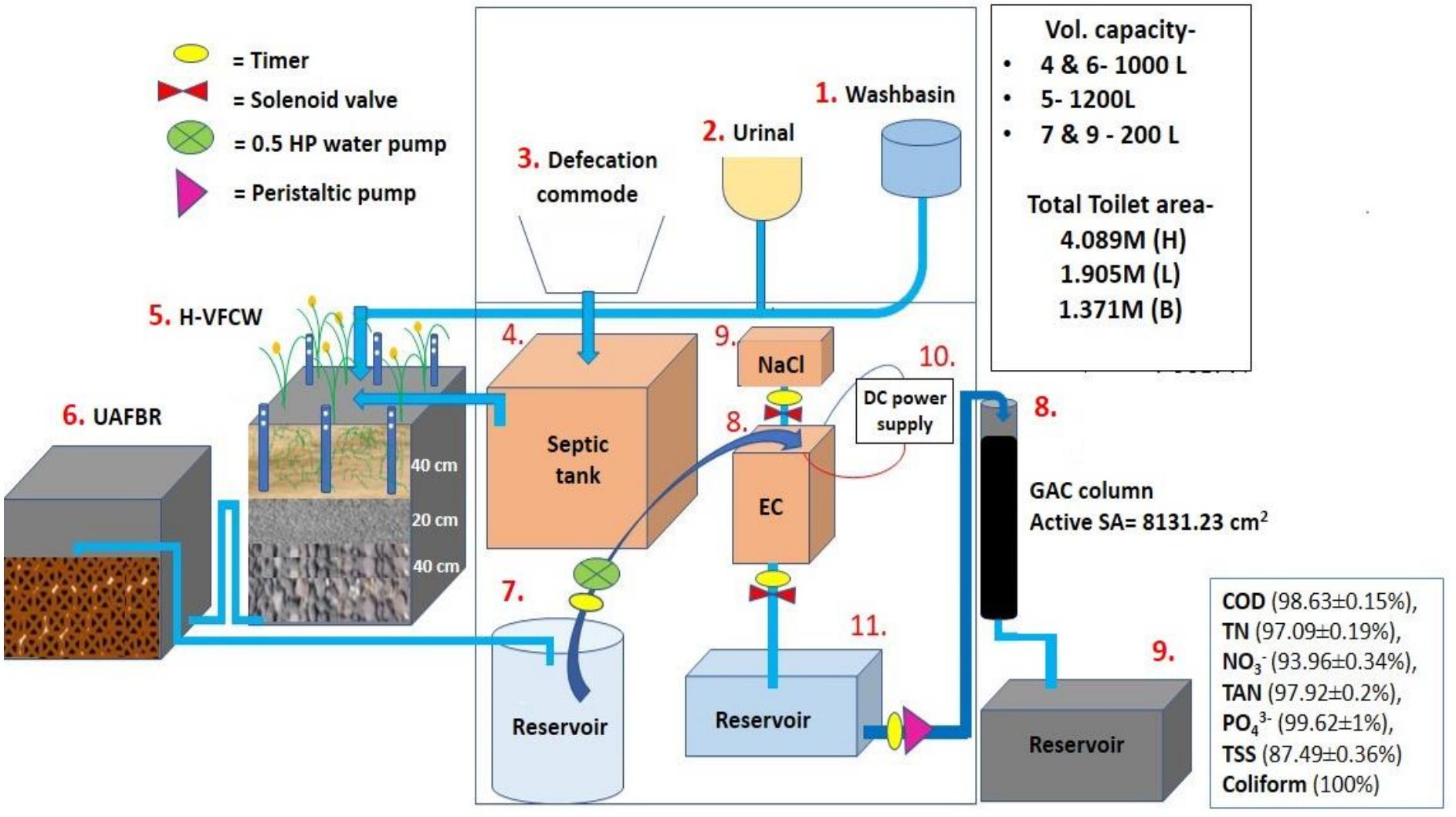


Fig 2. Schematic diagram of single household aqua–privies toilet integrated treatment system mechanism with the feed flow path

BITS Pilani
K K Birla Goa Campus

KEY FEATURES	
Location	BITS Pilani, KK Birla Goa campus (15.39° N, 73.88° E)
Total area of toilet with treatment system	5.35 m^2
Plant type	*Canna Indica*
No. of Plants/sq. m	4-6
Treatment capacity	~150-200 L/day
Wastewater generated per day	155 L/day
Total capital investment	~2-3 lakhs (INR)
Toilet users per day	~6 people equivalent
Power consumption per day by treatment system	1.81±0.14 ± $KWhrm^{-3}$
Power consumption cost of the treatment system	6.154 INR

