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

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European Union funding
for Research & Innovation

सत्यमेव जयते
DEPARTMENT OF BIOTECHNOLOGY
GOVERNMENT OF INDIA

STRATEGIC PLANNING FOR WATER RESOURCES, DEVELOPMENT AND IMPLEMENTATION OF NOVEL BIOTECHNICAL TREATMENT SOLUTIONS AND GOOD PRACTICES (SPRING)

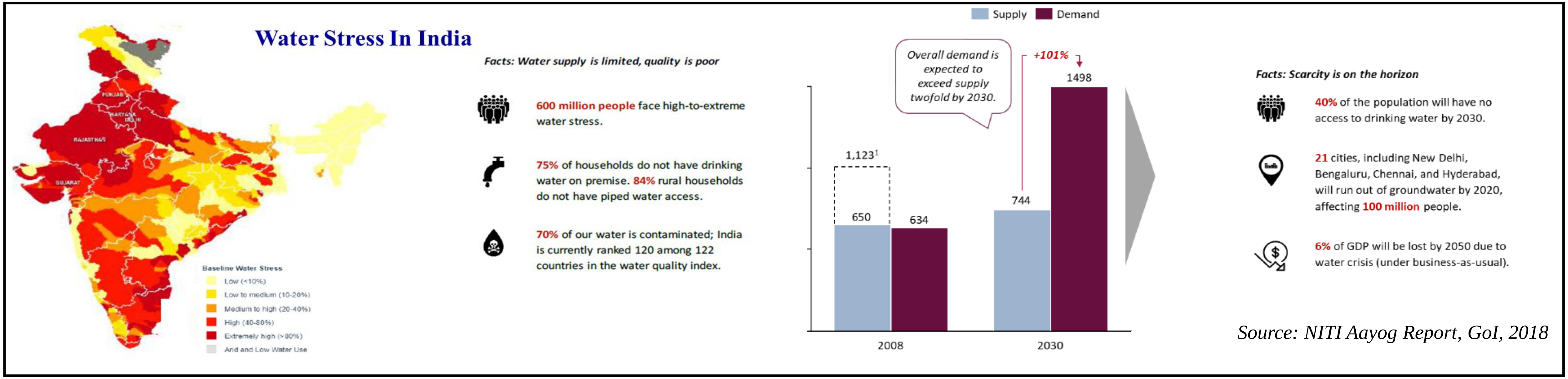
Coordinator (EU)

Prof. Rajnish Kaur Calay
University of Tromsø, Norway
Timeline: August 2019 - July 2024

Coordinator (India)

Prof. Sanjukta Patra
Indian Institute of Technology Guwahati, Assam
Timeline: May 14, 2020 - May 13, 2024

Review Meeting: January 29, 2024



Water Stress In India

Facts: Water supply is limited, quality is poor

600 million people face high-to-extreme water stress.

75% of households do not have drinking water on premise. **84%** rural households do not have piped water access.

70% of our water is contaminated; India is currently ranked 120 among 122 countries in the water quality index.

Facts: Scarcity is on the horizon

40% of the population will have no access to drinking water by 2030.

21 cities, including New Delhi, Bengaluru, Chennai, and Hyderabad, will run out of groundwater by 2020, affecting **100 million** people.

6% of GDP will be lost by 2050 due to water crisis (under business-as-usual).

Source: NITI Aayog Report, GoI, 2018

Sources of Water Pollution

- Urbanization
- Deforestation
- Industrial effluents
- Social and religious practices
- Use of detergents and fertilizers
- Agricultural run-offs
- Use of insecticides and pesticides

Water Pollution: An Epidemic

- Aquatic life affected
- Huge impact on the food chain
- Outbreak of infectious diseases

Integrated water resource management for clean and safe water supply: SPRING

Pollutant heterogeneity and sampling location

Real time monitoring

Pollutant sensing tools

Advanced Bio-oxidation

Treatment of water bodies

Implementing good water practices

SPRING PARTNERS

1. University of Tromsø

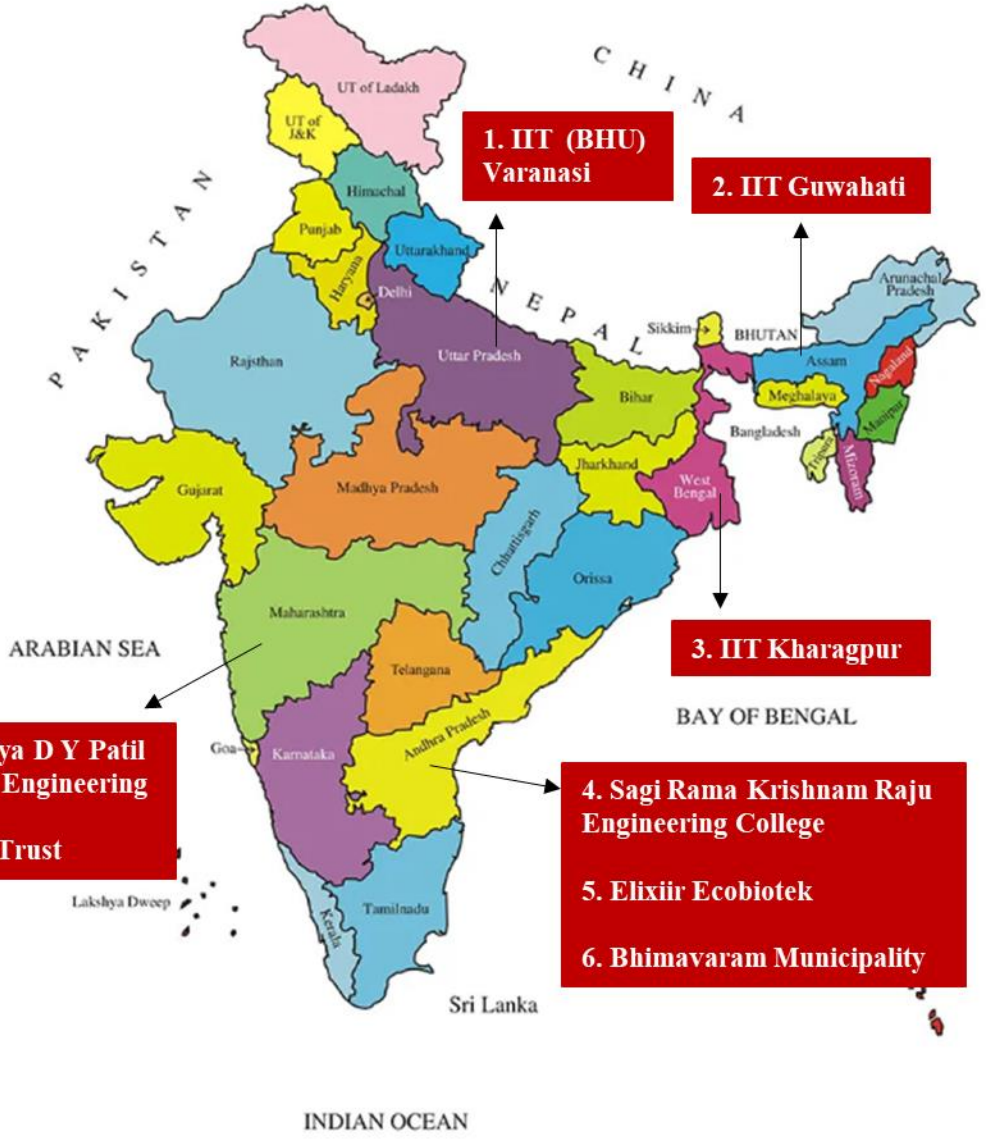
2. Northern Research Institute Narvik

3. INESC TEC

4. University of Pecs

5. Enviroinvest

6. Finnish Water Forum



1. IIT (BHU) Varanasi

2. IIT Guwahati

3. IIT Kharagpur

4. Sagi Rama Krishnam Raju Engineering College

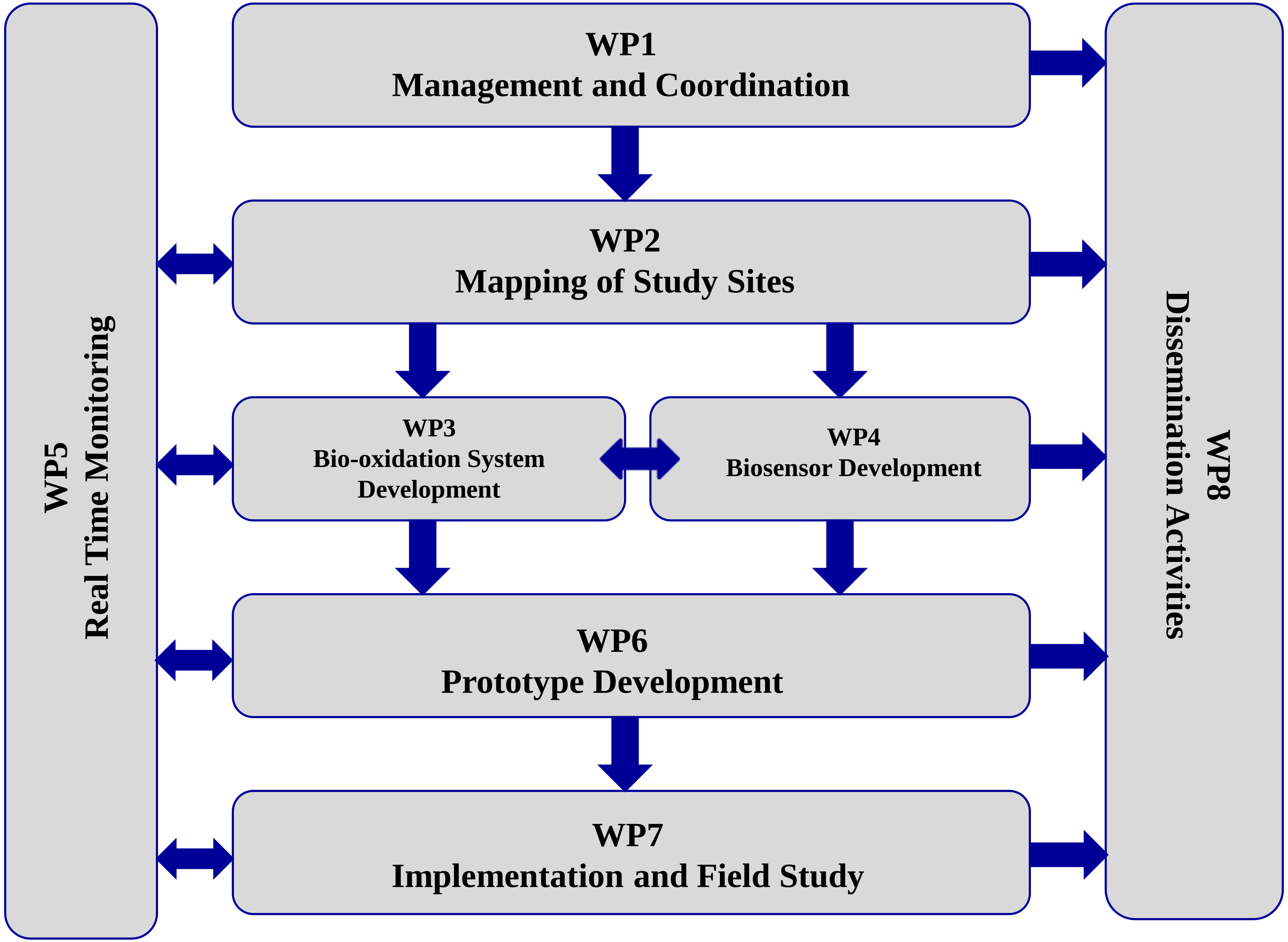
5. Elixiir Ecobiotek

6. Bhimavaram Municipality

7. Ajeenkya D Y Patil School of Engineering

8. Palavi Trust

INTERACTION BETWEEN WPs AND PARTNERS



WP1
Management and Coordination

WP2
Mapping of Study Sites

WP3
Bio-oxidation System Development

WP4
Biosensor Development

WP6
Prototype Development

WP7
Implementation and Field Study

WP5
Real Time Monitoring

WP8
Dissemination Activities

WP1: **IITG**, IITKGP, IITBHU, SRKRC, DYP, ELI, BMC, PAL, **UiT**, UP, NOR, FWF, INESC, ENV

WP2: **SRKRC**, IITBHU, DYP, PAL, UiT, UP, ENV

WP3: **IITG**, IITKGP, IITBHU, ELI, SRKRC

WP4: DYP, **UP**, UiT, FWF, NOR

WP5: IITG, IITKGP, IITBHU, SRKRC, DYP, ELI, BMC, PAL, UiT, NOR, **INESC**

WP6: IITG, IITKGP, IITBHU, SRKRC, DYP, **ELI**, BMC, PAL, UiT, NOR, INESC, UP, FWF

WP7: IITG, IITKGP, IITBHU, SRKRC, DYP, **ELI**, BMC, PAL, UiT, UP, NOR, FWF, INESC, ENV

WP8: **IITG**, IITKGP, IITBHU, SRKRC, DYP, ELI, BMC, PAL, **UiT**, UP, NOR, FWF, INESC, ENV

SPRING OBJECTIVES

1. Geospatial analysis for identification of point and non-point sources of pollution of water bodies using integrated remote sensing (Western Delta of Godavari river and mid Ganga river Basin near Varanasi)
2. Analysis of water samples for assessing pollutant heterogeneity
3. Development of robust enzyme(s) systems for pollutant removal and wastewater treatment
4. Scaling up of the enzymes systems for implementatio and commercial exploitation
5. Development of smart and cost-effective sensing systems for pollutant detection and actuation systems for bio-catalysis
6. Developing a prototype of the innovative low-cost advanced bio-oxidation treatment
7. Field trials and testing of prototype(s)
8. Developing stakeholders decision making and management framework

WORK PROGRESS

SO1: Geo spatial analysis with respect to land use/land coverage and water resources for identification of point and non-point sources of pollution of water bodies using integrated remote sensing (river Godavari delta and river Ganga near Varanasi are the two selected test sites).

SO2: Physicochemical and biochemical analysis of water samples collected from different point and non-point sources of pollution for assessing the heterogeneity of pollutants.

THE GANGA AND GODAVARI RIVER IN INDIA: AN OVERVIEW

- **River Ganga** is the Himalayan river and it is perennial.
- The Ganga is the 20th longest river in Asia and the 41st longest in the world (Philips World Atlas).
- The length of the Ganga is over 2500 km.
- The Ganges River runs through northern India and is sacred to people.
- The Ganges River originates in the Himalaya Mountains at Gomukh, the terminus of the Gongotri Glacier.

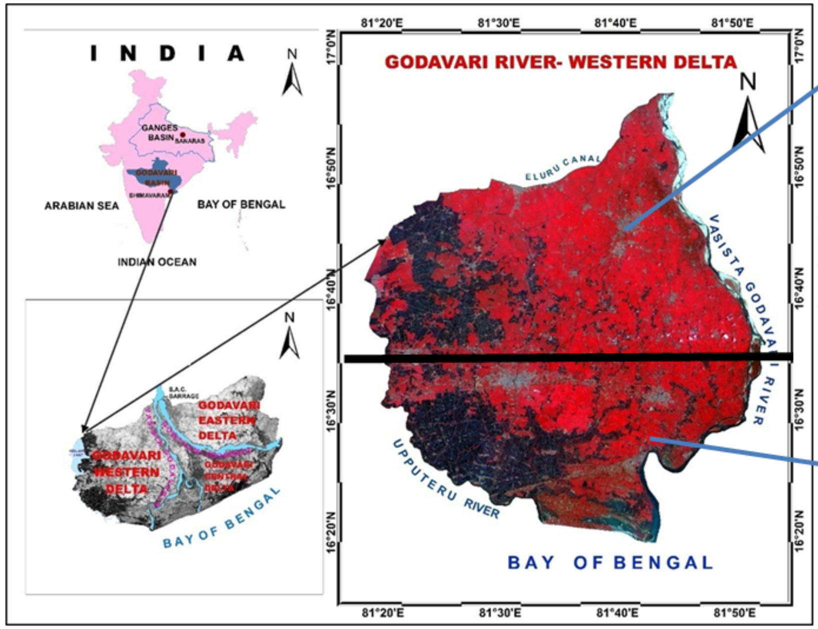
- **River Godavari** is the peninsular river and it is seasonal.
- The length of Godavari is about 1500 km.
- It is the largest peninsular river.
- It is originated from the slopes of the Western Ghats in the Nasik district of Maharashtra.

- **Anthropogenic contributions:**
- Rapid population growth
- Agricultural development
- Urbanisation
- Industrialisation
- Untreated discharges

WHY GODAVARI WESTERN DELTA SELECTED AS STUDY AREA?

Present day Western Godavari delta is carved out of the old Godavari district (during the British Rule) in the year 1925

Deltaic portion of West Godavari district of Andhra Pradesh state



Upland

Delta

The area under study covers the Delta portion of West Godavari which itself comprises about one third of the area of the entire Godavari Delta System.

*Entire study area spreads over an area of 7742 km2 with population density as high as 491 persons per km2.

Northern latitudes 16°19′06"and 16°56′10" and eastern longitudes 81°18′25" and 81°52′45"

Sl. No.	Land Use / Land Cover		Area (sq.km)	Percentage (%)
	Level 1	Level 2		
1.	Built-Up Land	Settlements	168.962	6.90
		Industry	3.329	0.14
2.	Agriculture	Crop Land	1318.550	53.83
		Plantations	101.301	4.14
		Fallow Land	2.117	0.09
3.	Forest	Mangroves	0.417	0.02
4.	Wastelands	Water-Logged	3.980	0.16
5.	Water Bodies	River	3.063	0.13
		Canal	6.215	0.25
		Drain	10.444	0.43
		Tanks	2.148	0.09
6.	Others	Aquaculture	752.600	30.72
		Poultry	1.211	0.05
		Saltpans	3.632	0.15

Drains---Canals

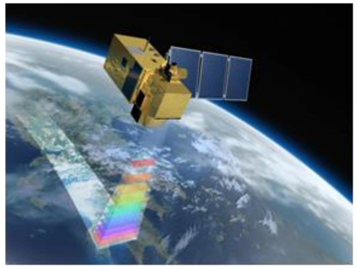
Sl.no	Drain name	Length (km)
1	Yanamadurru drain	64.88
2	Gosthanadhi drain	38.11
3	Nakkala drain	40.95
4	Bhaggeswaram drain	23.27
5	Gonteru drain	57.66
6	Old yenamadurru drain	15.49
7	Bondada drain	23.66
8	Rayalam drain	7.74
9	Rudrayakodu drain	22.35
10	Gunupudi drain	21.0
11	Kaza drain	24.31

Sl.no	Canal name	Length (km)
1	Eluru canal	32.47
2	Narsapur canal	66.05
3	Bank canal	36.48
4	Gosthani-Velpuru canal	53.89
5	Attili canal	27.86
6	Undi canal	47.82
7	Venkayya-Vayyeru canal	52.47

Pollution scenarios

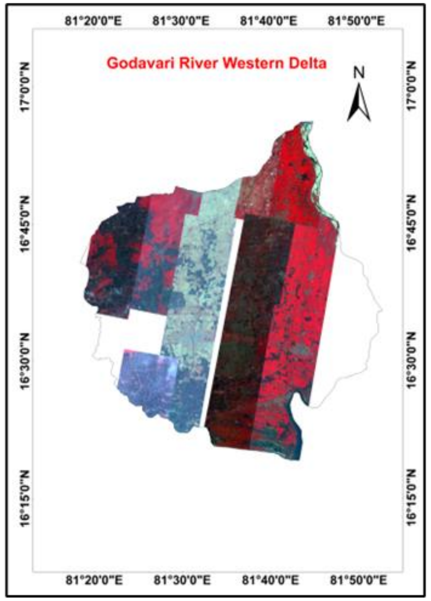
- Upper reaches of river polluted with untreated sewage and industrial effluents.
- Intensive agriculture and aquaculture
- 63 Major Urban habitats
- Major industries in the basin are Thermal, Pharma, Food processing, Distilleries, Sugar processing, Paper & pulp and shrimp processing.
- Approximately 1000 MLD sewage is discharged into the river.

OVERVIEW OF WORK FLOW

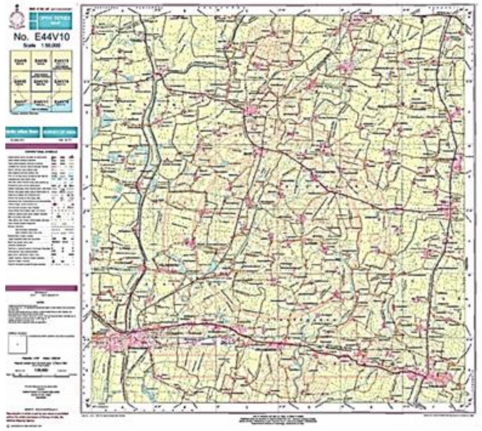


Cartosat 2E, Resourcesat LISS IV & Sentinel 2A

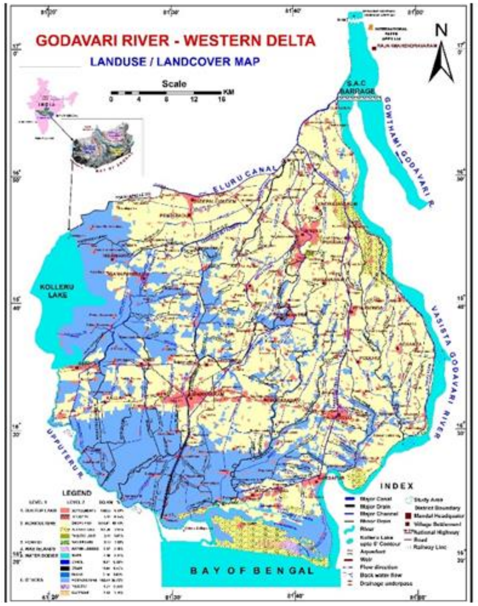
NRS Centre, Hyderabad, India



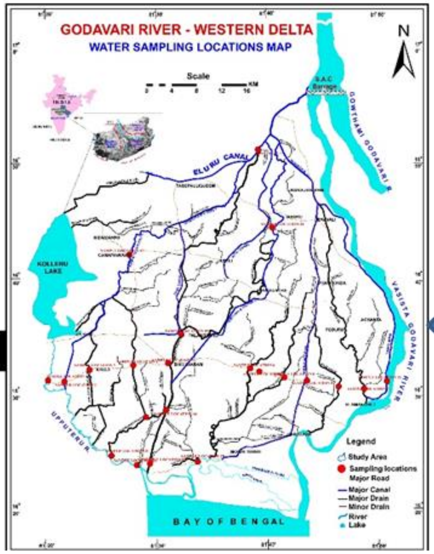
Survey of India



Canal and Drainage Map



Land use/Land Cover Map



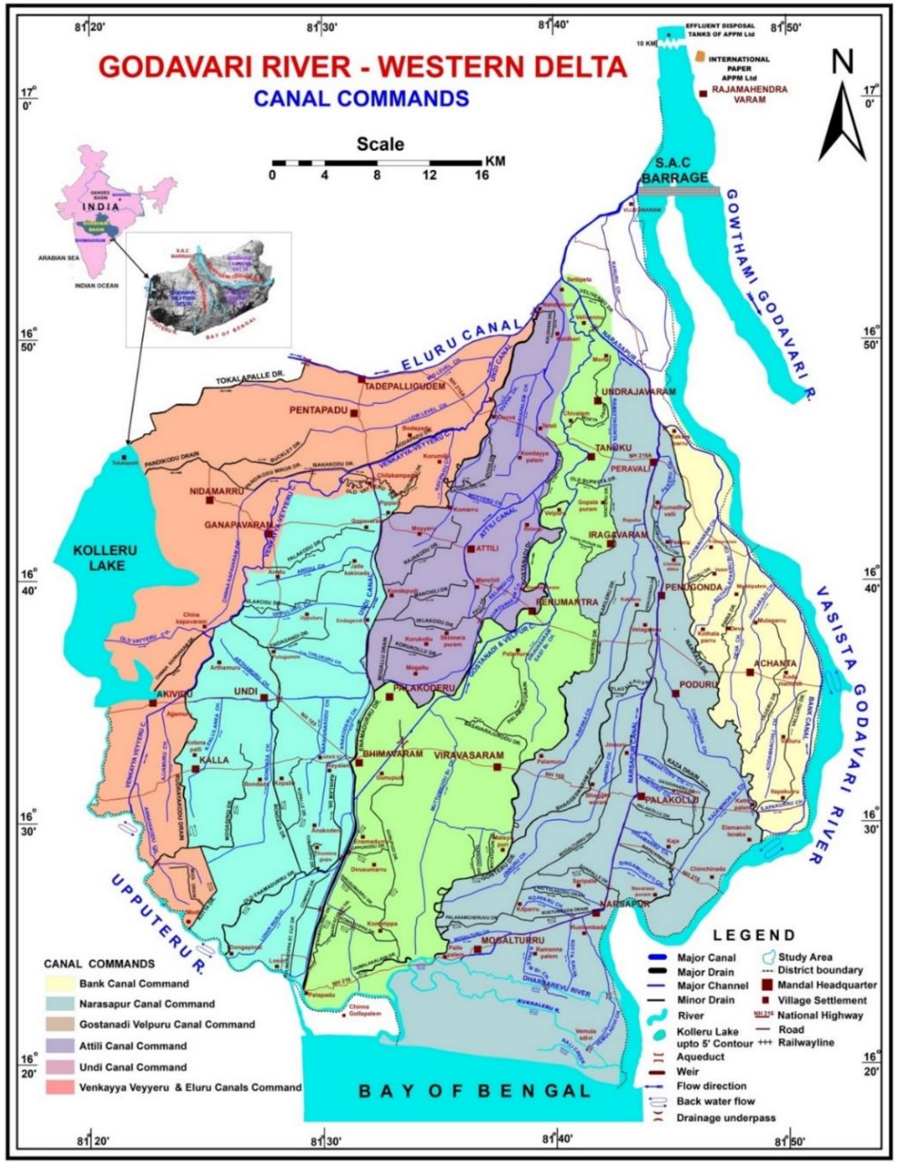
Pre-sampling Locations

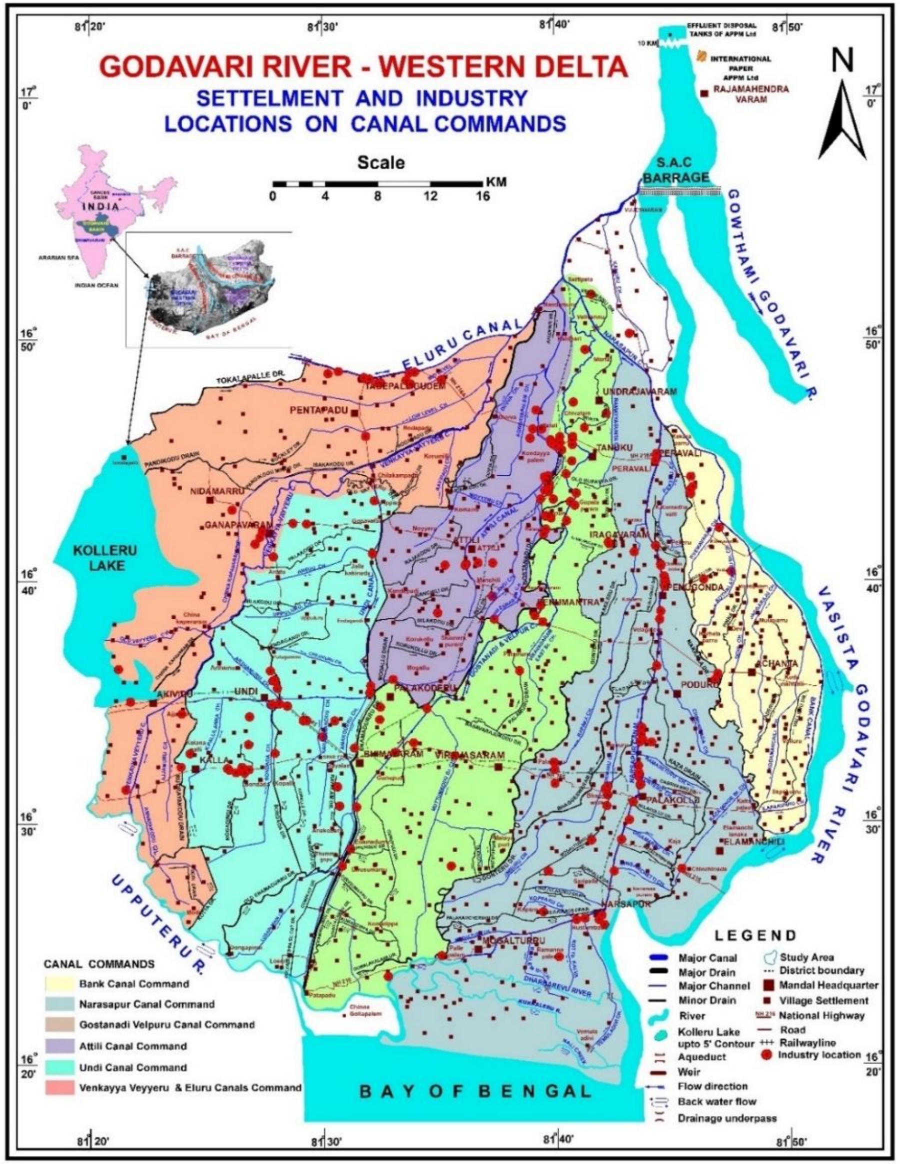
First Deliverable

Significant outputs

- Thematic maps are created.
- Point and non-point sources of pollutants are identified.
- The pre-sampling strategy proves worthwhile for sample location identification.
- Pre- and post-monsoon season sample analyses are performed.
- Pollution scenarios are integrated with thematic maps, and vulnerability maps are generated using geotechnical methods.
- Hot spots are identified on canals and drains in the study area.

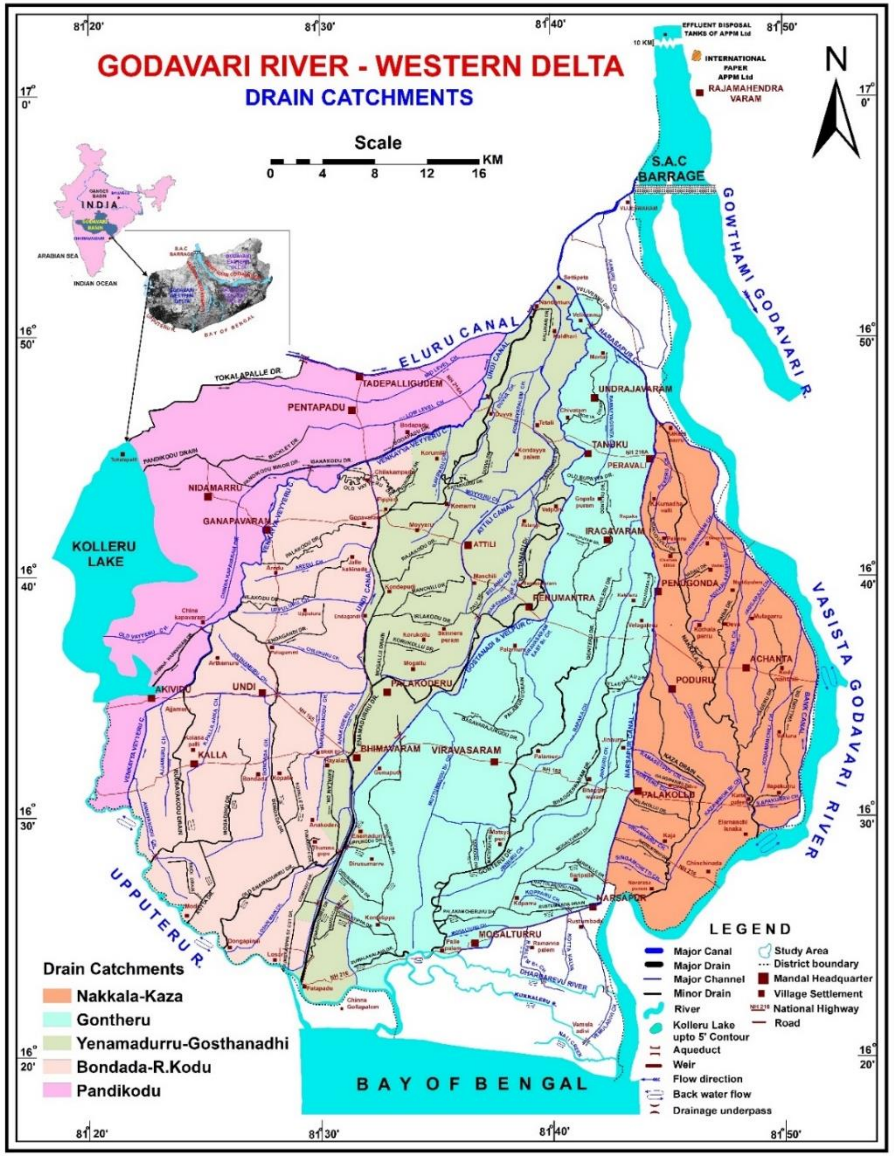
DELINEATION OF CANAL COMMANDS

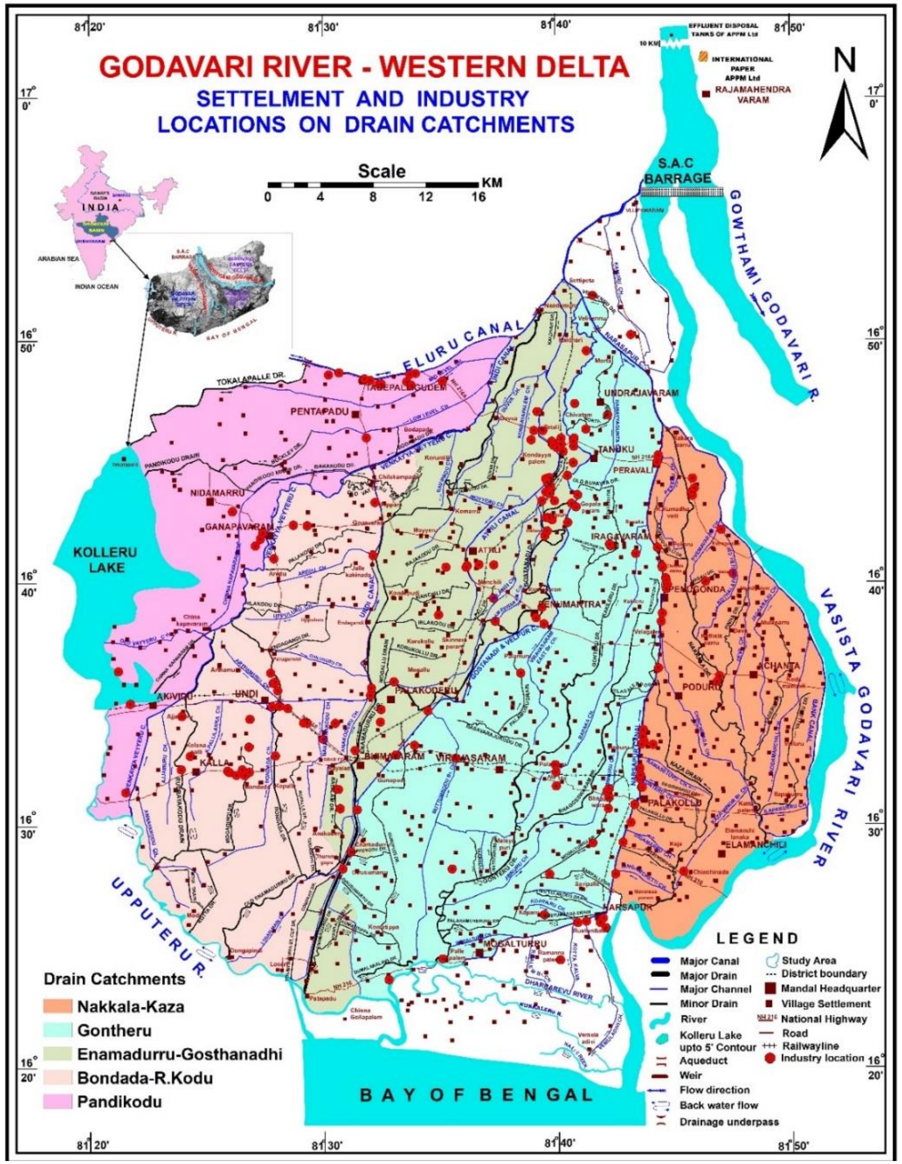




Significance
Canal commands are overlaid on settlement maps generated along with the industrial locations identified through both geotechnical methods and ground truthing. This further aids in the identification of point and non-point sources of pollution.

DELINEATION OF DRAIN CATCHMENTS





POINT AND NON-POINT SOURCES OF POLLUTION

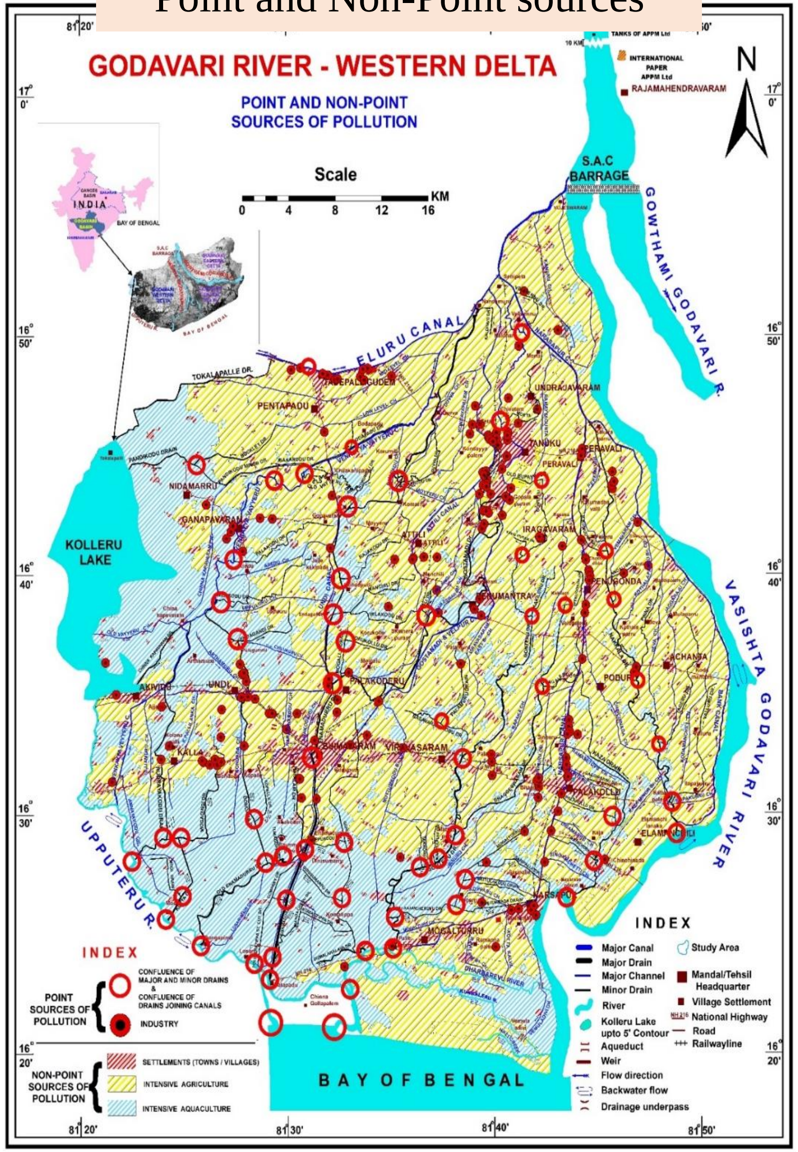
Point

- **Rice Mills, Sugar Mills, Poultry Farms, Fish Packing Sheds, Shrimp Packing Units, Pesticide Factories**
- **Confluence points of drains with canals,**
- **Confluence points of minor drains with major drains, Outlets of water from aquaculture ponds into channels**
- **Outfall points of major drains into rivers, etc.**

Non-point

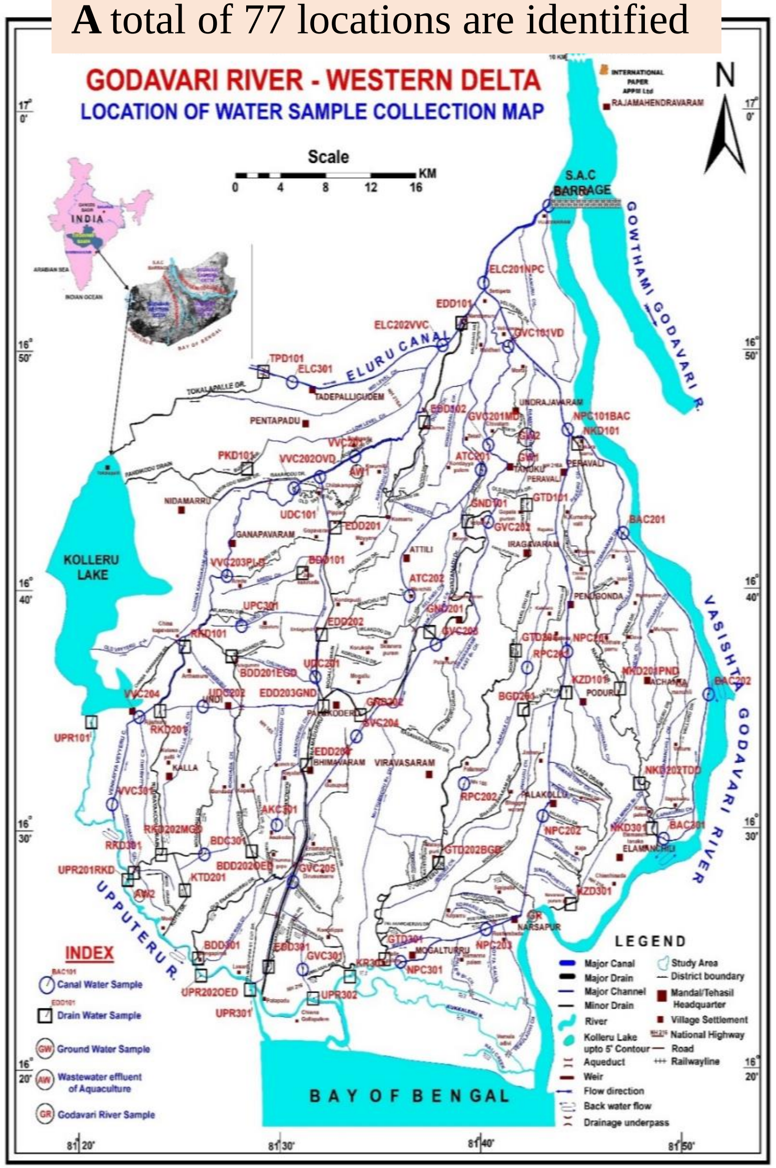
- **Agriculture abutting the flood banks of the channels**
- Aquaculture abutting the flood banks of the channels
- **Settlements along on the banks of canals**
- Solid Waste Dumps on the canal bank
- **Rainfall runoff from the flood banks, (especially over areas with open defecation by human beings)**