Project executed by:
Mr. Jayanta Gogoi

Funding agency:

Department of Biotechnology, Government of India

birac Biotechnology Industry Research Assistance Council (A Government of India Enterprise)
Ignite Innovate Incubate

BILL & MELINDA GATES foundation

Empowered Septic tank for 4 people at BITS Laundry and 100 people public toilet at Bogmalo Panchayat –- Hybrid of Vertical Flow Constructed wetland and Electrochemical system

Fig. 1 Public toilet with decentralized integrated treatment system at Bogmalo beach, Goa-India **(a)** Changing room, **(b)** Female toilet, **c)** Handicap toilet, **(d)** Electro-chlorinator room (EC), **(e)** Male toilet, **(f)** Male urinal, **(g & h)** Fresh water tank, **(i)** Toilet keeper, **(j)** 1st stage unsaturated- vertical flow constructed wetland (U-VFCW) **(k)** 2nd stage saturated- vertical flow constructed wetland (S-VFCW)

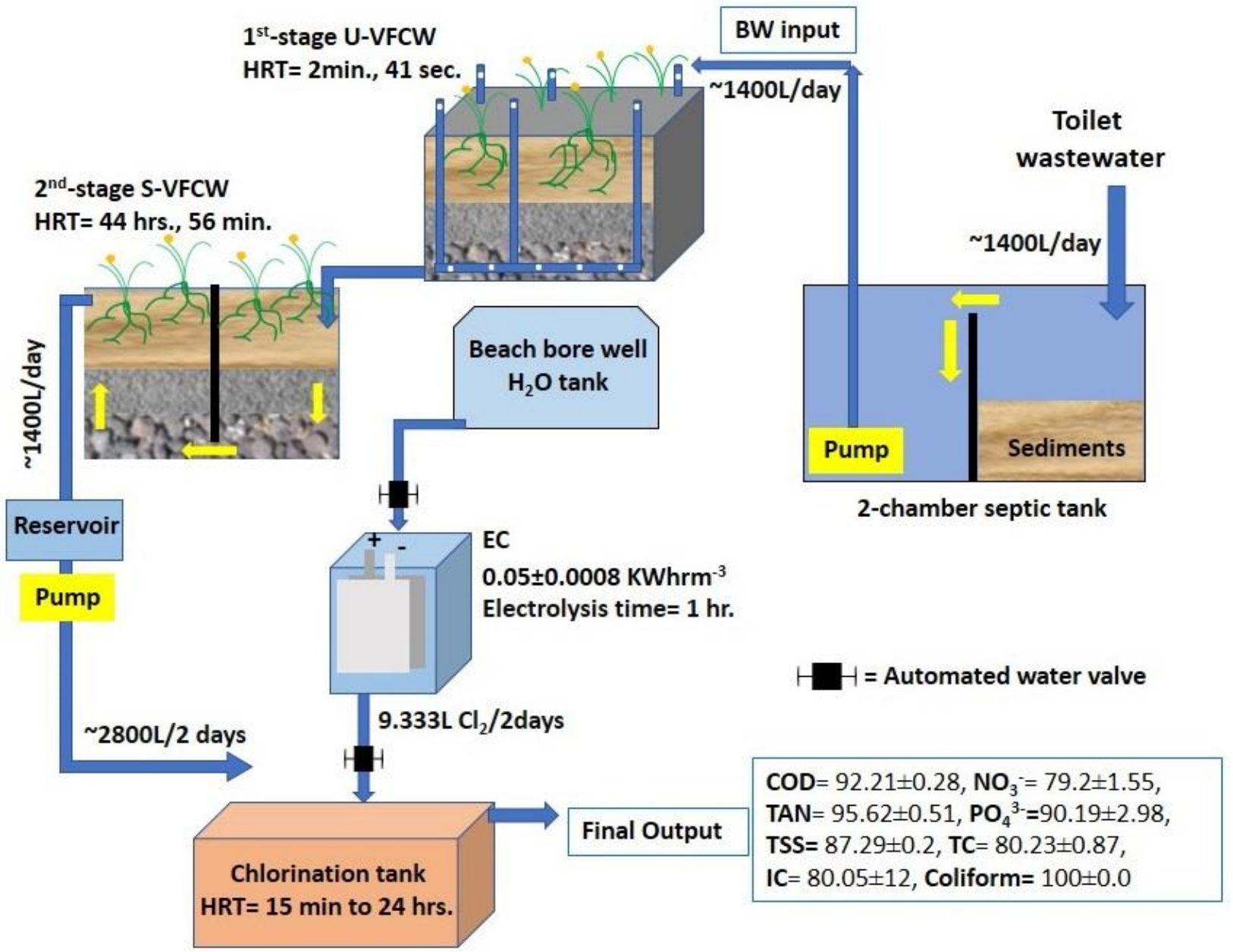


Fig. 2: Schematic diagram of bogmalo beach public toilet integrated treatment system mechanism with the feed flow path