Point and Non-Point sources

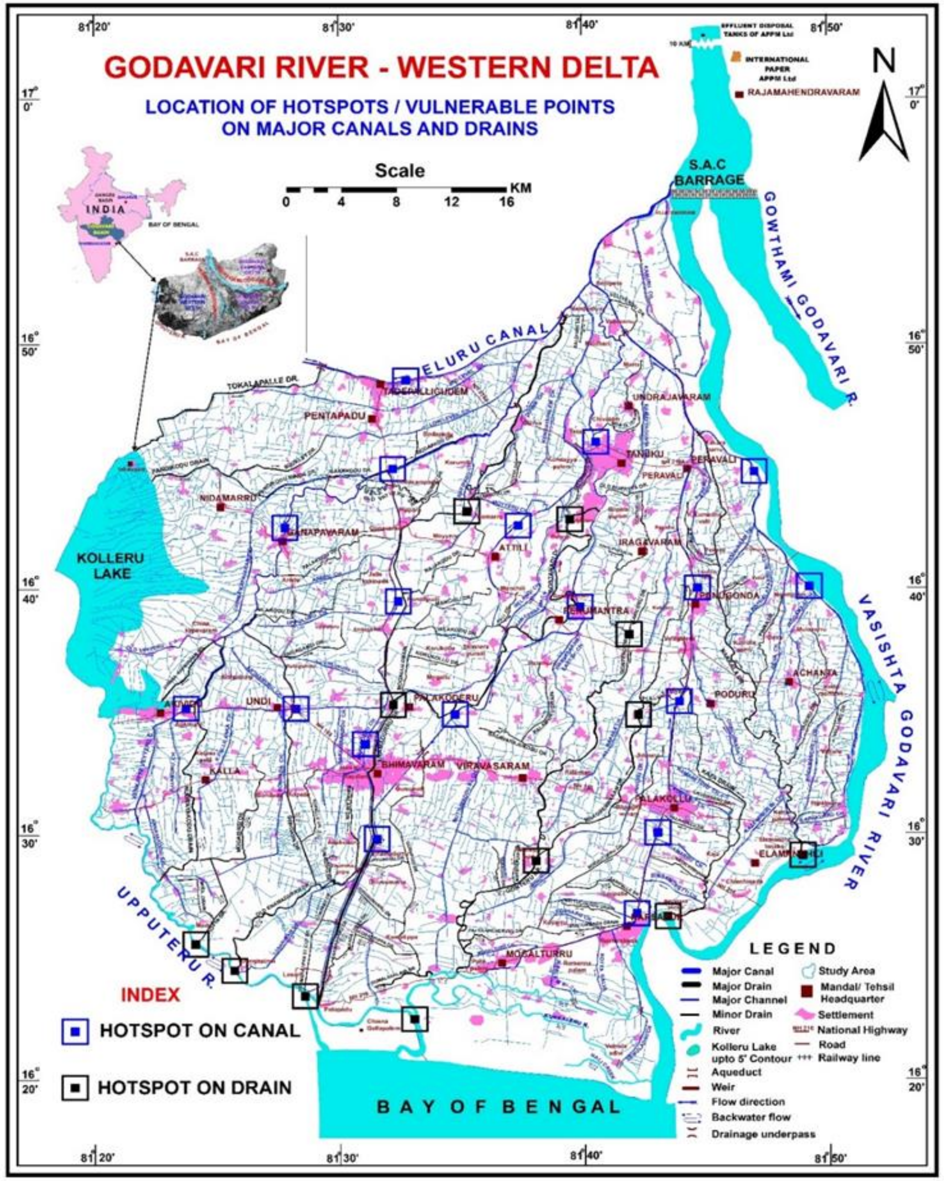


SAMPLE COLLECTION LOCATION MAP

A total of 77 locations are identified



HOT SPOTS / VULNERABLE LOCATIONS OF THE STUDY AREA



Number of HOTSPOTS identified: 30

On Canals: 18

On Drains: 12

S.No	Canal /Drain	Longitude	Latitude	Nearest Settlements
1	Anakoderu channel	81.5181	16.5613	Bhimavaram
2	Attili canal	81.6225	16.7098	Attili
3	Bank canal	81.8205	16.6680	Siddantham
4	Bank Canal	81.7833	16.7462	Khandavalli
5	Eluru canal	81.5462	16.8086	Tadepalligudem
6	Gosthanadi Velpuru canal	81.5792	16.5814	Bhimavaram
7	Gosthanadi Velpuru canal	81.6645	16.6544	Penumantra
8	Gosthanadi Velpuru canal	81.6755	16.7665	Chivatam
9	Gosthanadi Velpuru canal	81.5259	16.4969	Enamadurru
10	Narsapur canal	81.7320	16.5900	Kavitam
11	Narsapur Canal	81.7444	16.6672	Penugonda
12	Narsapur Canal	81.7169	16.5009	Palakollu
13	Narsapur Canal	81.7026	16.4460	Narsapur
14	Undi canal	81.5407	16.6584	Kondepudi
15	Undi canal	81.4709	16.5855	Undi
16	Venkayya Vayyeru canal	81.4636	16.7085	Ganapavaram
17	Venkayya Vayyeru canal	81.3961	16.5858	Akividu
18	Venkayya Vayyeru canal	81.5371	16.7484	Chilakampadu
19	Baggeswaram drain	81.7039	16.5811	Kavitam
20	Enamadurru drain	81.5372	16.5879	Palakoderu
21	Enamadurru drain	81.5876	16.7194	Komarru
22	Gosthanadi drain	81.6578	16.7139	Velpuru
23	Gonteru drain	81.6340	16.4820	Matsyapuri
24	Gonteru drain	81.6978	16.6356	Alamuru
25	Kaza drain	81.7236	16.4440	Navarasapuram
26	Nakkala drain	81.8156	16.4853	Vaddilanka
27	UPPUTERU river	81.4288	16.4076	Dongapindi
28	UPPUTERU river	81.4024	16.4255	Modi
29	UPPUTERU river St. cut	81.4767	16.3902	Losari
30	UPPUTERU Old course	81.5511	16.3744	Kalipatnam

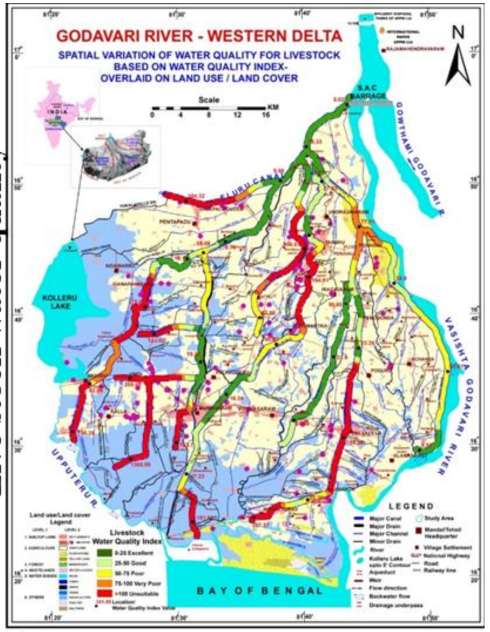
Demonstration points

- Gosthanadi velpuru canal, Bhimavaram
- Eluru canal, Tadepalligudem
- Gonteru drain, Matysapuri

FINAL MAPS

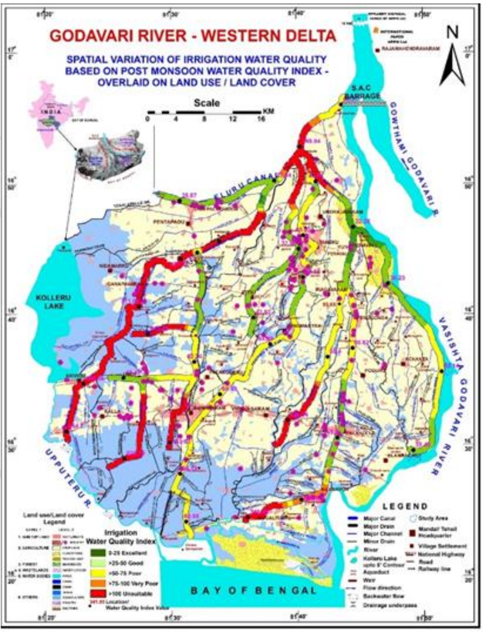
Drinking water quality

Live stock water quality



Irrigation water quality

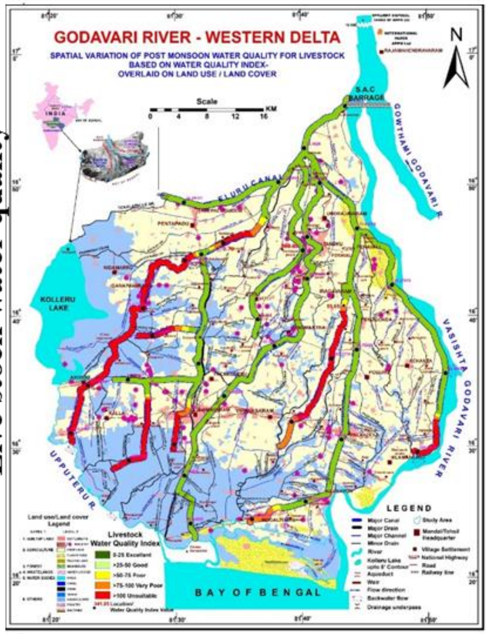
Aquaculture water quality



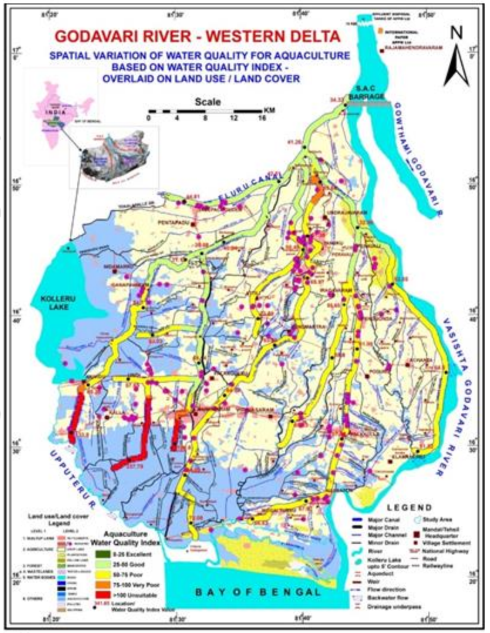
PRE-MONSOON

Drinking water quality

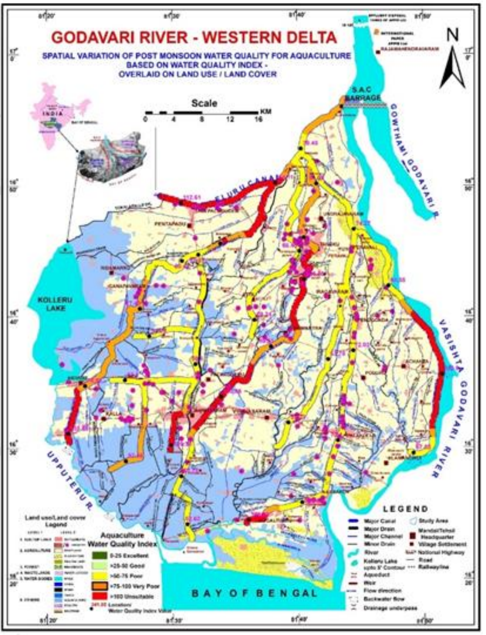
Live stock water quality



Irrigation water quality

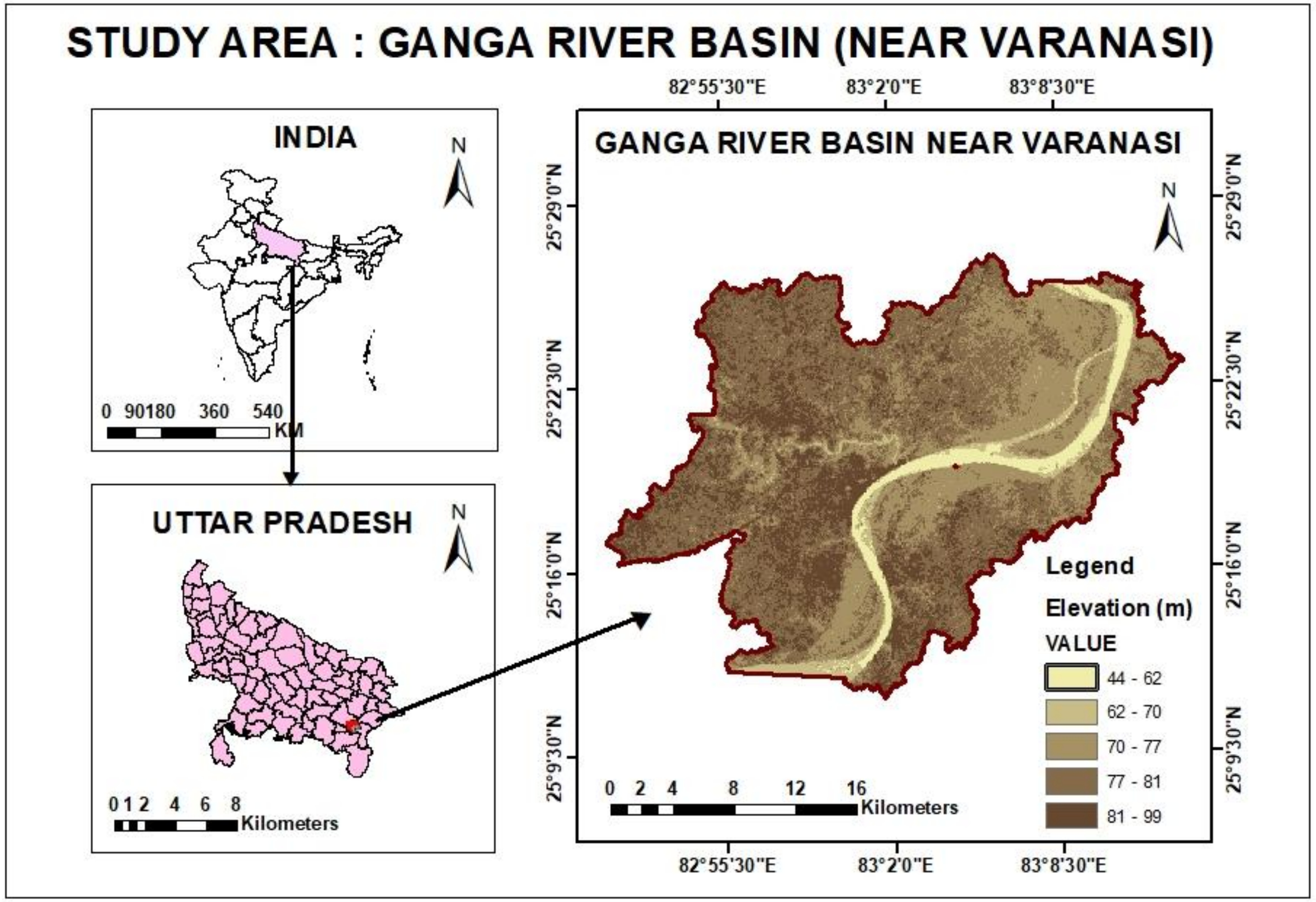


Aquaculture water quality



POST-MONSOON

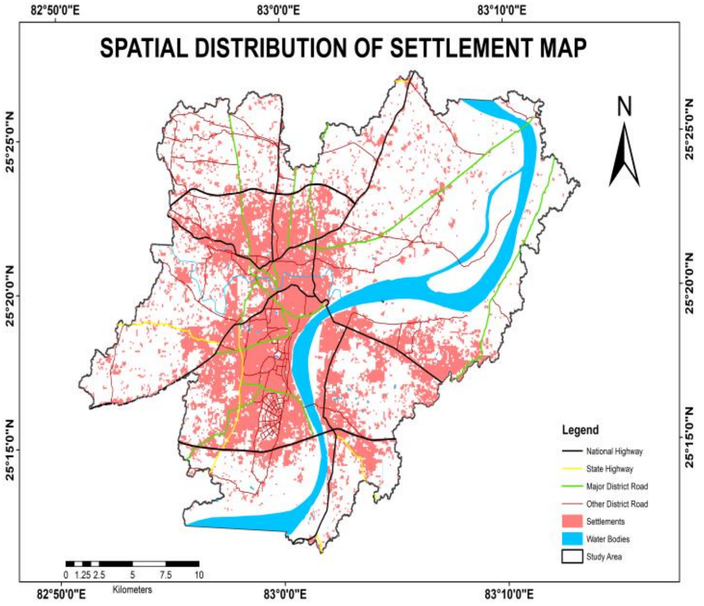
WHY GANGA RIVER BASIN NEAR VARANASI SELECTED AS STUDY AREA?



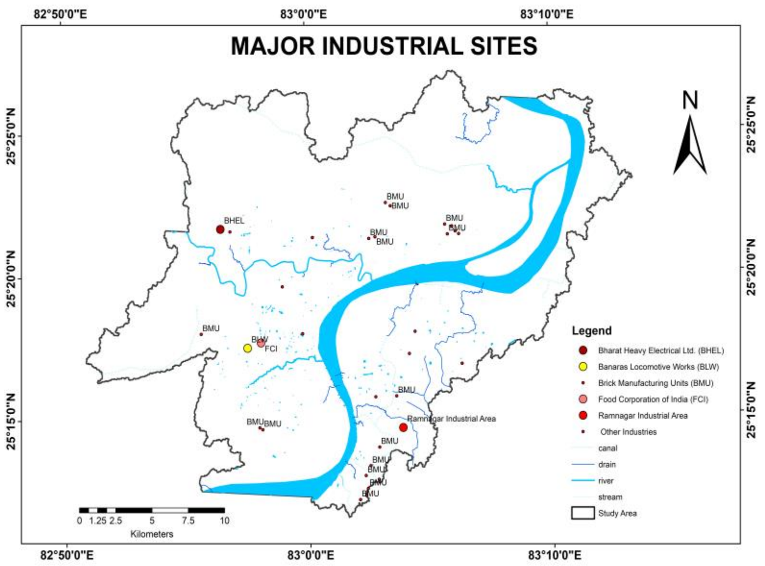
Study Area Ganga River Basin (Near Varanasi)

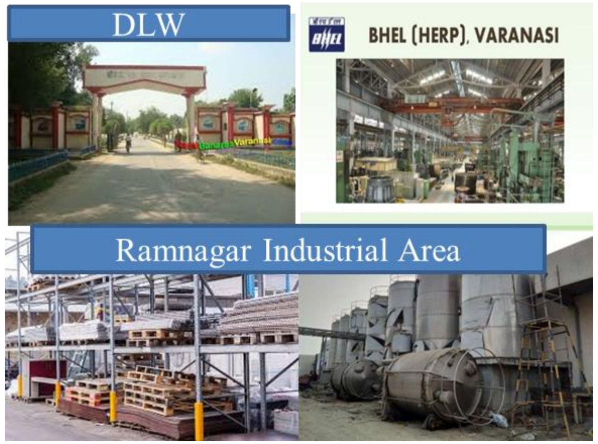
- River Ganga near Varanasi is of significant social and religious importance.
- People from all over the country visit Varanasi to take a holy dip in the Ganga.
- In Varanasi, the Ganga flows from south to north.
- The city's name, Varanasi, is derived from the rivers Varuna and Assi.
- The core part of the city is located between these two rivers.
- River Varuna meets the Ganga in the north of the city, while river Assi meets it in the south.
- Ramnagar is an industrial area situated on the eastern bank of the Ganga.
- Ramnagar drain and river Assi, located upstream of the bathing ghats and the city, play a crucial role in determining the bathing water quality in the Ganga near Varanasi.

SETTLEMENT MAP



INDUSTRIAL LOCATIONS MAP

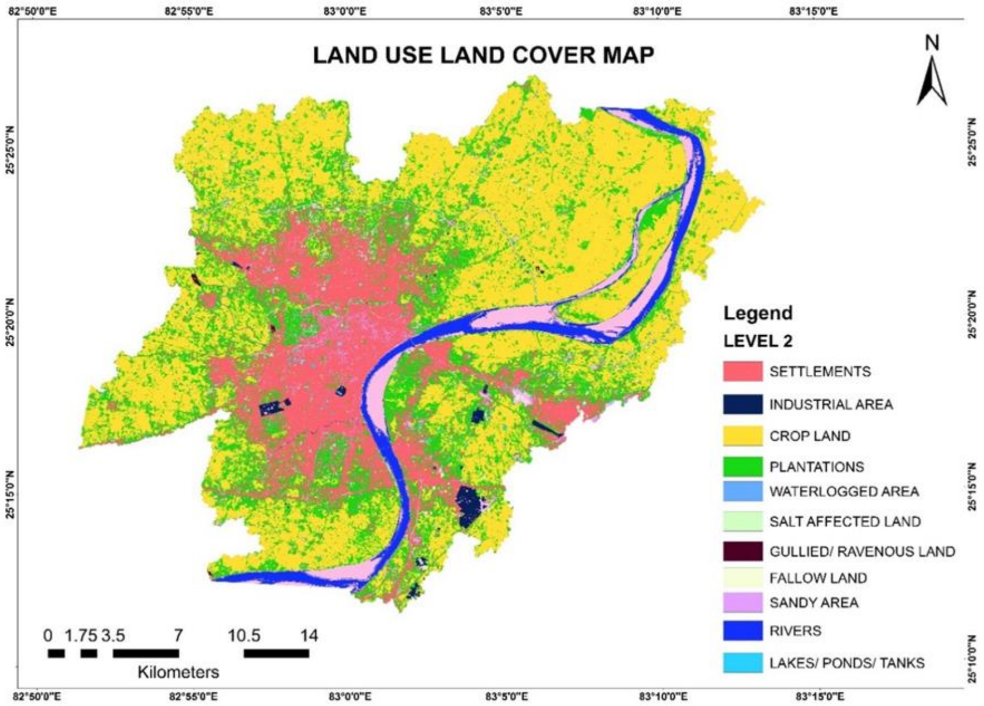




- ➢ The study area of Ganga basin near Varanasi is densely populated. There are approximately 597 settlements covering 189.06 sq.km.
- ➢ All settlements are connected with a network of National Highway/ State Highway/ Major and Minor district roads.
- ➢ Being natural drainage lines, majority of the settlements are situated in the catchment of the Varuna River and Assi River.
- ➢ Due to the heavy load of domestic sewage, river Assi is vividly called Assi Nala also.
- ➢ The majority of the settlements are situated in the catchment of the Varuna River.

- The total industrial area is approx. 5.05 sq.km. and it constitutes 0.83% of the study area.
- Agricultural produce processing units such as rice mills, sugar mills are mainly located in Varanasi city area.
- Ramnagar industrial area produces plastic materials, agricultural implements, electrical products, cement etc.
- Diesel Locomotive Works (DLW) situated in the catchment of river Assi is a production unit of Indian Railways.
- Brickwork manufacturing, industries of Food Corporation of India, BHEL etc. are in the study area.