KEY FEATURES	
Location of the work	Bogmalo beach (15.37°N, 73.83°E)- Goa
Total area of toilet with treatment system	4.63m * 16.4m (75.932m^2)
Plant type	*Canna Indica*
No. of Plants/sq. m	4-6
Treatment capacity	2-5 m^3 /day
Wastewater generated per day	1407.98±611.8
Total capital investment	$ 30,000
Toilet users per day	~100 people equivalent
Power consumption per day by treatment system	0.05±0.0008 $KWhrm^{-3}$
Power consumption cost of the treatment system	0.17 INR
Does the system require any off-site waste processing?	No.
Does the system require any waste to be dumped or infiltrated in adjacent soil?	No

Project executed by:

Dr. Guruprasad V. Talekar

Dr. Priya Sharma

Dr. Swapnil Punyapwar

Mr. Jayanta Gogoi

Mr. Keyur Namdev

Funding agency:

Wastewater-based epidemiology and screening for pathogens

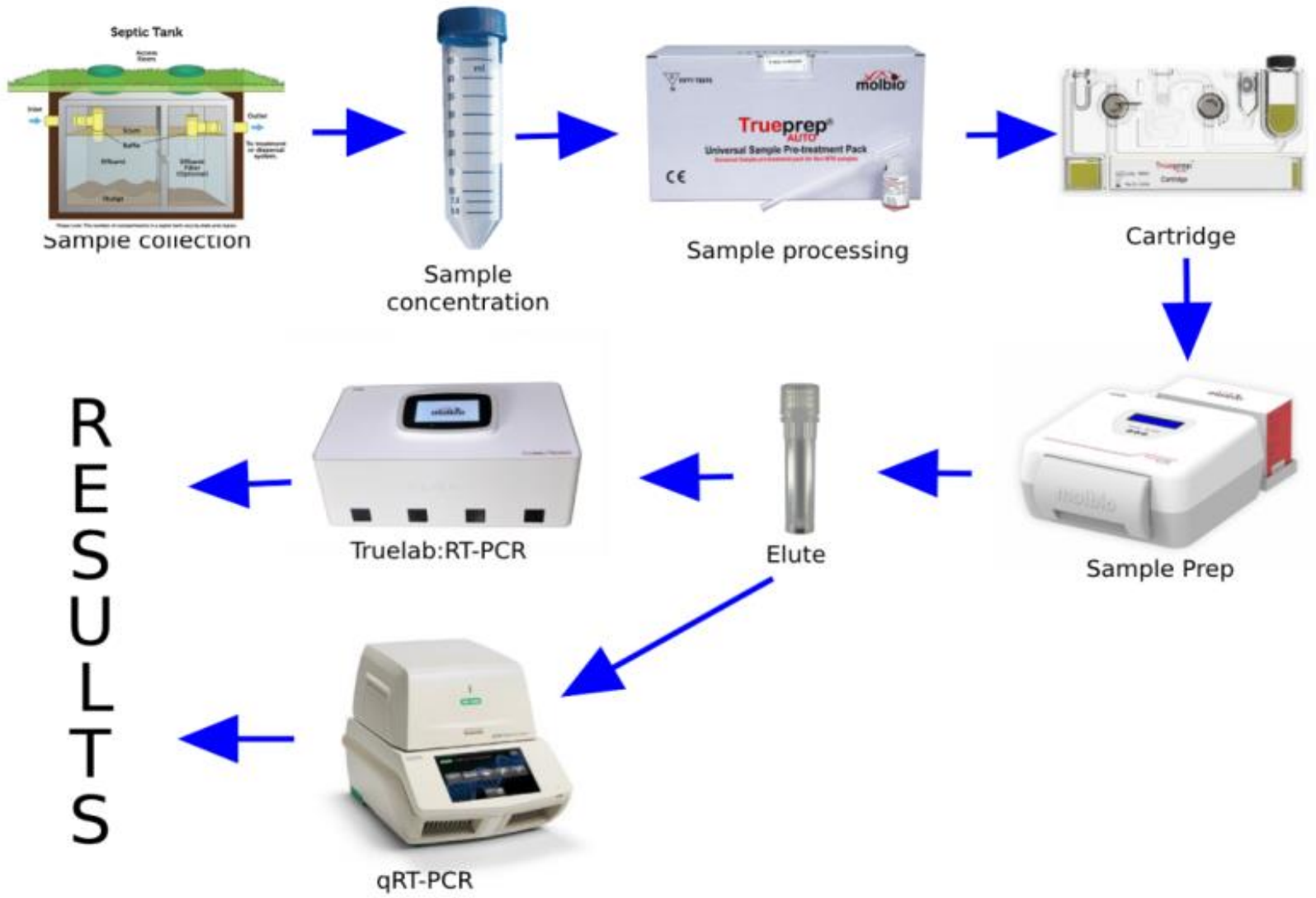
BITS Pilani
K K Birla Goa Campus

Project details:

- Detection of SARS-CoV-2 in wastewater from ten sites in and around BITS Goa Campus.
- Routine analysis and monitoring of the Strain of Virus present in wastewater obtained from Septic tanks and STPs.

Title: Wastewater-Based Epidemiology and Screening for Covid19

Process workflow:



Project executed by: Mr. Sanvidh Narkhede

Funding agency:

SERB INDIA

Tracking the import of SARS-CoV-2 and its variants by surveillance of Airport wastewater.

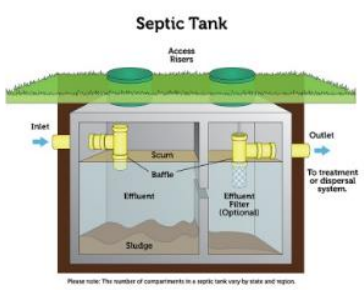
BITS Pilani
K K Birla Goa Campus

Project details:

- Detection of SARS-CoV-2 in wastewater sourced from Dabolim Airport, Goa.
- Routine analysis and monitoring of the Strain of Virus present in wastewater.

Title: Tracking the import of SARS-CoV-2 and its variants by surveillance of Airport wastewater.

Process workflow:



Sample collection

Direct Capture and Purification of Viral DNA/RNA From Wastewater

qRT-PCR

MinION

Sequencing

Phylogenetics and Lineage assesment

Features of the project:

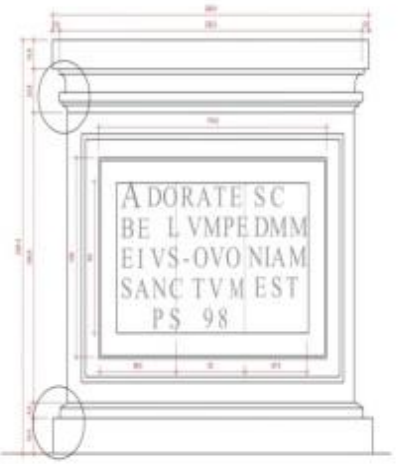
- Viruses can be detected in wastewater. Viral load in wastewater directly results from body fluids, primarily feces, saliva, and sputum.
- Wastewater Based Epidemiology(WBE) is a crucial tool to detect and monitor infectious disease-causing pathogens.
- WBE can monitor a given population by testing the wastewater of the community and thus warn the community of any upcoming infectious outbreaks.

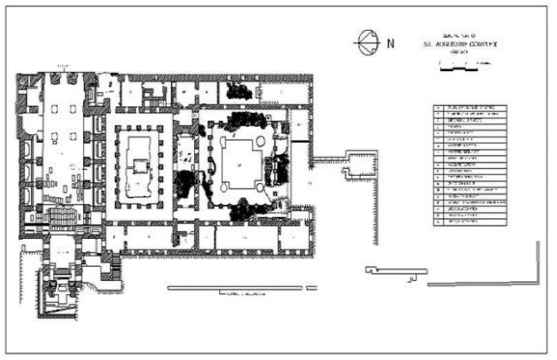
Project executed by: Mr. Sanvidh Narkhede