LAND USE/LAND COVER MAP

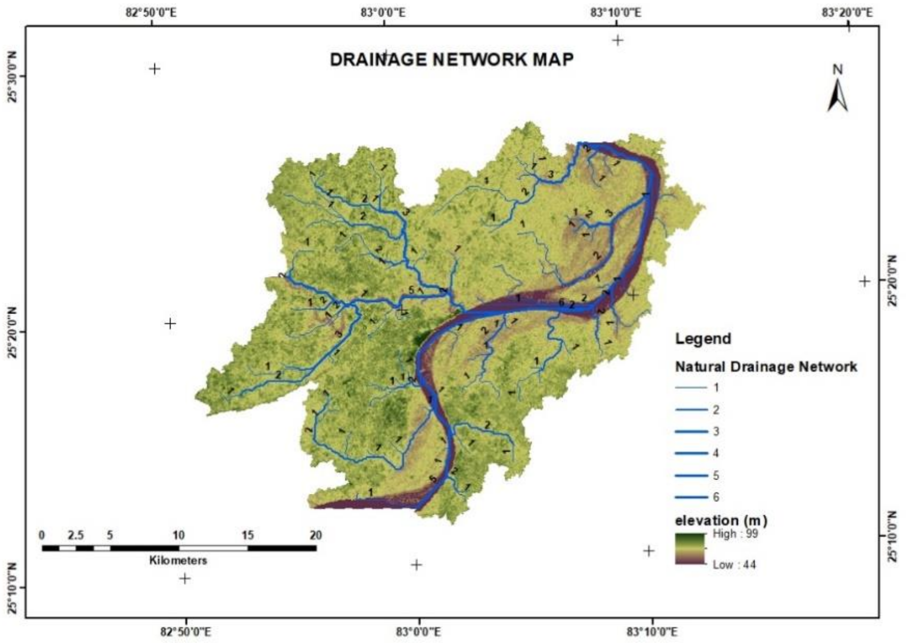


LAND USE LAND COVER DISTRIBUTION OF STUDY AREA

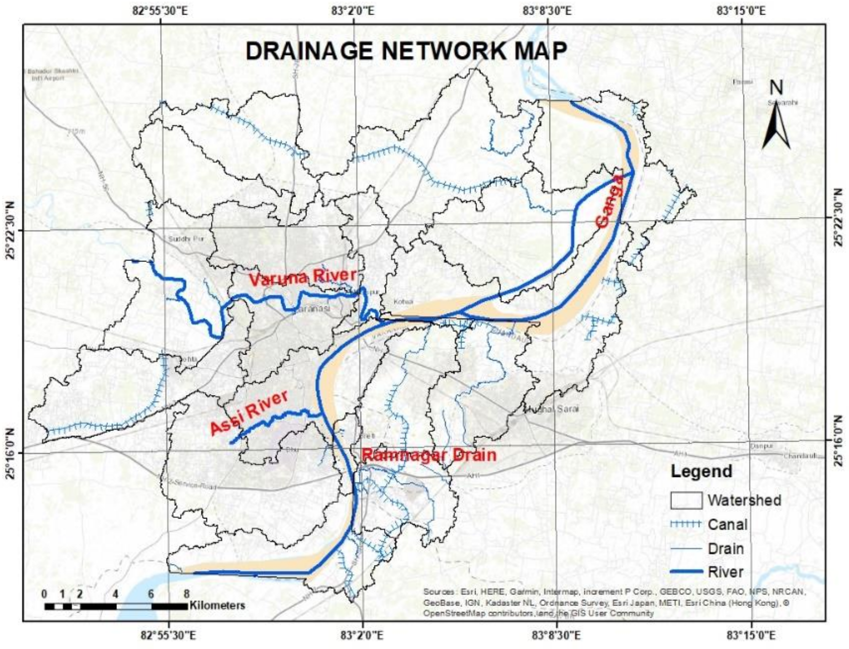
S. No	Level 1	Level 2	Area (km^2)	% Area
1	**Builtup Land**	Settlements	114.978	19.162%
		Industrial Area	4.948	0.825%
2	**Agricultural Land**	Crop Land	278.397	46.396%
		Plantations	143.900	23.982%
3	**Wasteland**	Waterlogged Area	0.003	0.001%
		Salt Affected Land	0.861	0.144%
		Gullied/ Ravenous Land	0.282	0.047%
		Fallow Land	10.943	1.824%
		Sandy Area	24.890	4.148%
4	**Water Bodies**	Rivers	19.350	3.225%
		Lakes/ Ponds/ Tanks	1.487	0.248%

- The land use/land cover categories in the area include Waterbodies, Sandy Area, Barren Land, Crop Land, Plantation and Settlements.
- The cropland and plantation area are the most predominant land use classes covering nearly 70% of the study area.
- The urban / village settlements occupy substantial extents that amount to 20% of the total area, mostly confined to the left bank of the Ganga River.
- Historically, the ‘holy’ city has grown along the Western Banks of the river and all the bathing ghats are found on the same side.
- The ‘trans-Ganga region of Varanasi which is on the Eastern bank of the river is witnessing the industrial expansion of the city. The LULC map is shown in Figure. The area distribution is detailed in Table.

DRAINAGE NETWORK MAP



Natural Drainage Network Map



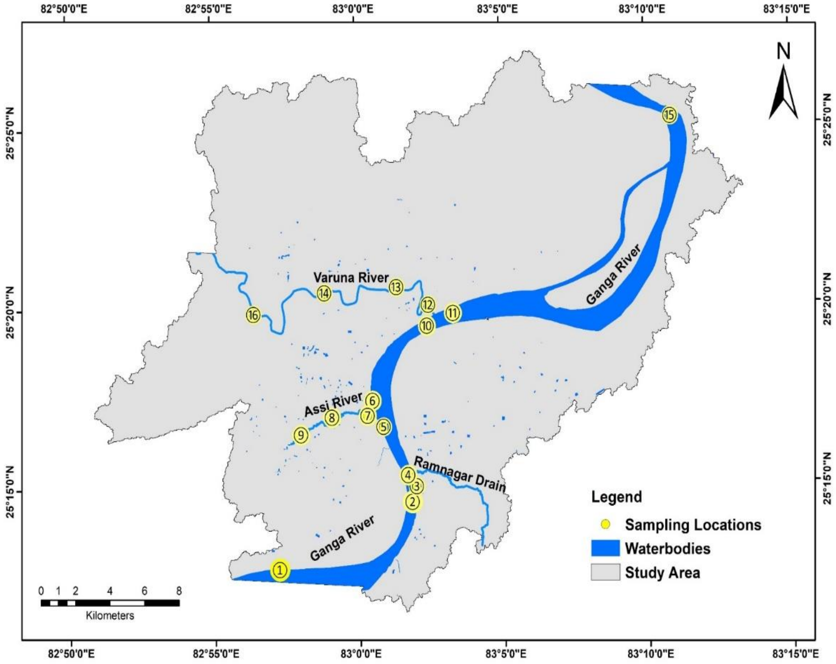
Drainage Network Map

- Near Varanasi, river Ganga provides major drainage line. Upstream of the city, Ramnagar drain joins from right hand side of the river. Around 3 km downstream of Ramnagar drain, Samne Ghat drain joins river Ganga from the left hand side.
- Further around 1.5km downstream, river Assi joins Ganga from the city side which is located on left bank of the river.
- River Varuna joins river Ganga around 7 km further downstream.
- Beyond Varanasi city limits, river Gomati is an important tributary of Ganga which meets around 35 km downstream from the confluence point of Varuna.
- Based on Digital Elevation Model (DEM) with 30 m resolution of SRTM data the natural drainage network of the study area has been prepared (Figure 5).
- There are streams of 1st to 6th order. River Ganga is observed as 6th order stream and river Varuna is found to be a 5th order stream.
- Ramnagar drain and river Assi are broadly 2nd order streams. In addition there are several drains of 1st order which join to form higher order streams.

Sampling locations and identification of pollution hotspots in the river Ganga near Varanasi

Sampling Locations in the Study Area

S. No.	Designation	Latitude	Longitude	Sampling Location
1	S1	25.20806	82.95603	Sampling point in Ganga River around 9km U/S of Ramnagar drain.
2	S2	25.24542	83.02977	Sampling point in Ganga River around 200 m U/S of confluence point with Ramnagar drain.
3	S3	25.24987	83.03281	Sampling point in Ramnagar drain around 200m U/S of the confluence point with Ganga River.
4	S4	25.25203	83.02857	Sampling point in Ganga River around 200m D/S of confluence point with Ramnagar drain.
5	S5	25.2822	83.01325	Sampling point in Ganga River around 200 m U/S of confluence point with Assi river.
6	S6	25.28642	83.01167	Sampling point in Ganga River around 200m D/S of confluence point with Assi river.
7	S7	25.2832	83.00634	Sampling point in Assi river around 200m U/S of the confluence point with Ganga River.
8	S8	25.28281	82.98503	Sampling point in Assi river around 3km U/S of the confluence point with Ganga River.
9	S9	25.27461	82.96649	Sampling point in Assi river around 5km U/S of the confluence point with Ganga River.
10	S10	25.32563	83.04455	Sampling point in Ganga River around 200m U/S of confluence point with Varuna river.
11	S11	25.32806	83.050321	Sampling point in Ganga River around 200m D/S of confluence point with Varuna river.
12	S12	25.33140	83.04336	Sampling point in Varuna river around 200m D/S of confluence point with Ganga River.
13	S13	25.34203	83.02268	Sampling point in Varuna river around 3km U/S of confluence point with Ganga River.
14	S14	25.34021	82.98016	Sampling point in Varuna river around 7km U/S of confluence point with Ganga River.
15	S15	25.42302	83.17514	Sampling point around 16km D/S of Varuna river.
16	S16	25.33055	82.94002	Sampling point in Varuna river around 16km U/S of confluence point with the Ganga River.



Sampling Locations in the Study Area

Total 16 water quality sampling sites

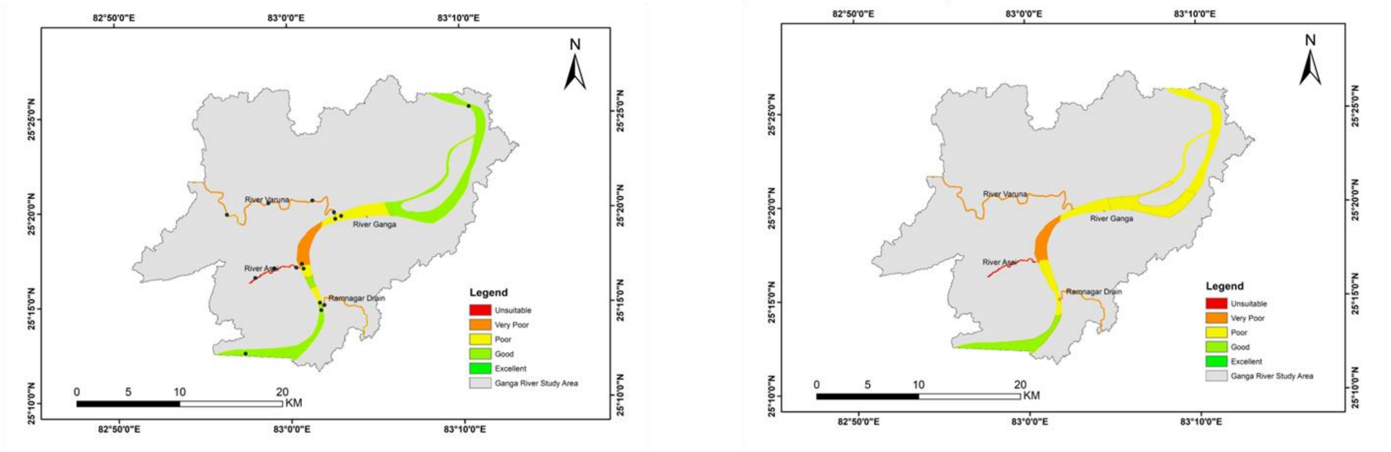
- 6 on Varuna
- 5 on Assi river
- 3 on Ramnagar drain
- 1 u/s and 1 d/s of Varanasi city

Identified hotspots in the river Ganga are

1. Confluence point of Ramnagar drain (S4, R)
2. Confluence point of River Assi (S6, L)
3. Confluence point of river Varuna (S11, L)

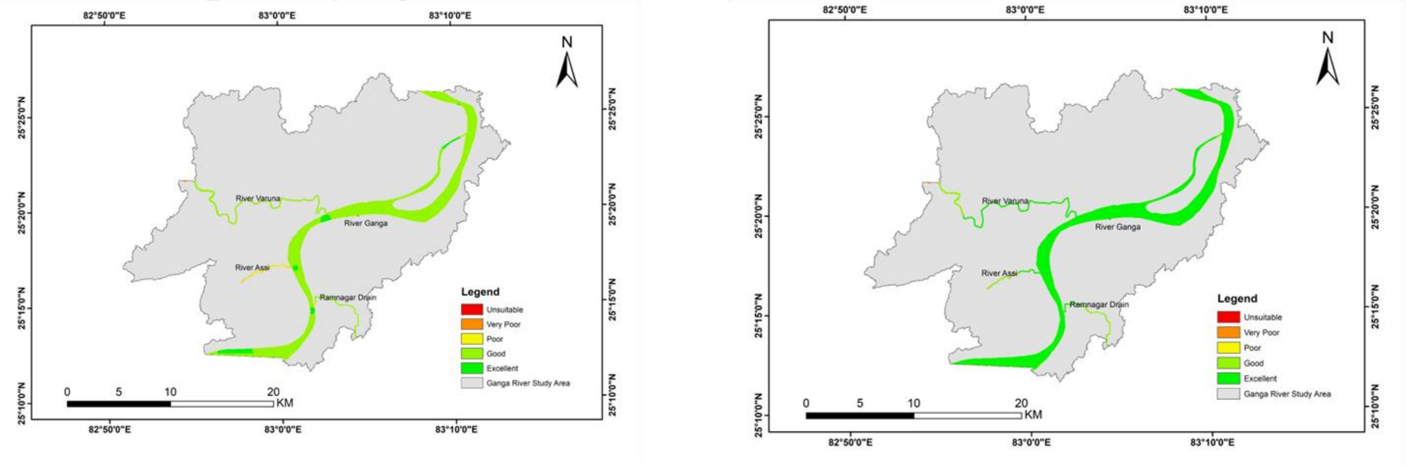
SPATIAL VARIATION OF WATER QUALITY INDEXES (WQI) IN THE GANGA RIVER NEAR VARANASI

Water Quality Index (Pre-Monsoon)



Bathing Water Quality Index

Drinking Source Water Quality Index



Livestock Water Quality Index

Irrigation Water Quality Index

Spatial variation of water quality indexes in the Ganga river near Varanasi in pre-monsoon seasons

During the pre-monsoon period in the Ganga River near Varanasi:

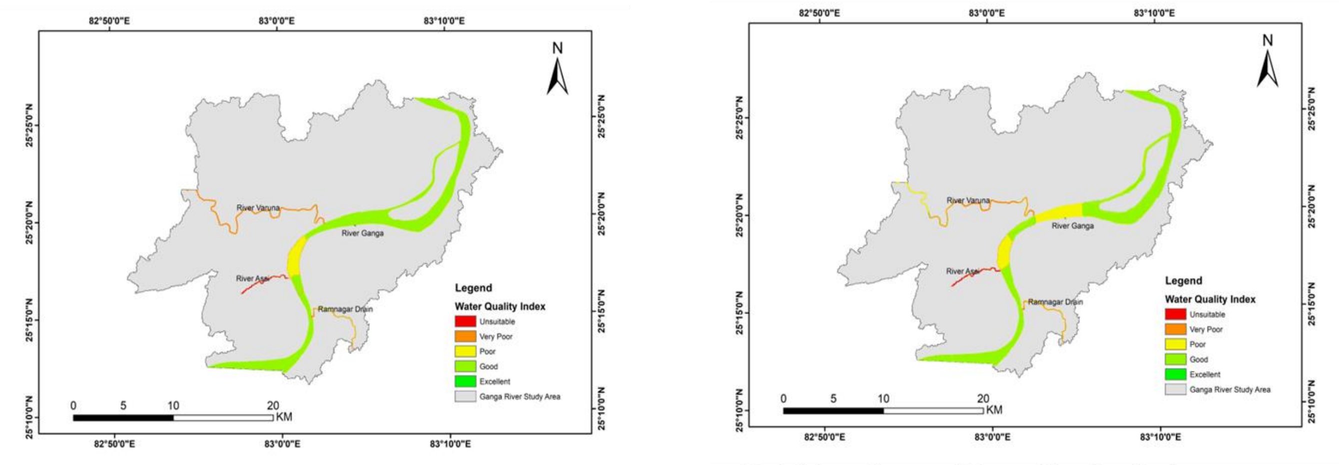
- **Bathing water quality**
  - Good category from Shooltankeshwer to U/S of Ramnagar drain.
  - Poor condition is observed from Ramnagar D/S to Assi U/S.
  - Very poor condition is observed downstream of river Assi to Panchganga ghat.

- **Drinking water source quality**
  - Good from Shooltankeshwer to U/S of Ramnagar drain
  - Poor condition appears Ramnagar U/S to Assi D/S
  - Very poor from downstream of River Assi to Panchganga ghat.

- For livestock use and irrigation purposes, the river water quality is generally good to excellent along the entire stretch of the river Ganga near Varanasi.

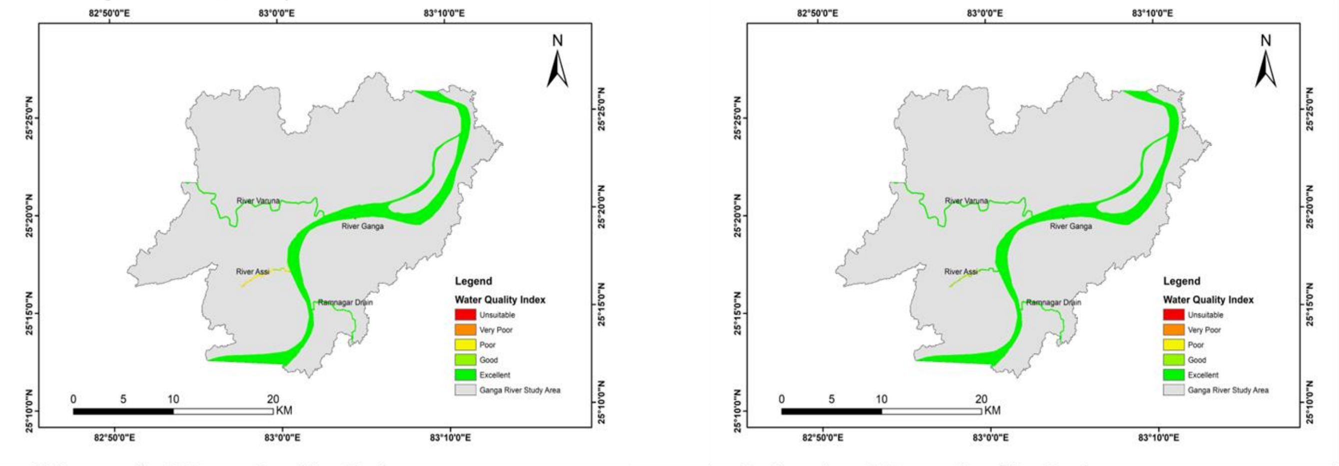
SPATIAL VARIATION OF WATER QUALITY INDEXES IN THE GANGA RIVER NEAR VARANASI

Water Quality Index (Post-Monsoon)



Bathing Water Quality Index

Drinking Source Water Quality Index



Livestock Water Quality Index

Irrigation Water Quality Index

Spatial variation of water quality indexes in the Ganga river near Varanasi in post-monsoon seasons

During the post-monsoon period in the Ganga River near Varanasi:

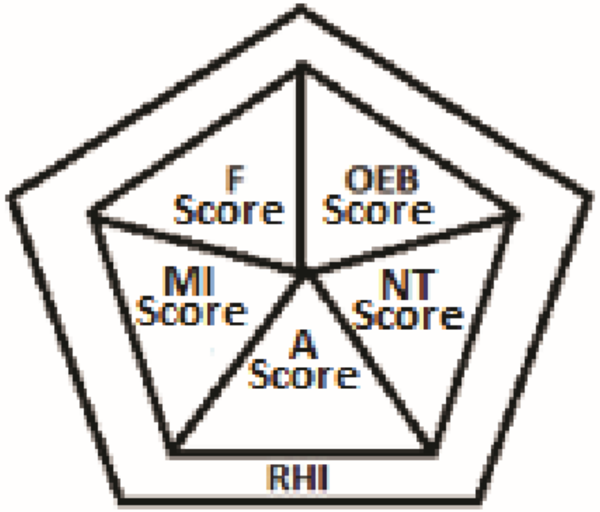
- **For bathing purposes**
  - ➢ Good category from Shooltankeshwer to Assi U/S.
  - ➢ Poor category could be observed from D/S of Assi to Panchganga ghat.
- **Drinking water source quality**
  - ➢ Good category from Shooltankeshwer to U/S of River Assi.
  - ➢ D/S of River Assi to Panchganga ghat comes under poor category.
  - ➢ Current raw water intake structure at Bhaidaini ghat D/S of river Assi is under very poor category in pre monsoon season and poor category in post monsoon season.
- For livestock use and irrigation purposes, the river water quality is generally good to excellent along the entire stretch.

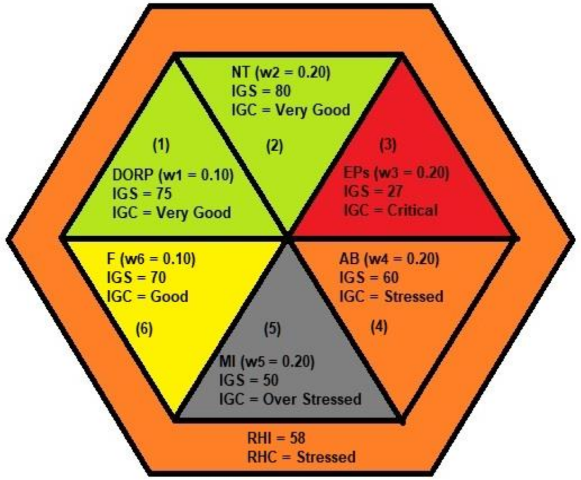
UNDERSTANDING RIVER HEALTH CONDITION (RHC) THROUGH RIVER HEALTH INDEX (RHI): UNIQUE TOOL

- **River Health Index (RHI) = [(OEB x W1) + (NT x W2) + (A x W3) + (MI x W4) + (F x W5)]**

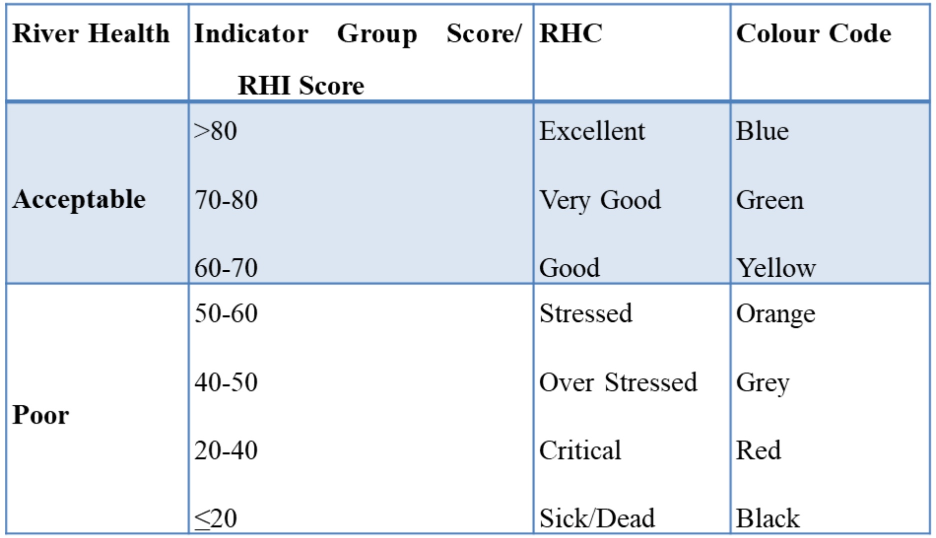
W1, W2, W3, W4 and W5 are weightages given to different groups.

- Scores of aquatic environment parameters divided into five indicator groups:
  1. Organo-Electrolytic-Bacterial (OEB) group: (Comprising of EC, DO, BOD, COD and FC)
  2. Nutrients (NT) group: (Comprising NH3-N, TN and TP)
  3. Algae
  4. Macroinvertebrate and
  5. Fishes





RHC based on Indicator Group Score and RHI



River Health	**Indicator Group Score/ RHI Score**	**RHC**	**Colour Code**
Acceptable	>80	Excellent	Blue
	70-80	Very Good	Green
	60-70	Good	Yellow
Poor	50-60	Stressed	Orange
	40-50	Over Stressed	Grey
	20-40	Critical	Red
	≤20	Sick/Dead	Black

Stressed' River Health Condition (RHC) of the river Ganga at upstream of Varanasi city (India)

CONCLUSION

1. Thematic maps were created.
2. Point and non-point sources of pollutants were identified.
3. Pre- and post-monsoon season sample analyses were performed.
4. Pollution scenarios were integrated with thematic maps, and vulnerability maps were generated using geotechnical methods.
5. Hot spots were identified on canals and drains in the study areas (30 and 03 for river Godavari and ganga, respectively).
6. River Health Condition was determined.

Deliverable Reference No.	Deliverable Title
D2.4	Site Mapping
D3.1	Spatial Database
D3.2	Vulnerability Maps
D3.3	Database of Pollutants and Sludge Library

Identification of polluted sites and physicochemical analysis of water quality; development of initial water health maps of the sites using geospatial techniques: **TRL 4; Expected to reach TRL 6 (at the end of project tenure)**

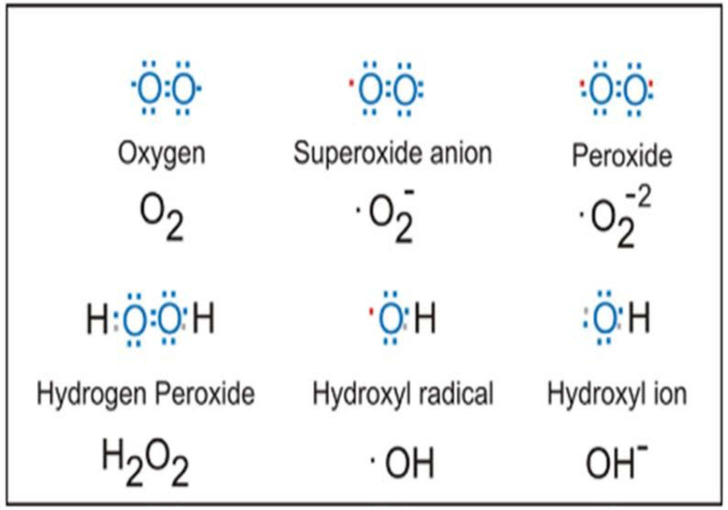
SO3: Development of robust enzyme(s) systems for pollutant removal and wastewater treatment.

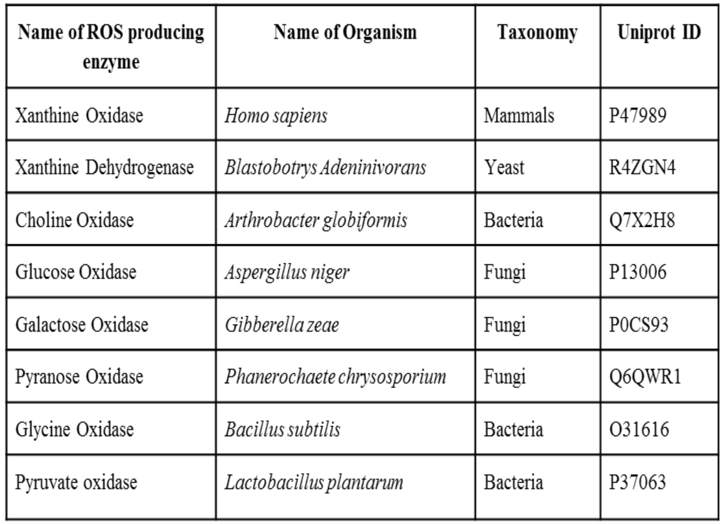
SO4: Scaling up of the enzyme systems for implementation and commercial exploitation.

ADVANCED BIO-OXIDATION: A GREEN PROCESS

THE ENZYME WORK HORSE

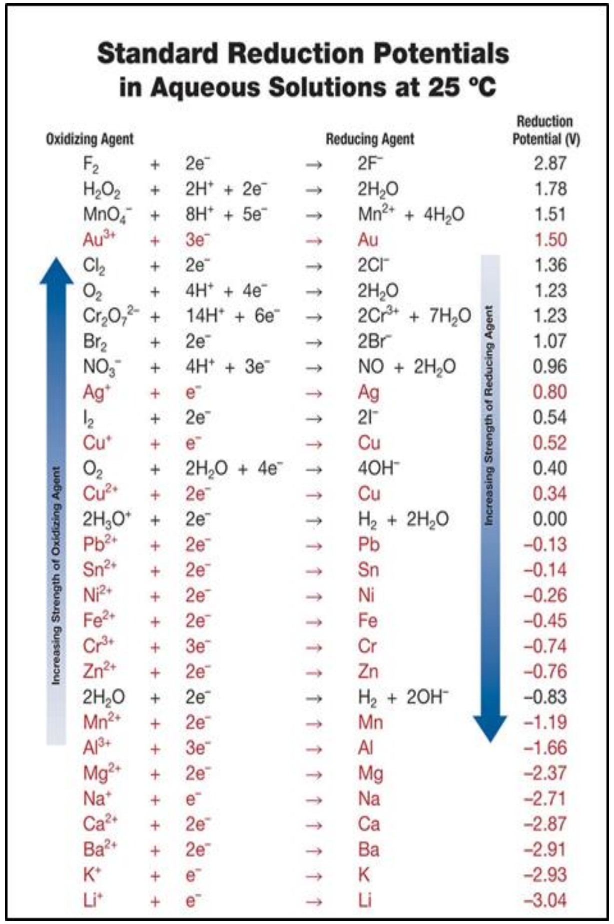
Reactive Oxygen Species





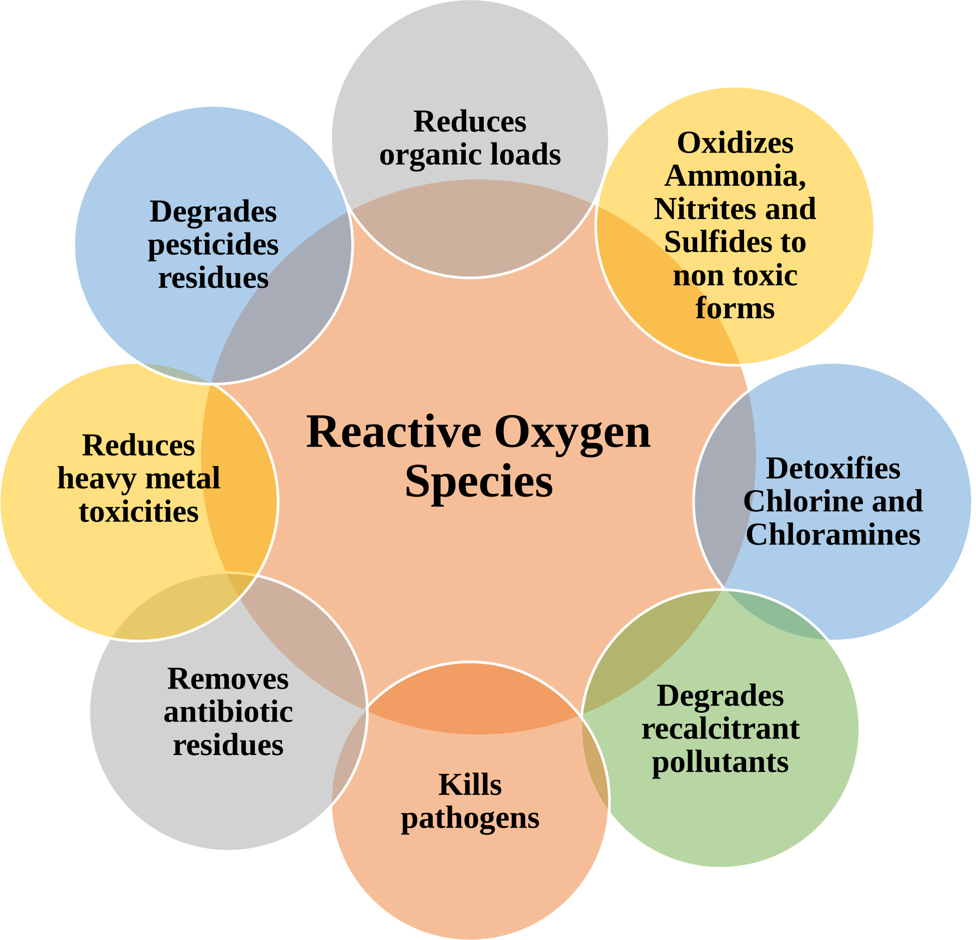
Name of ROS producing enzyme	Name of Organism	Taxonomy	Uniprot ID
Xanthine Oxidase	*Homo sapiens*	Mammals	P47989
Xanthine Dehydrogenase	*Blastobotrys Adeninivorans*	Yeast	R4ZGN4
Choline Oxidase	*Arthrobacter globiformis*	Bacteria	Q7X2H8
Glucose Oxidase	*Aspergillus niger*	Fungi	P13006
Galactose Oxidase	*Gibberella zeae*	Fungi	P0CS93
Pyranose Oxidase	*Phanerochaete chrysosporium*	Fungi	Q6QWR1
Glycine Oxidase	*Bacillus subtilis*	Bacteria	O31616
Pyruvate oxidase	*Lactobacillus plantarum*	Bacteria	P37063

Enzymes producing ROS and their sources



Standard Reduction Potentials in Aqueous Solutions at 25 °C

Oxidizing Agent				Reducing Agent	Reduction Potential (V)
F_2	+	$2e^-$	→	$2F^-$	2.87
H_2O_2	+	$2H^+ + 2e^-$	→	$2H_2O$	1.78
MnO_4^-	+	$8H^+ + 5e^-$	→	$Mn^{2+} + 4H_2O$	1.51
Au^{3+}	+	$3e^-$	→	Au	1.50
Cl_2	+	$2e^-$	→	$2Cl^-$	1.36
O_2	+	$4H^+ + 4e^-$	→	$2H_2O$	1.23
$Cr_2O_7^{2-}$	+	$14H^+ + 6e^-$	→	$2Cr^{3+} + 7H_2O$	1.23
Br_2	+	$2e^-$	→	$2Br^-$	1.07
NO_3^-	+	$4H^+ + 3e^-$	→	$NO + 2H_2O$	0.96
Ag^+	+	e^-	→	Ag	0.80
I_2	+	$2e^-$	→	$2I^-$	0.54
Cu^+	+	e^-	→	Cu	0.52
O_2	+	$2H_2O + 4e^-$	→	$4OH^-$	0.40
Cu^{2+}	+	$2e^-$	→	Cu	0.34
$2H_3O^+$	+	$2e^-$	→	$H_2 + 2H_2O$	0.00
Pb^{2+}	+	$2e^-$	→	Pb	−0.13
Sn^{2+}	+	$2e^-$	→	Sn	−0.14
Ni^{2+}	+	$2e^-$	→	Ni	−0.26
Fe^{2+}	+	$2e^-$	→	Fe	−0.45
Cr^{3+}	+	$3e^-$	→	Cr	−0.74
Zn^{2+}	+	$2e^-$	→	Zn	−0.76
$2H_2O$	+	$2e^-$	→	$H_2 + 2OH^-$	−0.83
Mn^{2+}	+	$2e^-$	→	Mn	−1.19
Al^{3+}	+	$3e^-$	→	Al	−1.66
Mg^{2+}	+	$2e^-$	→	Mg	−2.37
Na^+	+	e^-	→	Na	−2.71
Ca^{2+}	+	$2e^-$	→	Ca	−2.87
Ba^{2+}	+	$2e^-$	→	Ba	−2.91
K^+	+	e^-	→	K	−2.93
Li^+	+	e^-	→	Li	−3.04



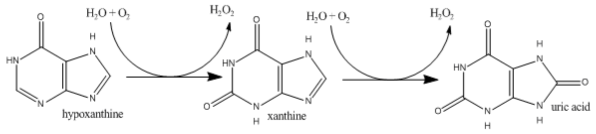
Reactive Oxygen Species

- Reduces organic loads
- Oxidizes Ammonia, Nitrites and Sulfides to non toxic forms
- Detoxifies Chlorine and Chloramines
- Degrades recalcitrant pollutants
- Kills pathogens
- Removes antibiotic residues
- Reduces heavy metal toxicities
- Degrades pesticides residues

ROS as tool to address pollutant heterogeneity

ENZYME ASSISTED WASTEWATER REMEDIATION SYSTEM FOR ORGANIC POLLUTANTS

Heterologous expression of Human Xanthine Oxidase in *Pichia pastoris* using pPICZα A expression vector



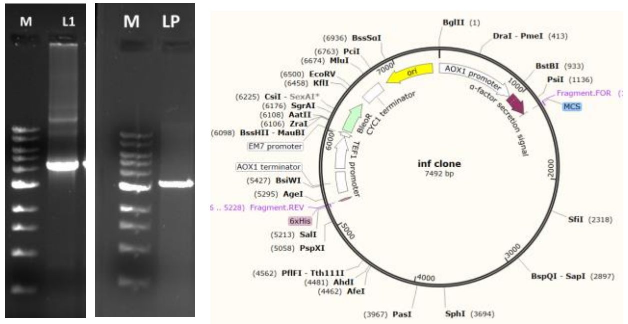


Fig #. A. 0.8% AGE showing Hu-XDH (4,000 bp); B. Digested pPICZα B vector by EcoRI and SalI; C. Final construct

Transformation of Pichia pastoris

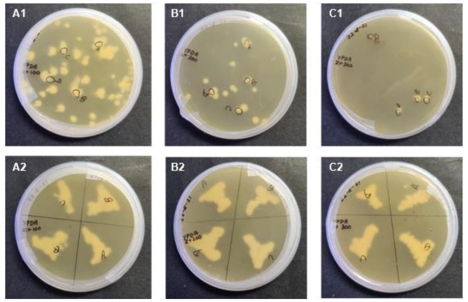
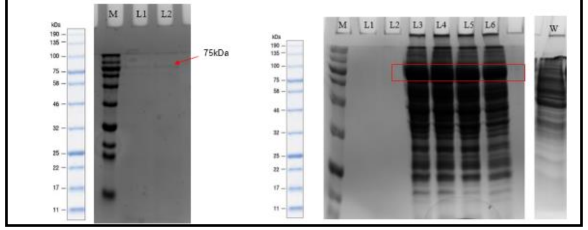
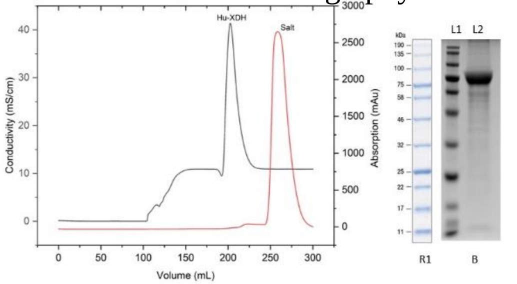


Fig #. *Pichia pastoris* transformants in YPDA plates | A1&A2=100µg/ml Zeocine | B1&B2=200µg/ml Zeocine | C1&C2=300µg/ml Zeocine

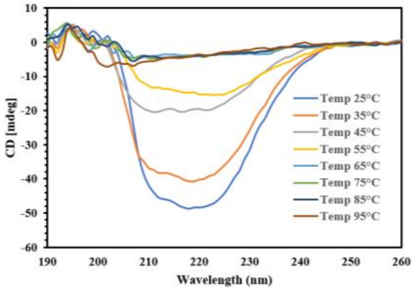
Protein expression: Checking extracellular fraction & intracellular fraction of wild/cloned strain.



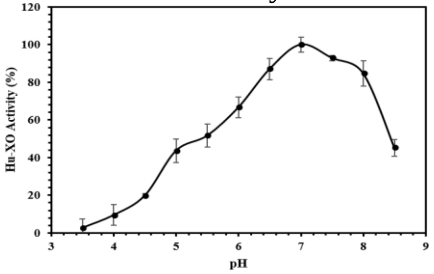
Protein purification using gel filtration chromatography



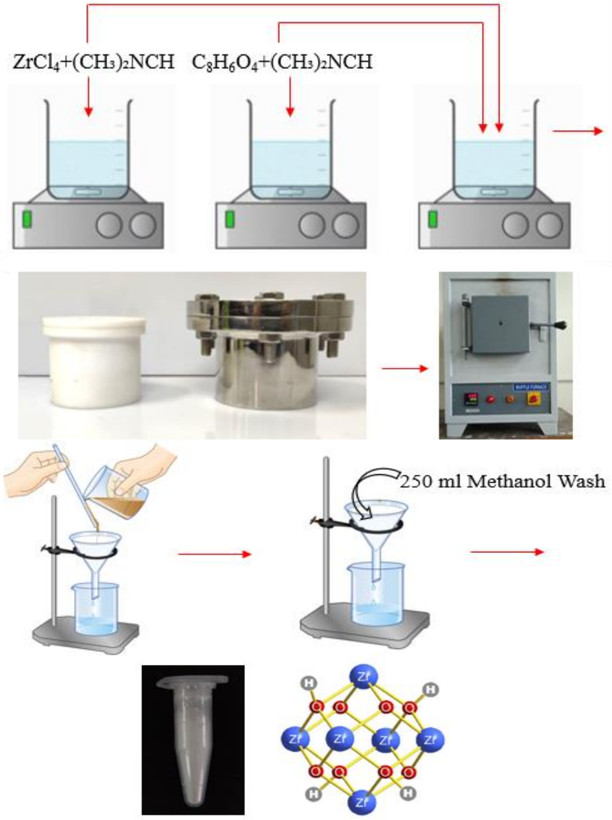
Hu-XO enzyme thermal stability check using CD

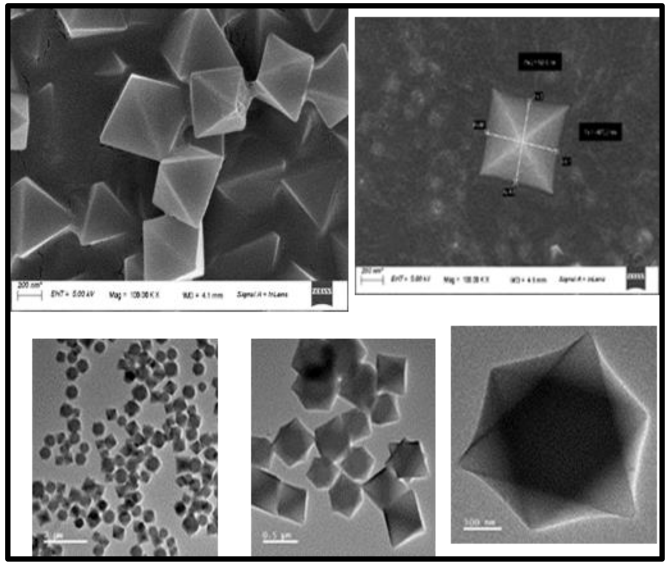


Effect of pH (3.5-8.5) on Hu-XO activity



Development of MOF assisted wastewater remediation system for inorganic pollutants.