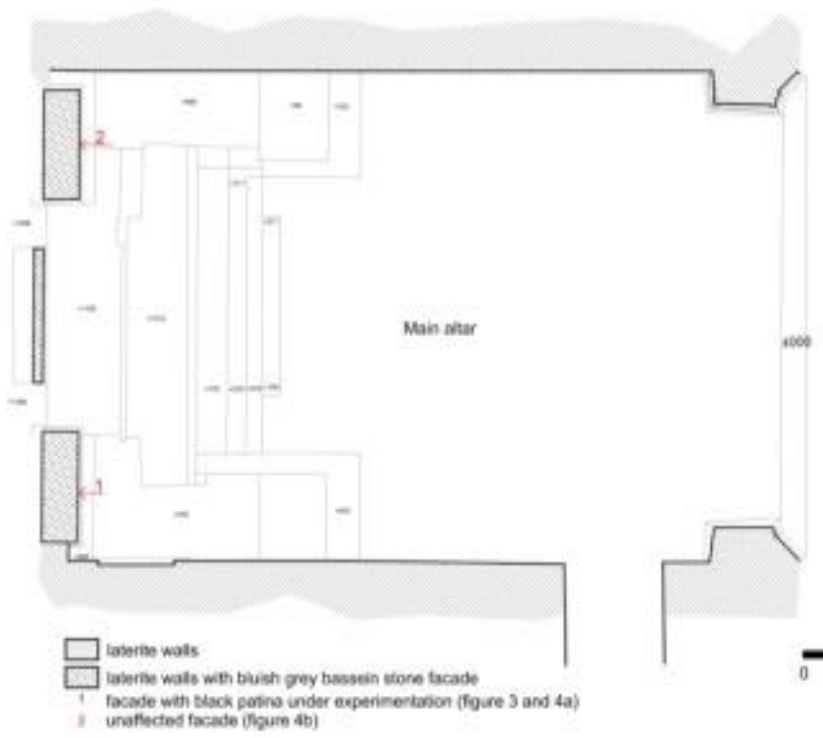
Funding agency:

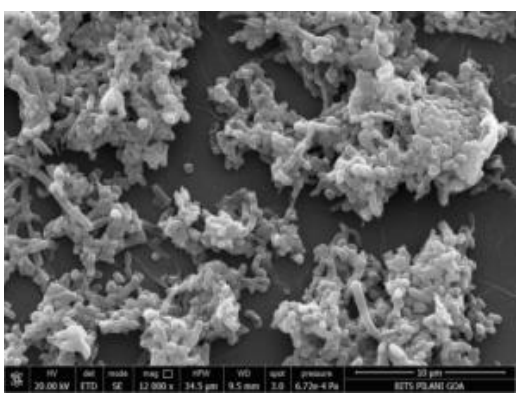
SERB INDIA

Bioremediation and Digital Documentation towards the conservation of Cultural Heritage









KEY FEATURES	
Location of the work	St Augustine tower, Old-Goa, India
Area	242.4 cm x 226.3 cm (height) X 87.5cm
Bacterial culture used	Sulfate reducing bacteria (SRB)
CFU/mL	21×10^4 cells/mL
Cell concentration measurement	Flow cytometry
Carrier used	Carbogel
Expected treatment time	45 hours
Instruments used	Scanning electron microscopy, Centrifuge, Flow cytometry, incubator, Spectrophotometer
Mechanism of treatment	SRB reduce sulfates accumulated on the surface of heritage sites responsible for black crust formation.
Software used for architectural documentation	AutoCAD
Type of biorestoration method	Biological
Chemicals used	Sulfate reducing medium, Phosphate buffered saline, Carbogel.
Does the treatment system require any decontamination procedure at the site?	No.

Project executed by:

Ms. Mamta Kodarkar

Mr. Sanam Prabhudessai

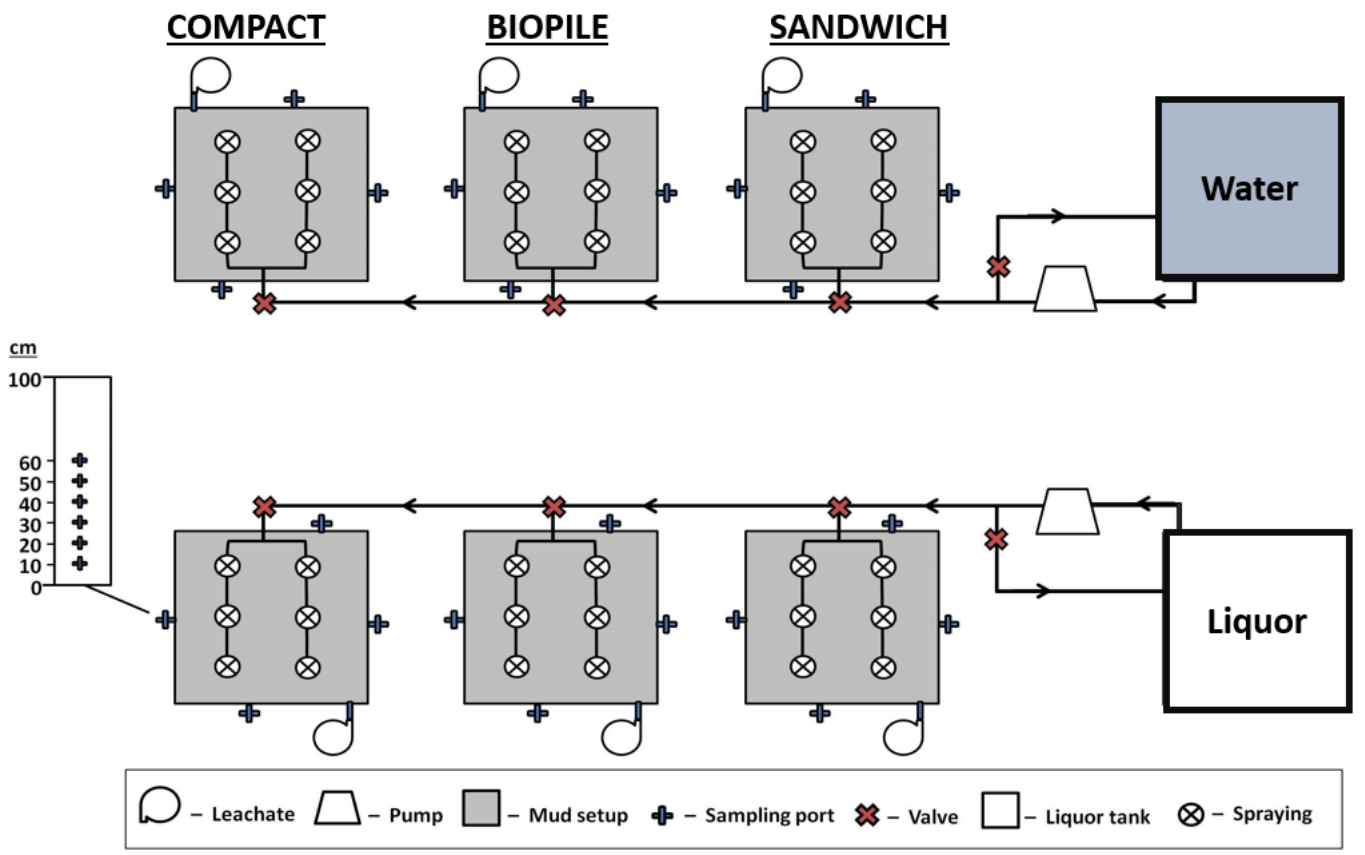
Funding agency:

सत्यमेव जयते
Department of Science and Technology
Ministry of Science and Technology
Government of India

Bioremediation of Red Mud using acidogenic Fermentation By product and By Biopiling

BITS Pilani
K K Birla Goa Campus

Experimental design:

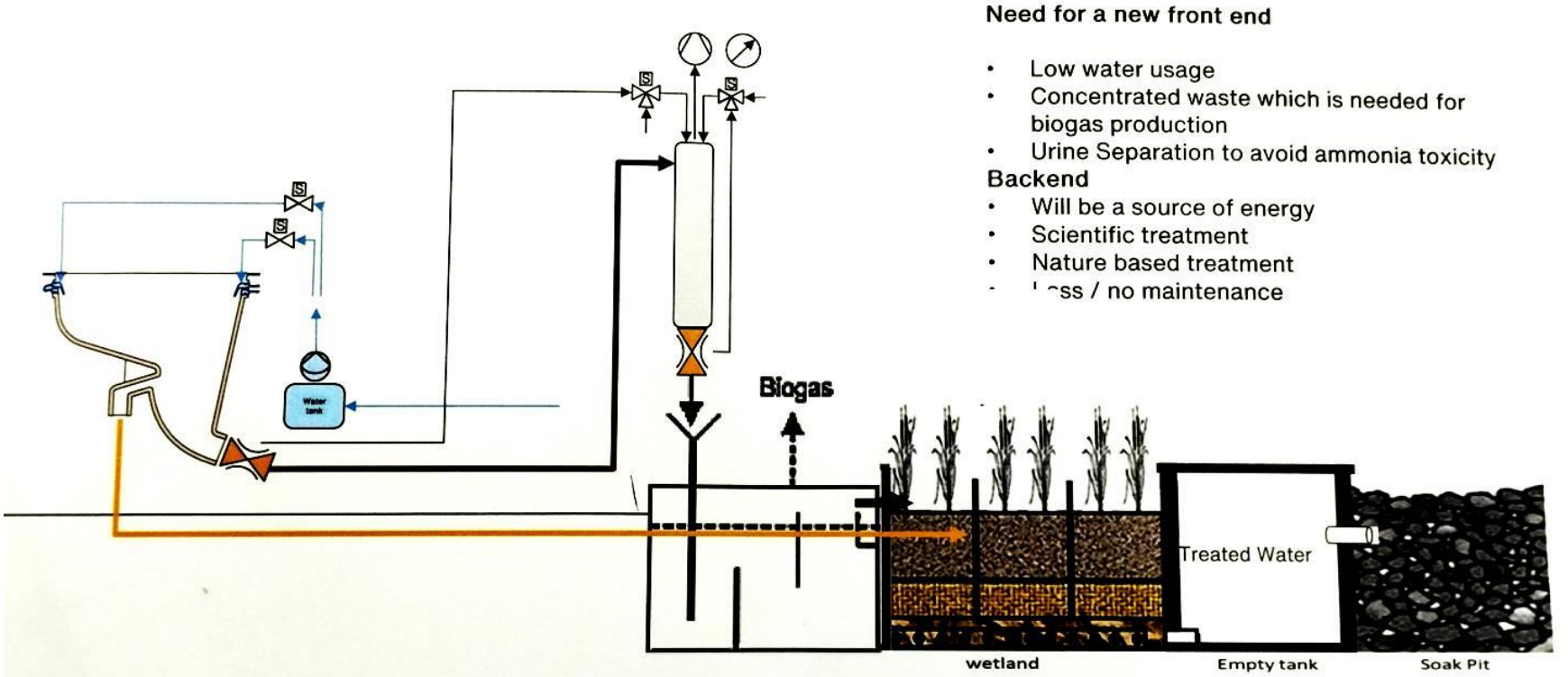


KEY FEATURES	
Location of the work	BITS Pilani, Goa Campus
No. of tanks	6
Treatment capacity	577 kgs
Does the system use any other “Consumable” material	Yes
Are Biological processes used?	Yes
Does the system require an external source of electricity?	Yes
Does the system use any other “Consumable” material?	Yes

Project executed by:
Mr. Paresh Gaonkar

Funding agency:

Commercialization Support of the Source Separation Toilet User Interface



Need for a new front end

- Low water usage
- Concentrated waste which is needed for biogas production
- Urine Separation to avoid ammonia toxicity

Backend

- Will be a source of energy
- Scientific treatment
- Nature based treatment
- Less / no maintenance

Biogas + wetland system = Biowet

Toilet setup at BITS + EOOS Frontend + Anaerobic Digester + Wetland

Community toilet setup at Sancoale, Goa

KEY FEATURES	
Location of the work	BITS Goa and Sancoale, Goa
Total area of toilet with treatment system	48 sq. ft
Number of toilet setup	5
Quantity of waste water generated per day per setup	~ 35 L
Quantity of water per flush	0.8 – 1.2 L
Cost of usage per day	< 1 INR per day
Power required	80 to 180 watts depending on detergent used
Type of treatment	Biological (constructed wetlands)
Technology readiness level	TRL 6
Consumables needed	-
COD of treated water	< 50 ppm
Disinfection achieved	>90%

Project executed by:
Dr. Ravikiran Shet

Funding agency:

EOOS NEXT

Grey Water Treatment for Washing Machine

Lab scale electrocoagulation setup

Coagulation

Carbon Filter

Reuse of treated water for next wash cycle

Electrocoagulation is a water treatment technology that involves the generation of coagulant in situ by electro-oxidation. Aluminum electrodes are commonly used in electrocoagulation processes due to their effectiveness in removing various contaminants from water, including organic matter, dyes, aromatic compounds, drugs, and petroleum derivatives. The advantages of electrocoagulation include easy operation, removal of suspended solids by flotation and precipitation, and the feasibility of controlling the amount of sludge and energy used in the process. The optimal operating conditions for electrocoagulation with aluminum electrodes depend on factors such as the current density applied, distance between the electrodes, and electrode contact area.