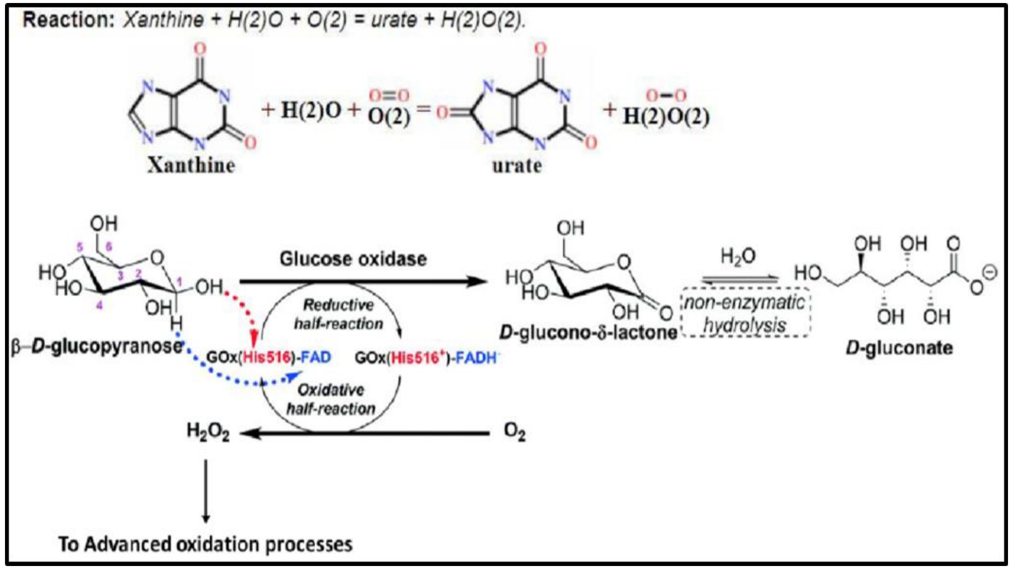


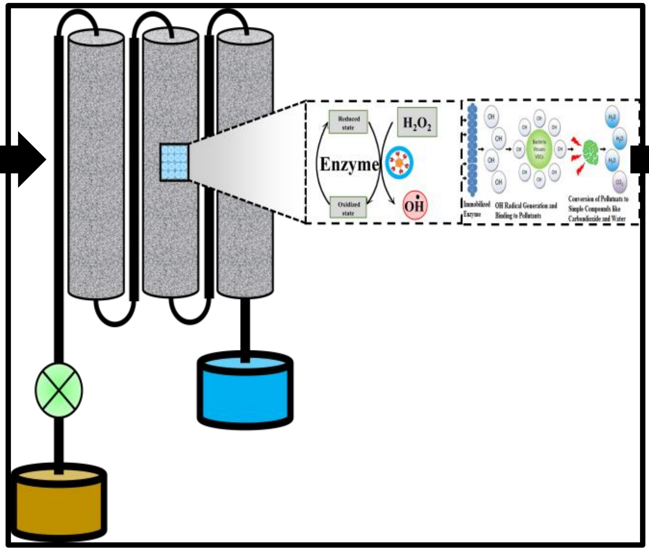


SEM & TEM Characterization of Zr MOF

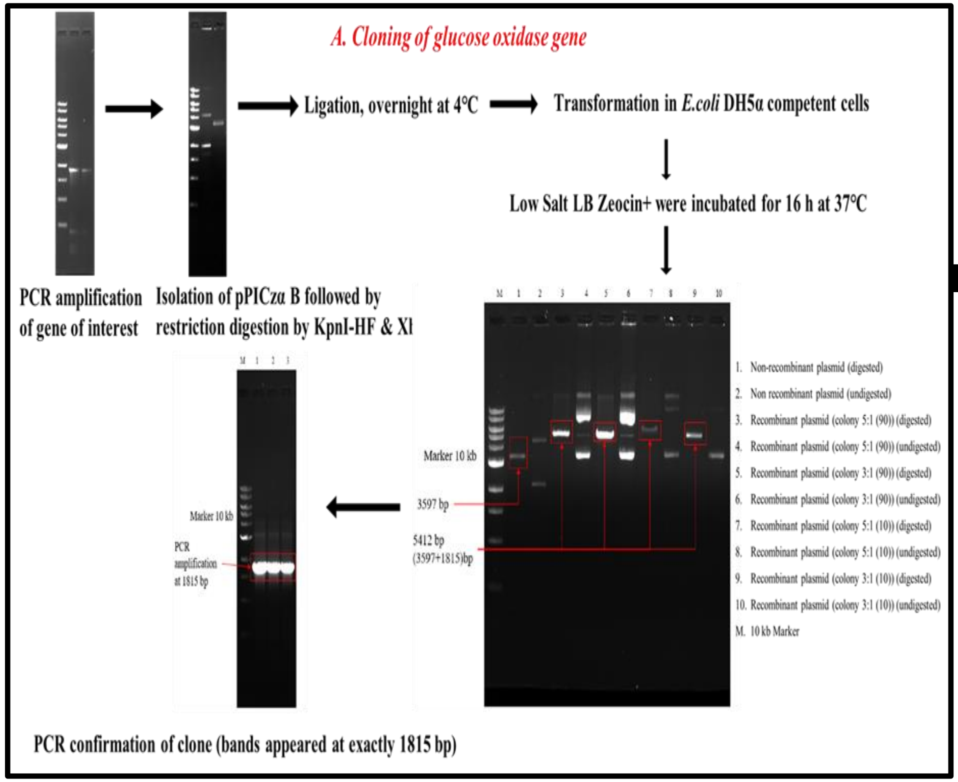
Immobilization & Applications

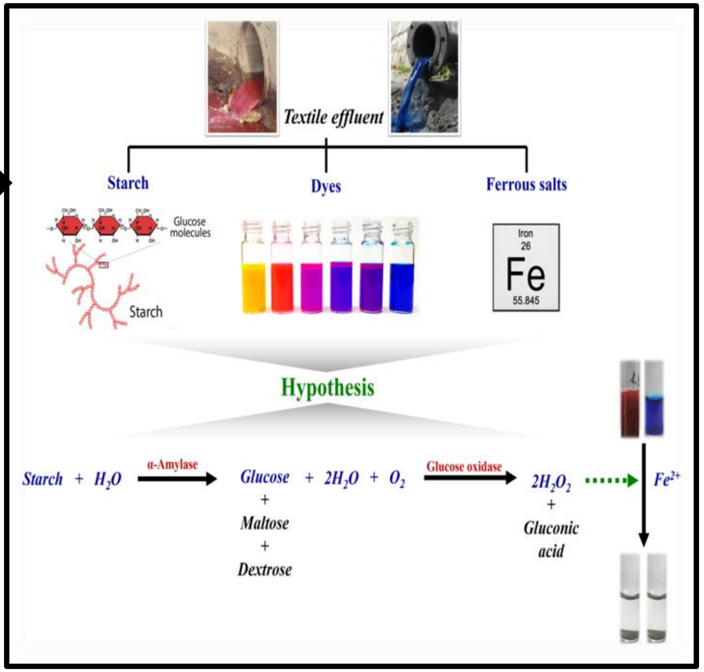
TEXTILE AND PAPER INDUSTRY

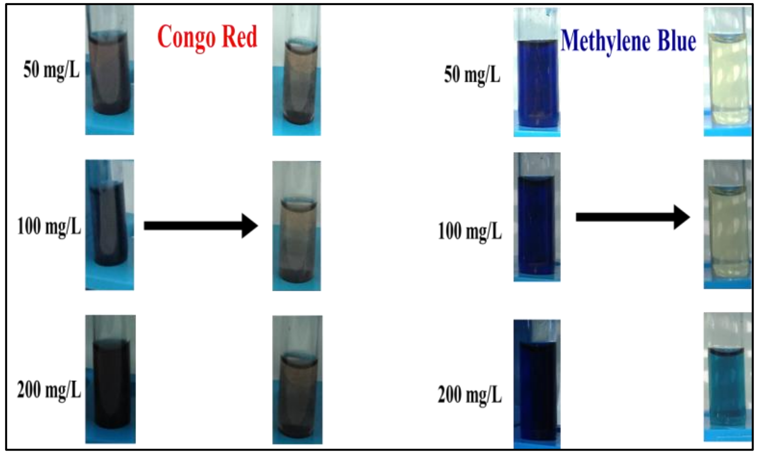




1. Textile industry: Starch acted upon by Amylase – Glucose
2. Paper industry: Cellulose acted upon by cellulase gives glucose







Decolourization of dyes under optimized conditions

LEATHER INDUSTRY WASTEWATER - POLLUTION HETEROGENEITY AND REMEDIATION

Assessing pollution heterogeneity of leather industry wastewater

CLC Tanners association, Kolkata

CLC Tanners Campus, WW reservoir

Initial wastewater parameters at the time of collection

Collected sample parameters	Value
Location	Calcutta Leather Complex
GPS Coordinates	22°29'40.3''N 88°31'28.8''E
pH	6
Colour	Grey
Temperature (Collection point)/Date	34°C (2-June 2022)
Transit temperature	4°C
Storage temperature	-80°C

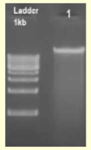
Assessing pollution heterogeneity of leather industry wastewater

Sr .No	Parameters	Methods	Result	Permissible Limit
1	Color	8025 USEPA METHOD 3rd edition of HACH	318 Pt.Co.*	15 Pt.Co. USEPA
2	Total suspended solids	8006 USEPA METHOD 3rd edition of HACH	28 mg/L	1 mg/L in D/W 3.mg/L in R/W EPA
3	Turbidity	8195 USEPA METHOD 3rd edition of HACH	20.3 NTU	0.3 NTU EPA / 5 NTU WHO
4	Electrical conductivity	1755 USEPA METHOD 3rd edition of HACH	1755 µS/cm	500 µS/cm WHO
5	Salinity	10073 USEPA METHOD 3rd edition of HACH	1.6 %	0.1% WHO
6	Total dissolved solids	8277 USEPA METHOD 3rd edition of HACH	1456 mg/L	500-1000 mg/L EPA
7	Total solids	8271 USEPA METHOD 3rd edition of HACH	1484 mg/L	50 mg/L EPA
8	Nitrate	8192 USEPA METHOD 3rd edition of HACH	7.8 mg/L	>10 mg/L EPA
9	Total hardness as $CaCO_3$	2340 .C APHA METHOD 21th edition 2005	116 mg/L	50-150 mg/L EPA
10	Sulphide	8131 USEPA METHOD 3rd edition of HACH	0.172 mg/L	0.05 mg/L EPA
11	Ammonical Nitrogen	8038 USEPA METHOD 3rd edition of HACH	31.78 mg/L	0.5-1.5 mg/L EPA/EU
12	Chlorine	8167 USEPA METHOD 3rd edition of HACH	0.41 mg/L	1-4 mg/L EPA
13	Hexavelent Chromium	8023 USEPA METHOD 3rd edition of HACH	0.100 mg/L	0.05 mg/L EU
14	COD	5220.B APHA METHOD 21th edition 2005	360 mg/L	>50 mg/L
15	BOD	5210.D APHA METHOD 21th edition 2005	143 mg/L	>10 mg/L

* Pt.Co. refers to the platinum-cobalt colour scale | R/W=River water | D/W= Drinking water

Metagenomic Analysis

Quality check of isolated DNA from leather industry wastewater

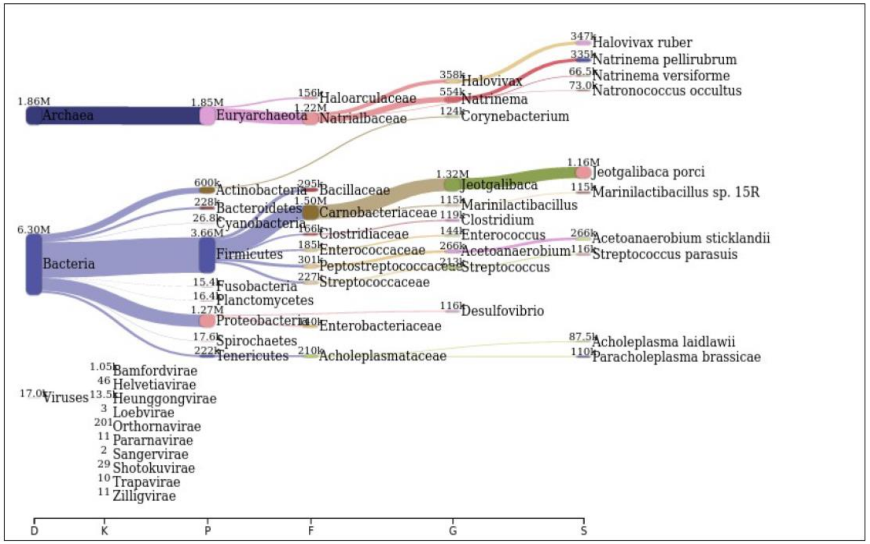


S.N.	DNA Conc. (ng/µL)	Volume (µL)	Total Yield (ng)
1.	23.3	30	699

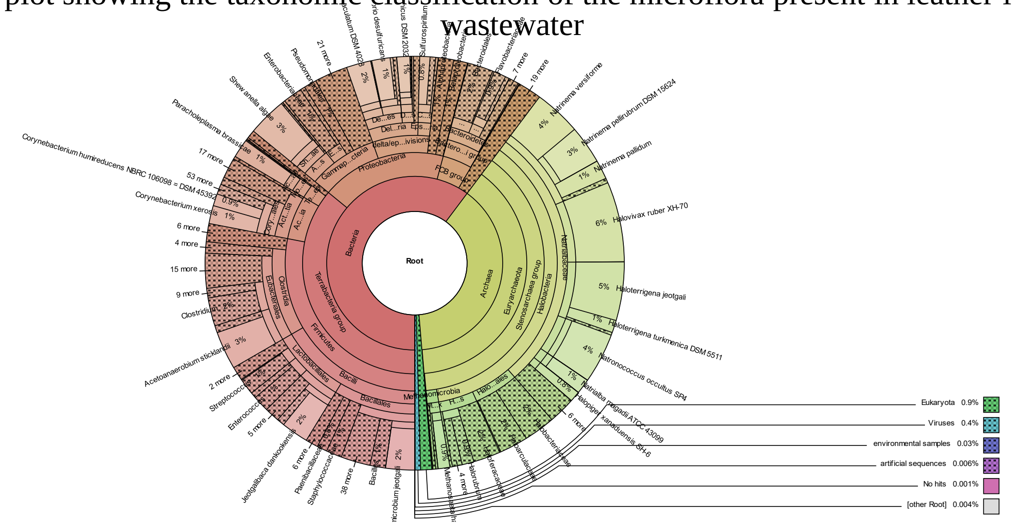
Summary of raw sequence data

S.N.	No. of Reads	GC %	Read length
1.	66531352	49	151

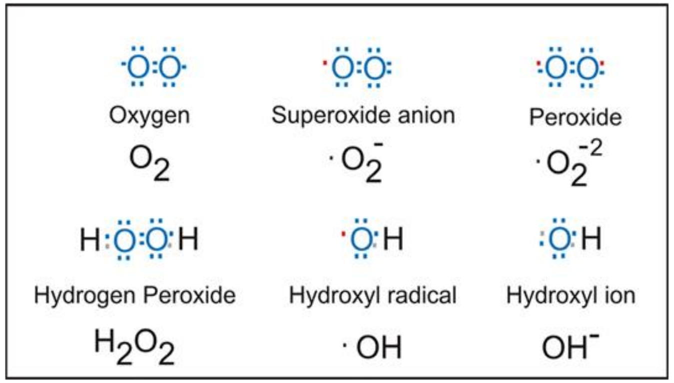
Sankey plot showing the distribution of reads



Krona plot showing the taxonomic classification of the microflora present in leather industry wastewater



HYPOTHESIS



Reactive oxygen species

Exploited for

Dairy industry waste-water

Pollutant heterogeneity

- Proteins (casein 560 mg/l)
- Carbohydrates lactose (1-8%)
- Heavy metals Cadmium (0.035 mg/l)
- Microbial load

$$\text{Lactose} \xrightarrow{\text{Lactase}} \text{Glucose} + \text{Galactose}$$

$$\text{Glucose} + O_2 \xrightarrow{\text{Glucose oxidase}} \text{Gluconic acid} + H_2O_2$$

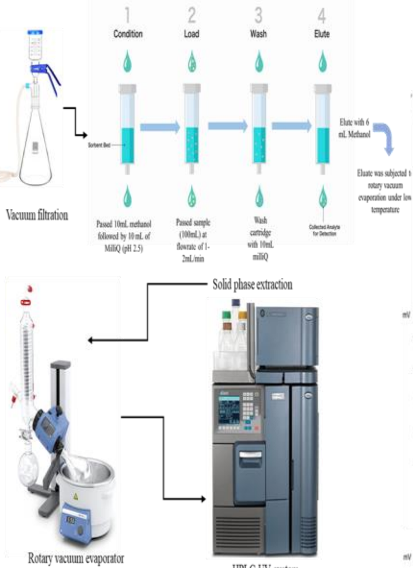
$$\text{Xanthine} + H_2O + O_2 \xrightarrow{\text{Xanthine oxidase}} H_2O_2 + \text{Uric acid}$$

$$H_2O_2 \xrightarrow{Cu^{2+}} OH^-$$

- Oxidation of heavy metals
- Lactose & protein breakdown
- Microbial load

ASSESSMENT OF ANTIBIOTICS IN WATER AND ENZYMATIC REMEDIATION PHARAMACEUTICAL INDUSTRY

Different sampling locations



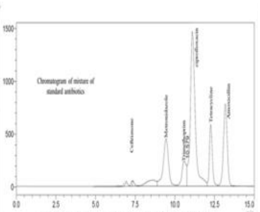


Fig: Chromatogram of mixture of standard antibiotics

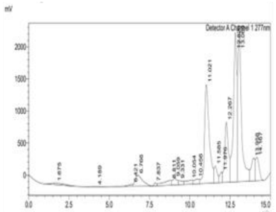


Fig: Chromatogram of Pig Slaughter house sample

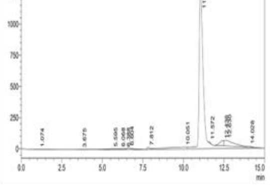


Fig: Chromatogram of Sewage treatment plant (IITG) sample (untreated)

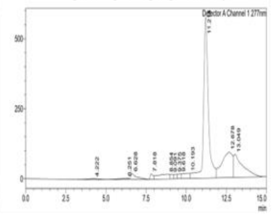


Fig: Chromatogram of Sewage Treatment plant (IITG) sample (treated)

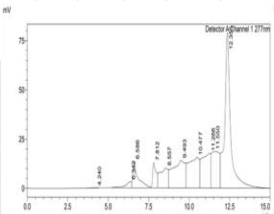


Fig: Chromatogram of Veterinary Hospital sample

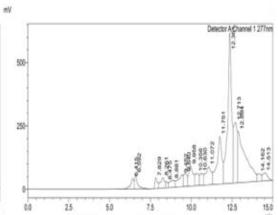
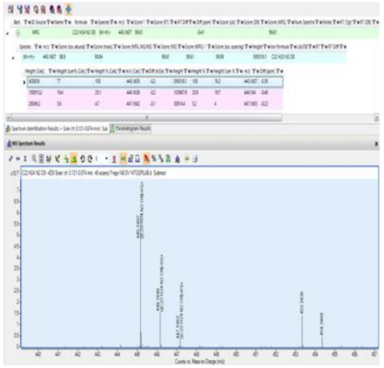


Fig: Chromatogram of Cow Farm (2) sample

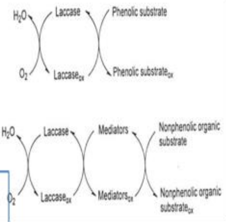
Amount of antibiotics found in the water samples

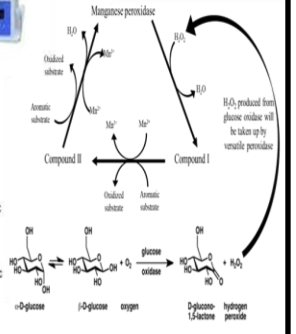
Sample	Amount in µgL^{-1}					
	Amoxicillin	Tetracycline	Ciprofloxacin	Trimethoprim	Metronidazole	Ceftriaxone
Cow Farm (1)	n.d.[a]	n.d.	n.d.	n.d.	n.d.	n.d.
Cow Farm (2)	n.d.	**210.37**	< LOD	<LOD	<LOD	n.d.
Pig Slaughterhouse	**121.72**	**306.44**	**54.94**	<LOD	<LOD	<LOD
Ground Water	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Veterinary Hospital	n.d.	**55.49**	<LOD	n.d.	n.d.	n.d.
Pig House	n.d.	n.d.	<LOD	n.d.	n.d.	n.d.
Poultry Farm	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Untreated water (IITG STP)	n.d.	<LOD	**49.35**	n.d.	n.d.	n.d.
Treated water (IITG STP)	n.d.	<LOD	**39.63**	n.d.	n.d.	n.d.
Treated water (water treatment plant)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Water pumping site (Brahmaputra)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Water sample from flocculator	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Brahmaputra Ghat (near Saraighat bridge)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

[a] *Not detected*

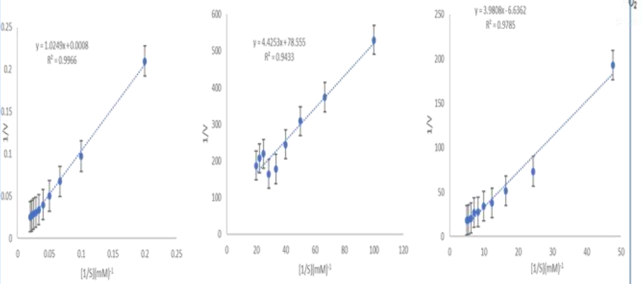


MS-spectra for confirmation of analyte





Kinetic analysis of manganese peroxidase, laccase and glucose oxidase

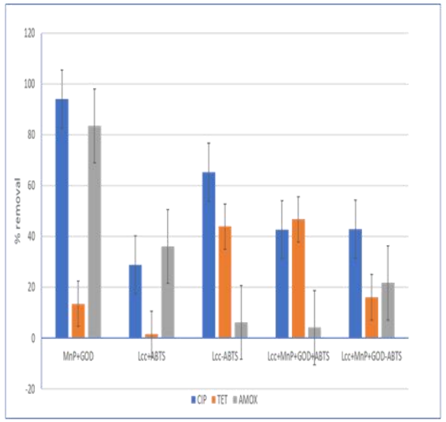


Enzyme	MnP
$K_{m\ (mM)}$	1281.125
V_{max}	1250
$K_{cat}(sec^{-1})$	6250
$K_{cat}/k_m(sec^{-1}mM^{-1})$	4.879

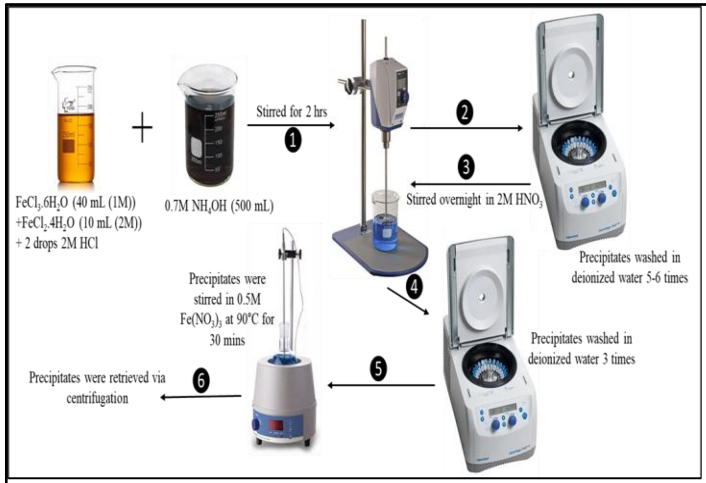
Enzyme	Lcc1
$K_{m\ (mM)}$	0.057
V_{max}	0.013
$K_{cat}(sec^{-1})$	0.0013
$K_{cat}/k_m(sec^{-1}mM^{-1})$	0.023

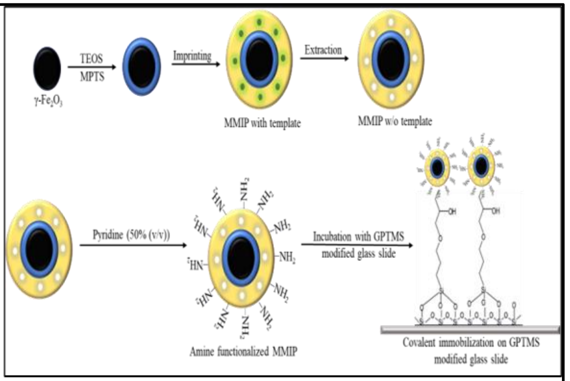
Enzyme	GOD
$K_{m\ (mM)}$	0.60
V_{max}	0.15
$K_{cat}(sec^{-1})$	0.00030
$K_{cat}/k_m(sec^{-1}mM^{-1})$	0.00050

Antibiotic degradation via free enzymes in different combinations

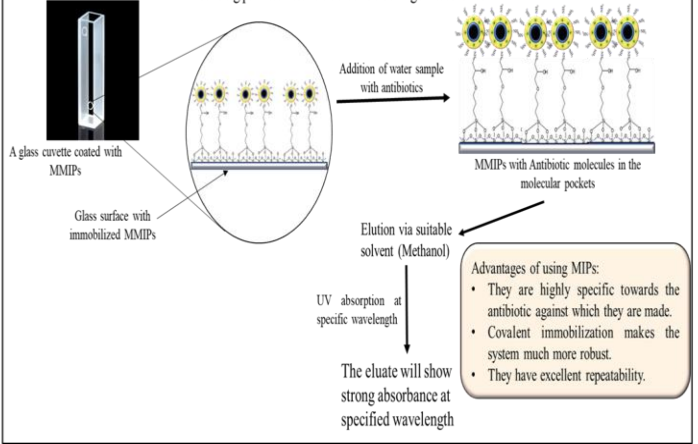


DEVELOPMENT OF MULTI-ANALYTE PLATFORM FOR DETECTION OF ANTIBIOTICS





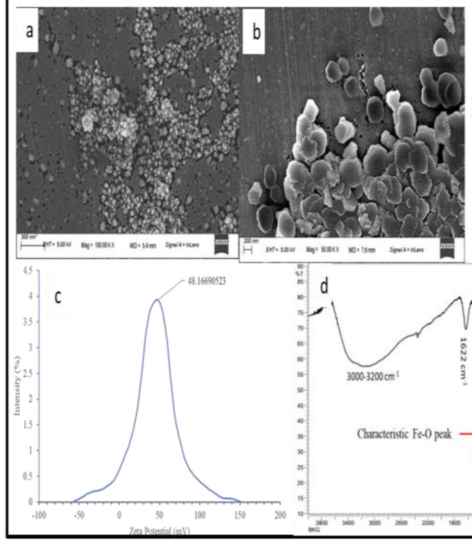
A sensing platform for the detection of target antibiotics



Advantages of using MIPs:

- They are highly specific towards the antibiotic against which they are made.
- Covalent immobilization makes the system much more robust.
- They have excellent repeatability.

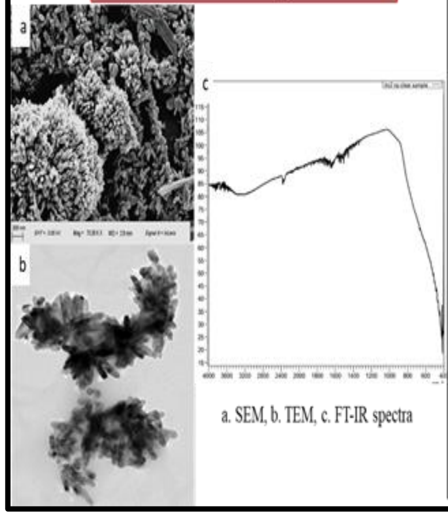
Characterisation of γ-Fe_2O_3 nanoparticles and MIPs



a. SEM, c. zeta potential, d. FT-IR (γ-Fe_2O_3), b. SEM (MIPs)

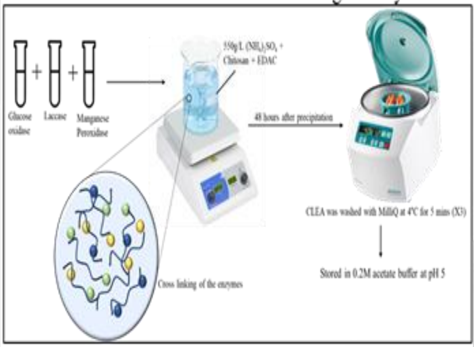
IMMOBILIZATION OF ENZYMES ON TIO$_2$ NANOFLOWERS

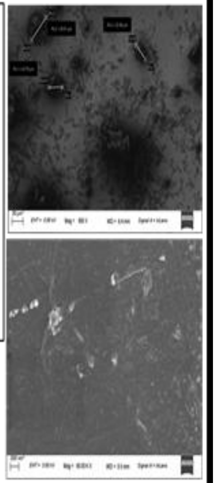
Characterization of TiO_2 Nanoflowers



a. SEM, b. TEM, c. FT-IR spectra

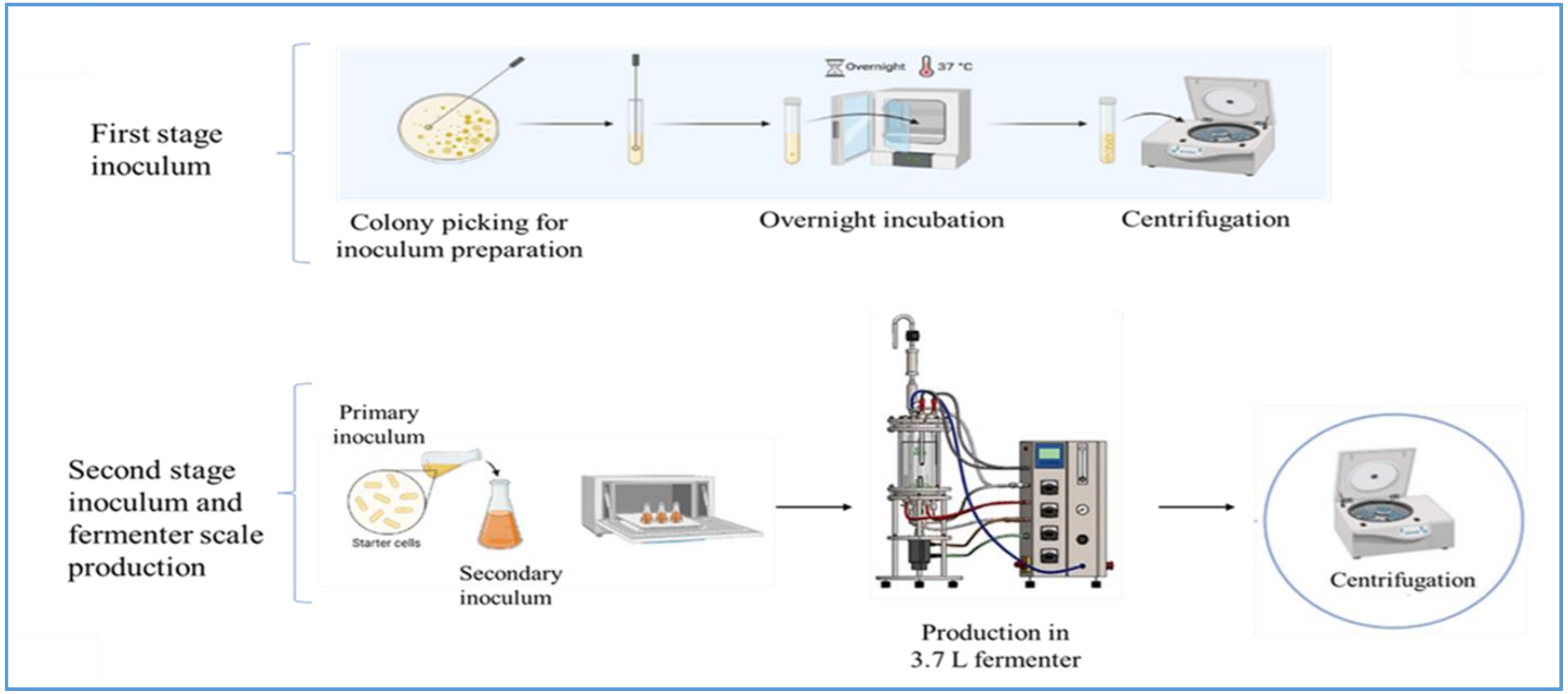
Cross-linking of enzymes



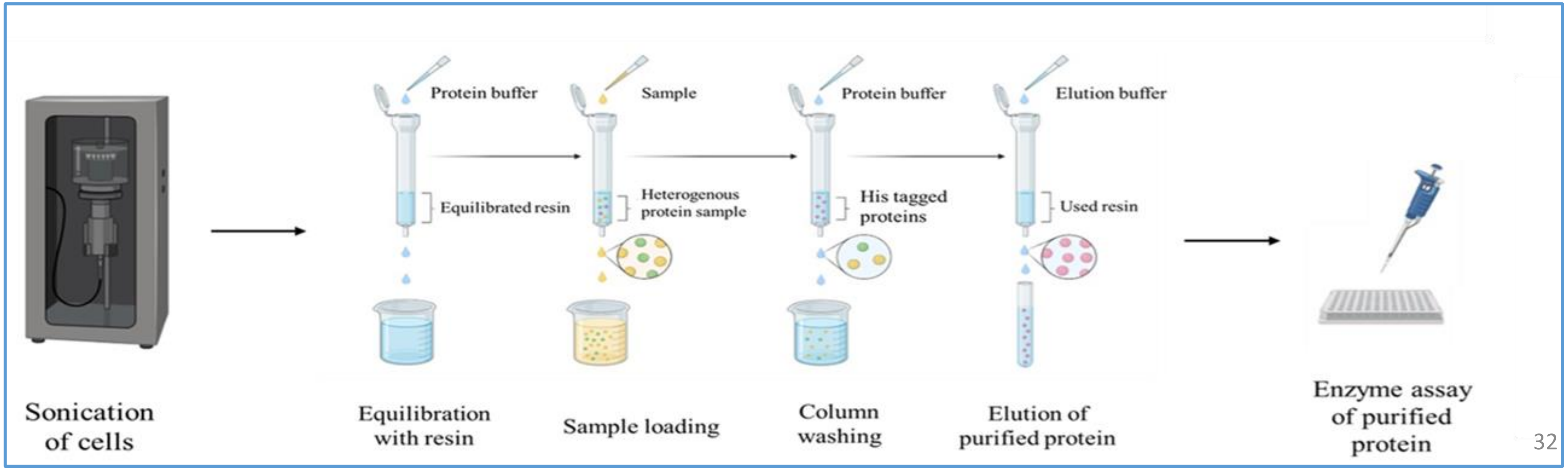


Immobilization efficiency	
Initial concentration protein (in enzyme cocktail)	1.171 mg/mL
Final concentration of protein (in wash)	0.135 mg/mL
Immobilization efficiency	88.47 %

UPSTREAM PROCESSING



DOWNSTREAM PROCESSING



Cultivation of *Pichia pastoris* in 3.7 L fermenter (un-optimized)

0 h

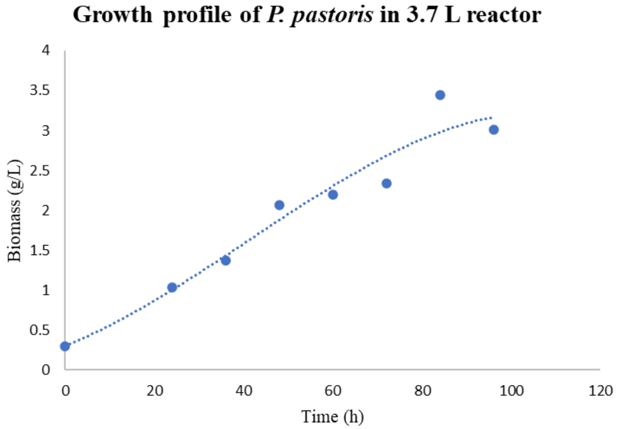
After 24 h

Batch operation	**Agitation (rpm)**	**Aeration (Lpm)**	**Purified Xanthine oxidase activity (milliunit/ml)**
Shake flask (50 mL)	150	-	7429.3
Shake flask (200 mL)	150	-	10406.81
Reactor batch 1 (1.6 L)	200	0.5	22,506.49
Reactor batch 2 (1.6 L)	200	1	18,834.99
Reactor batch 3 (1.6 L)	200	1.5	4070.35

First set of purified enzyme of batch showing maximum activity was dispatched to ELI in March 2023

Optimization of process parameters using response surface methodology

- Preliminary **rector batches** helped to **determine the initial parameters for optimization study**.
- The process parameters were improvised to **enhance overall biomass yield for maximum enzyme recovery**.

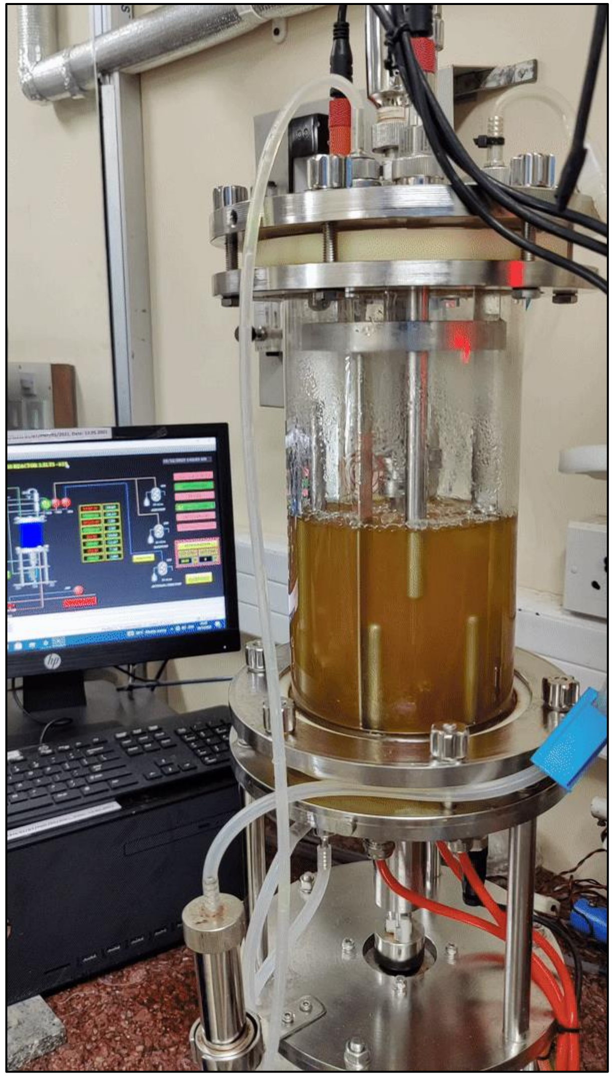


Growth profile of *P. pastoris* in 3.7 L reactor indicating maximum biomass concentration at 84 h

- Three **test variables (agitation, aeration, and % inoculum) were selected**, each one at three levels of concentration (-1, 0, +1).
- **Central composite design (CCD) was employed using Design Expert Software version 8.0.6.** (Stat–Easy Inc., Minneapolis, USA).
- The **model prediction was confirmed** with the suggested **optimized value of parameters** in **triplicate**.

EXPERIMENTAL CLIPS OF BATCH RUNS

Inoculum transfer for various runs (varying inoculum size)

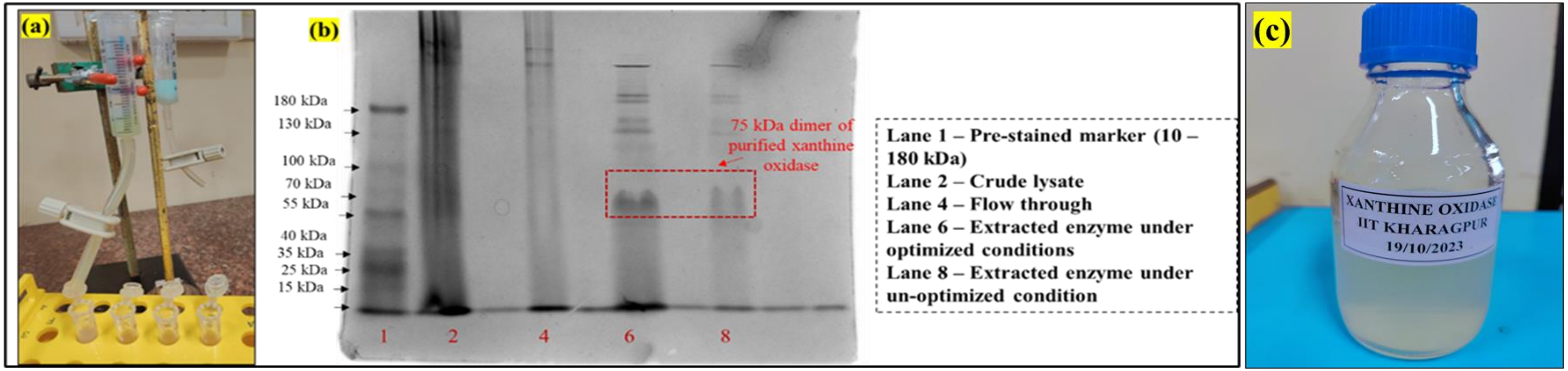


Batch run of *P. pastoris* after 24 h of inoculation

Batch run of *P. pastoris* after 84 h

Experimental validation of model at optimized conditions for maximum biomass production

Parameters	Optimized conditions	Predicted value of Biomass (g/L)	Experimental value of Biomass (g/L)	Purified Xanthine Oxidase activity (milliunit/mL)
Agitation (rpm)	113	5.07±0.9	5.3±2.31	39,417.63
Aeration (L/h)	0.77			
Inoculum size (%)	12			



(a) Purification of xanthine oxidase using Ni-NTA column (1 mL column) (b) SDS-PAGE of purified enzyme with (Lane 6) under optimized conditions and (Lane 8) under un-optimized condition (c) Purified Xanthine Oxidase enzyme from optimized process parameters sent to ELI in October 2023

- The experimental result gave an average biomass concentration of 5.3±2.31 g/L.
- Enhancement in biomass production was around 60% in comparison to unoptimized reactor studies.
- Enzyme activity increased from 22,506.49 milliunit/mL to 39,417.63 milliunit/mL under optimized conditions.

CONCLUSION

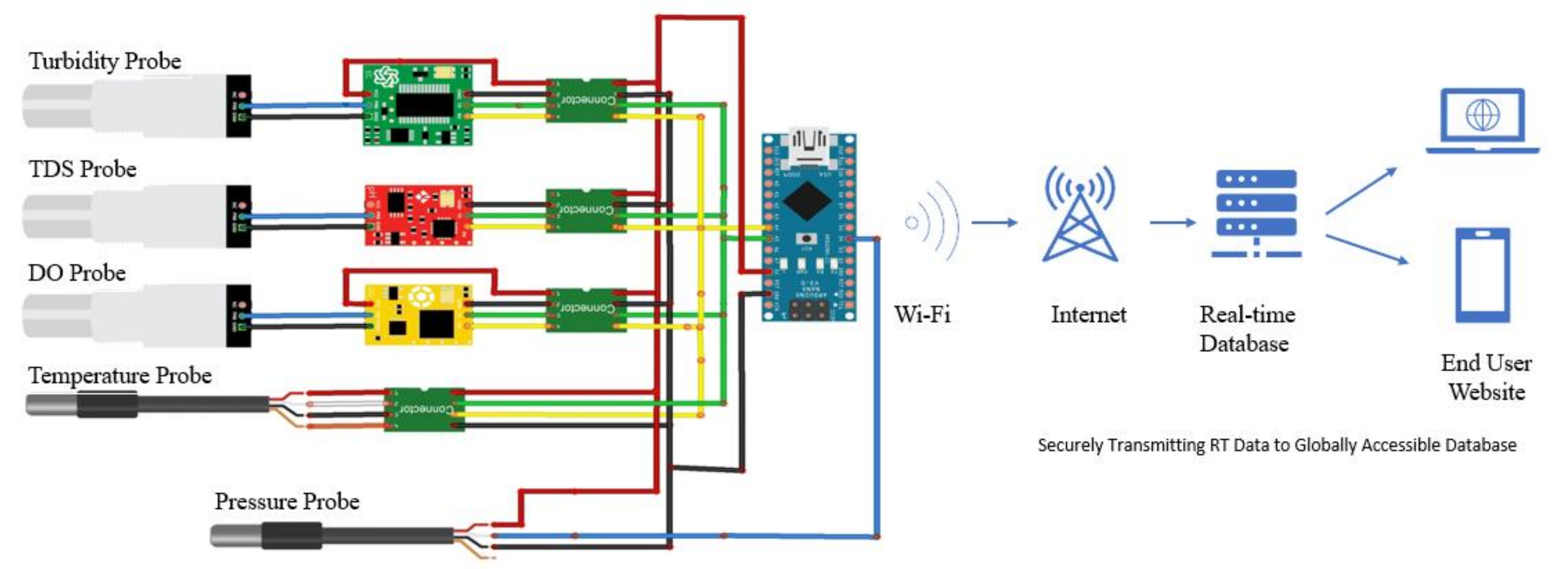
1. Human Xanthine Dehydrogenase (HuXDH) was cloned and expressed in *Pichia pastoris* and purified.
2. The Glucose Oxidase gene from *Aspergillus niger* was cloned and expressed in *E. coli*.
3. Scale-up of the Xanthine Oxidase production was done in 3.7 L fermenter.
4. Xanthine Oxidase activity was enhanced using statistical optimization process.
5. Enzyme assisted wastewater remediation system for treatment of organic pollutants, antibiotics, textile, paper, leather, dairy industry was developed.

Deliverable Reference No.	Deliverable Title
D4.1	Enzyme system for bio-oxidation
D4.2	Bioreactor system

Enzyme based bio-oxidation system for treatment of polluted water bodies: **TRL 4; Expected to reach TRL 6 (at the end of project tenure)**

SO5: Development of smart and cost-effective sensing systems for pollutant detection and actuation systems for bio-catalysis.