KEY FEATURES	
Location of the work	AH-6 Treatment facilty
Treatment Capacity	30 litres of third rinse water
Treatment cost	<2 rupee per batch
Power required	80 to180 watts depending on detergent used
Type of treatment	Electrochemical Coagulation
Treatment time	30 to 45 minutes
Technology readiness level	TRL 4
Consumables needed	Electrodes
COD of treated water	< 50 ppm
Disinfection achieved	100%
Detergents that are compatible	All solid and liquid detergents
Total turbidity Reduction	95-100%


Project executed by:
Ms. Devika Arsekar & Dr. Ravikiran Shet

Valorization of Organic Waste

- **Vitamin D_2 Mushroom Fortification**
  - UV light exposure duration
  - Distance between UV light source & mushroom
- **Enzyme Recovery from SMC***
  - Enzyme Recovery Process Optimization
  - Enzyme Characterization
  - Fungal Diversity Studies
- **Industrial Applications of Enzymes**
  - Enhancing Biogas Production
  - Animal Feed Production
  - Dye Decolorization
- **Solution of Solid Waste Management**
  - PROM Production
  - Briquette Manufacturing

Project executed by:
Dr. Anumeha Vats

Our Startups

BITS Pilani
K K Birla Goa Campus

Sustainable Biosolutions LLP.

- Waste Water Treatment
- Solid Waste Management
- Consultancy & Contract Research
- Nutrient recovery from waste

Bactreat Environmental Solutions LLP

- Decentralized wastewater systems and waste to energy projects (Biogas)
- Anaerobic digestion systems for solid waste management
- Carbon dioxide sequesteration using microalgae
- Bioremediation solutions for different pollutants

BacTreat Environmental Solutions LLP
bactreat@gmail.com

Our Collaborators

BITS Pilani
K K Birla Goa Campus

UNIVERSITEIT GENT

TUHH
Hamburg University of Technology

INRA
SCIENCE & IMPACT

INDIAN INSTITUTE OF SCIENCE

HITACHI
Inspire the Next

Caltech

MINES Nantes

IWMI
International Water Management Institute

ओएनजीसी
ONGC

National Institute of Urban Affairs

Cranfield University

eawag
aquatic research

RTI INTERNATIONAL

helbling

BOKU

UNISC
UNIVERSIDADE DE SANTA CRUZ DO SUL

UNIVERSITY OF KWAZULU-NATAL

Duke
UNIVERSITY

teri

EOOS NEXT

INSTITUTO SUPERIOR D AGRONOMIA

UNESCO IHE DELFT

Georgia Tech

L&T Construction
Water & Effluent Treatment

Department of Biotechnology, Government of India

birac
Ignite Innovate Incubate
Biotechnology Industry Research Assistance Council
(A Government of India Enterprise)

BILL & MELINDA GATES foundation

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

सत्यमेव जयते
Department of Science and Technology
Ministry of Science and Technology
Government of India

GOVERNMENT OF GOA

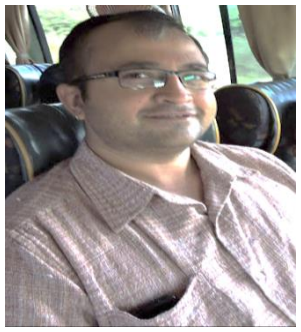
CEFIPRA

ADITYA BIRLA
SCIENCE & TECHNOLOGY

Notes

BITS Pilani
K K Birla Goa Campus

Team



Prof. Srikanth Mutnuri

Shubham Counder
-Lab Manager

Ravikiran Shet
-Postdoc

PhD's

Prajakta Patil

Rajashree Yaragal

Aatiya Shaikh

Sanam Prabhudessai

Mamta Kodarkar

Jayanta Gogoi

Shamik Prabhu Chodnekar

Sanvidh Narkhede

Keyur Namdev

Yuga Gotge

Siddhanth Shetkar
-3D printer
Technician

Paresh Gaonkar
-Technical Assistant

Mahi Asukar
-Lab Assistant

Sristi Parsekar
-BacTreat

Nand Nitin Kamat
-BacTreat

Devika Arsekar
-Intern

Past PhDs and Post-Docs

P. Sivaraman

Vidhya Prabhudessai

Vaishnavi Unde

Rajesh Pasumarthi

Meghanath Prabhu

Ram Chavan

Anant Yadav

Guruprasad V.
Talekar

Priya Sharma

Anumeha Vats

Swapnil
Punyapwar

Lalitha Baragi
-Postdoc

Mansur Elahi
-Postdoc

Radhamani V.
Manager