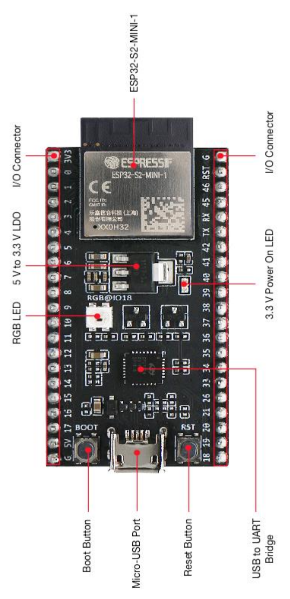
DEVELOPMENT OF MULTIPARAMETRIC REAL-TIME WATER MONITORING SYSTEM TO ACCESS POLLUTION HETEROGENEITY



Securely Transmitting RT Data to Globally Accessible Database

End –User Experience

Developed Prototype



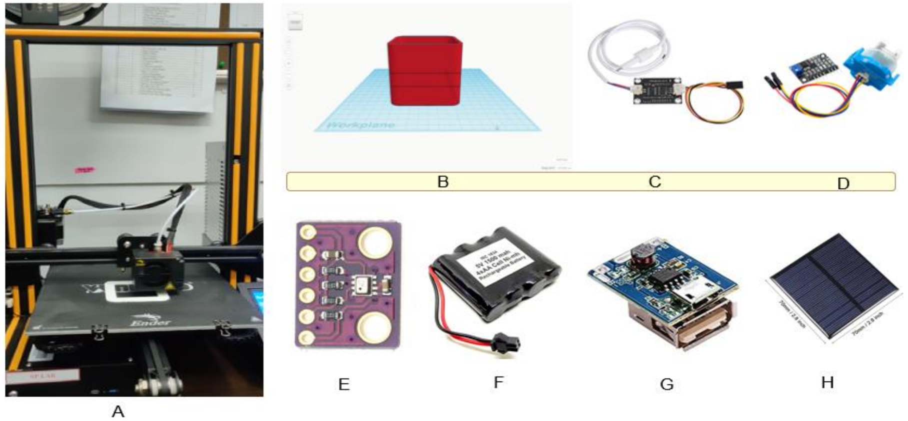
Robust Design | Ultra-Low Power Consumption | High Level of Integration | Hybrid Wi-Fi & Bluetooth Chip

Capable of functioning reliably in industrial environments, with an operating temperature ranging from –40°C to +125°C.

Engineered for mobile devices, wearable electronics and IoT applications, have ultra-low power consumption (3-5V).

Highly-integrated with in-built antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules.

Can perform as a complete standalone system or as a slave device to a host multipoint control unit, reducing communication stack overhead on the main application processor. ESP32 can interface with other systems to provide Wi-Fi and Bluetooth functionality



(A) External case of the sensor being printed with PLA filament (B) 3D render of the case in thinker CAD (C) Generic TDS sensor (D) Generic turbidity sensor (E) BME280 sensor for temperature, humidity and pressure (F) 5V Battery (G) Charge control unit (H) 5V Solar Panel

Award & Support

- Supported by SPRING.
- Got RnD support from Makerbhawan foundation & Win foundation.
- Won “Best product design” at Vishwakarma awards 2023 IIT Delhi.

Use Case:

- Industrial WWTP & wastewater ejection site

- Municipal Water Points

- River Dynamics Monitoring

- Overhead Tanks

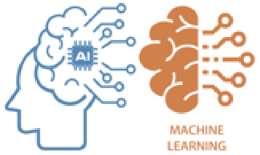
What is Unique?

- Price

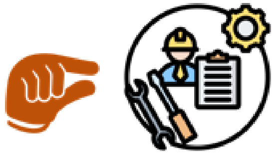
Brand	Model	Price	Integrated IoT
YSI	ProDSS	₹1,57,000 - ₹2,63,000	No
Hanna	HI98194	₹1,25,000	No
WTW	Multi 3510 IDS	₹97,000	No
Our device	R-SAM-Pro	₹12,000	Yes

- Green & Sustainable Fabrication

- Artificial Intelligence & Machine Learning Ready



- Small Form Factor & Low Maintenance



Market Size & Growth

Demographics & End User

- The major end-user are Municipal corporations, Industries and Academia.
- The largest market is North America, followed by Asia-Pacific and Europe.

Market

- Global water and wastewater sensors market- USD 3.80 billion (2019).
- Expected to register a CAGR of approximately 7.4% (2021-2026).
- Expected to reach USD 7.5 billion by 2028.

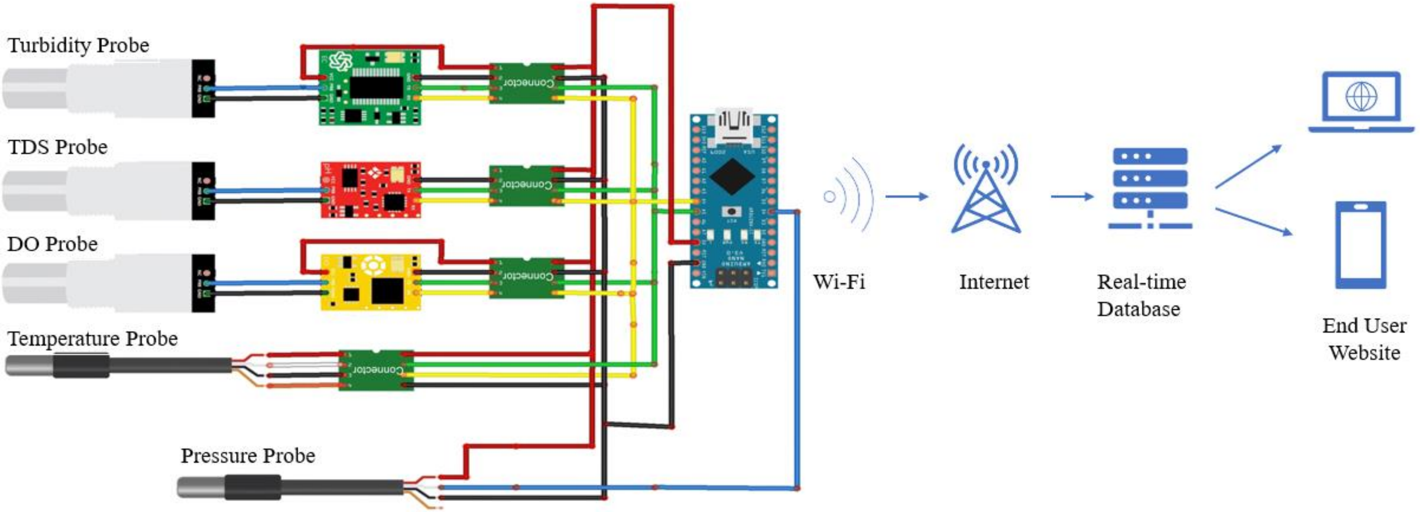
Competition

- The water quality monitoring systems market is moderately competitive with some dominant players holding significant market share.
- Key players include General Electric Company, Shimadzu Corporation, Thermo Fisher Scientific Inc.

Market Segmentation

- Wastewater sensors market is segmented by type, application and geography.
- The major types of sensors are pH sensors, DO sensors, Temperature sensors and Turbidity sensors.

SUMMARY



EMT Laboratory

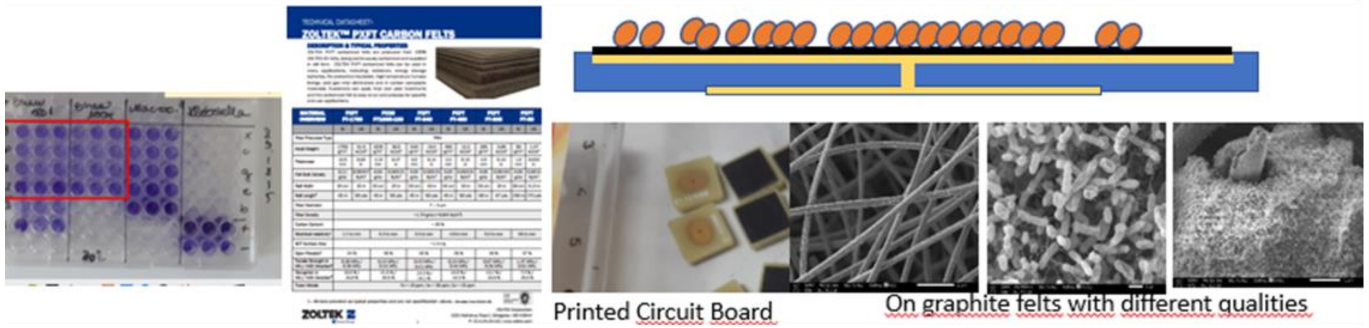
Analytics Dashboard

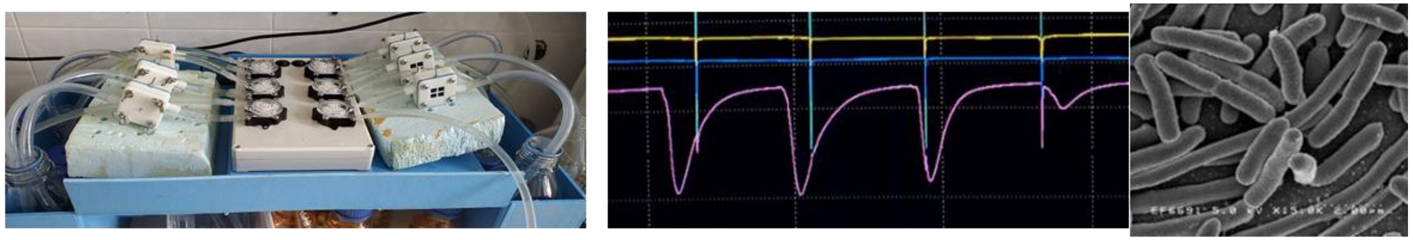
EMT LAB's Water Monitoring Console

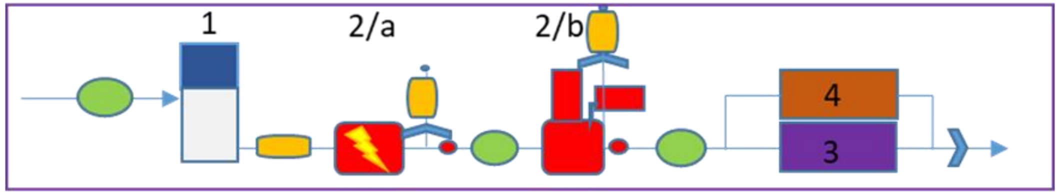
TDS 368

MICROBIAL SENSORY PLATFORM FOR BOD AND TOXIC COMPOUND DETECTION-I

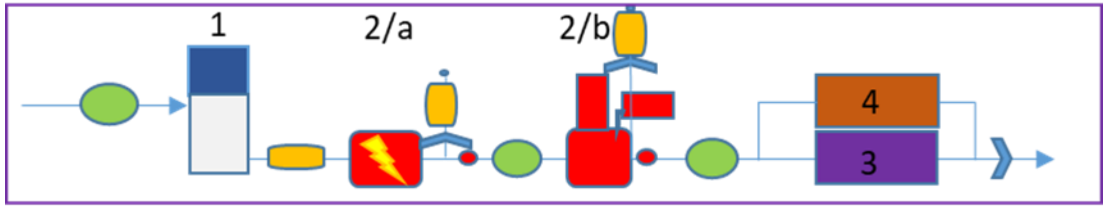
- **Selection isolation and testing** of electroactive bacteria in different systems, to reveal their electron- transfer efficacies. Strains were identified and a library was established.
- **Biofilm forming** capacities were tested on different matrices.
- **The efficacy of mixed consortia** was tested on biofilm tolerance and BOD measurements
- **Schematic parts of the sensoric platform**
- Sensoric unit for basic parameter
- Pretreatment units
- MFC units
- Heavy Metal sensor unit







MICROBIAL SENSORY PLATFORM FOR BOD AND TOXIC COMPOUND DETECTION-II

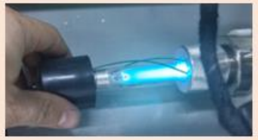


1.
Sensoric unit measuring basic parameters

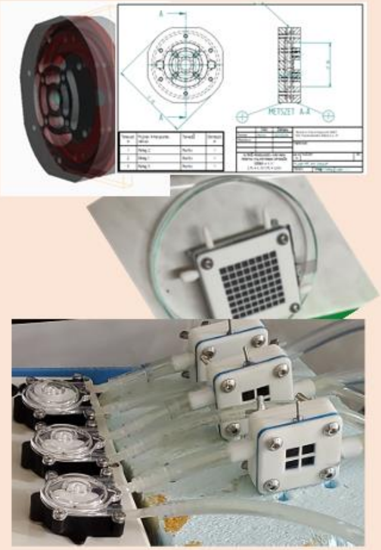
This unit is able to measure: Temperature, pH, Turbidity, Salinity, Conductivity, DO (Dissolved oxygen)
ORP (Oxidative Reductive Potential), Ammonium- and Chloride concentration, and Pathogenic bacterium number - coliforms

2.
Water sample pre-treatment units

Vacuum combined sonication and desinfection unit pretreats water samples for the MFC units



3.
MFC sensoric units



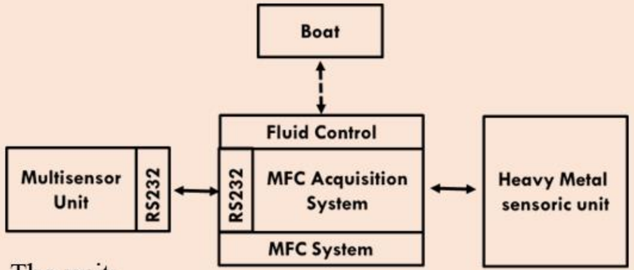
Small scale MFCs were established and integrated into the sensoric platform

4.
Heavy-metal sensoric unit

NIR was planned, but now printed sensoric units are under construction.
Cu, Hg, Ar

Printed sensors are under field tests

5.
Data aquisition and control



Boat

Fluid Control

Multisensor Unit

RS232

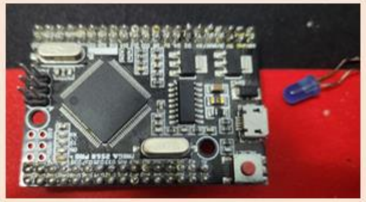
RS232

MFC Acquisition System

MFC System

Heavy Metal sensoric unit

The unit:
- collects data, from the sensoric systems,
- controls sampling and sample treatments,
- has the ability to perform samplings and tests in the determined/installed time periods,
- communicates with the central computer of the sampling boat during that receives commands and modifies sampling times.



CONCLUSION

1. Prototype for Multiparametric real-time water monitoring system to access pollution heterogeneity was developed.

2. Microbial sensory platform for detection of BOD and toxic compound was developed.

Deliverable Reference No.	**Deliverable Title**
D5.1	Bio-sensory panel
D5.2	Software

Development of multi-analyte sensor for determination of pollutants in water: : **TRL 4, Expected to reach TRL 6 (at the end of project tenure)**

SO6: Developing a prototype of the innovative low-cost advanced bio-oxidation treatment system for polluted water (for stagnant and flowing water bodies, such as bore wells, lakes and sewers, drains).

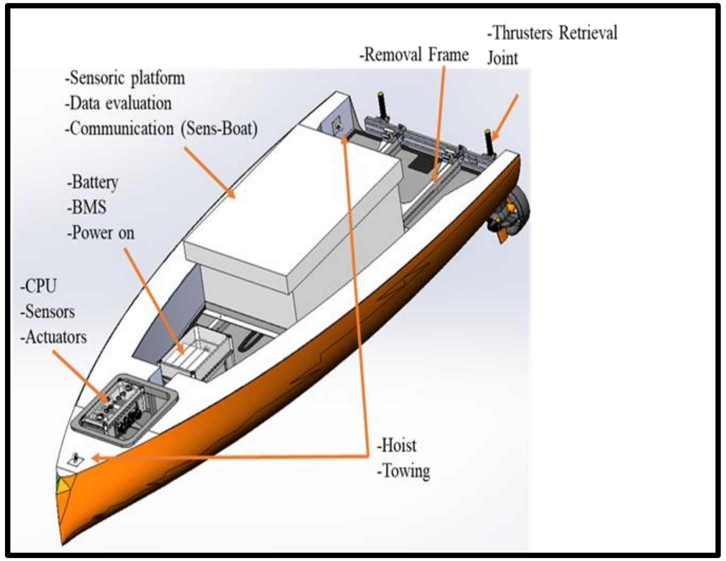
REAL-TIME MONITORING AND CONTROL SYSTEMS

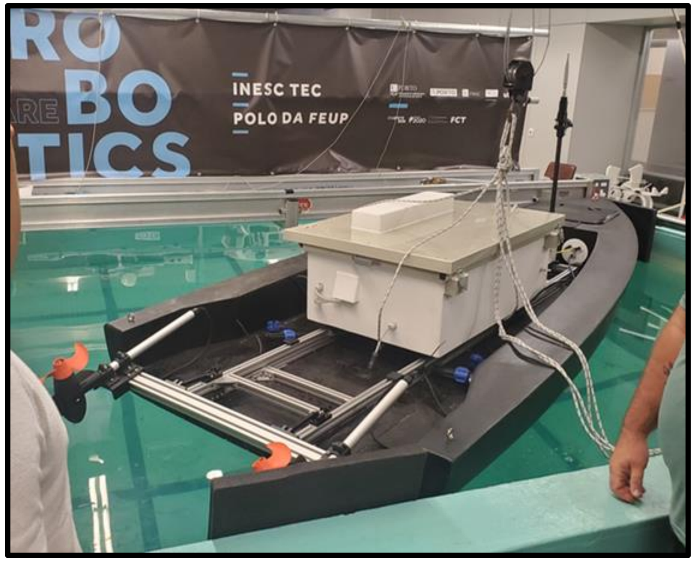
A. Developed a multipurpose boat system:

1. Integrated modular sensoric platform
2. Capable of carrying remediation system (bio-oxidation system)
3. Robotic and Navigation system
4. Teleoperation and Autonomous operation

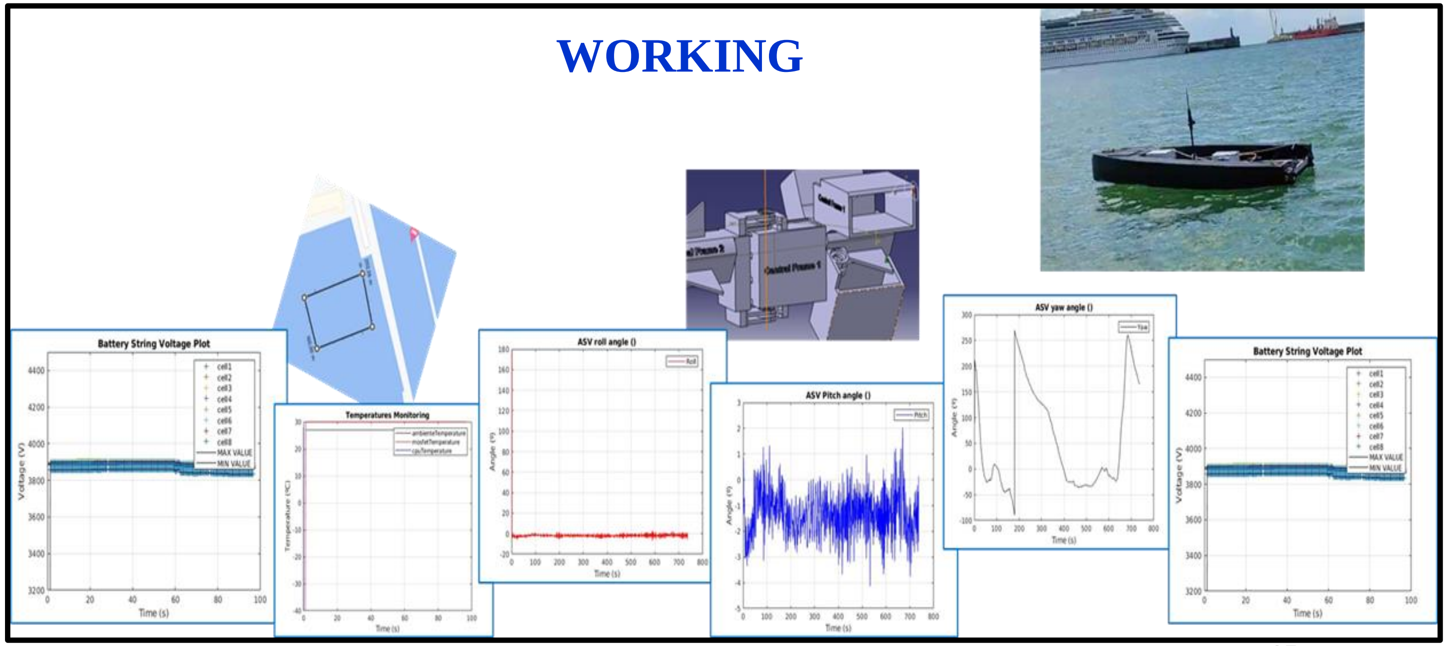
B. ASV Prototype - Specifications

- Dimensions of Hull: 3.6x1.4x0.7 m
  - Frame: 2.4x0.5x0.5
- Weight: 200 Kg
- Additional Payload:
  - 100Kg
  - 2m x 0.75m
- Actuation: 2-Degree of Freedom
- Autonomy:
  - Continuous Operation: 2h30m
- Speed:
  - Typical: 1.5 m/s
  - Max: 2 m/s

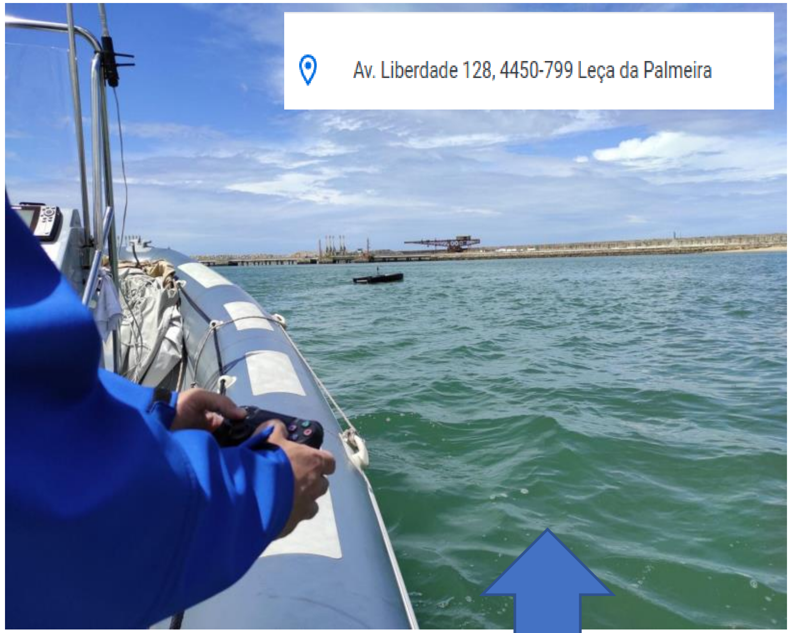


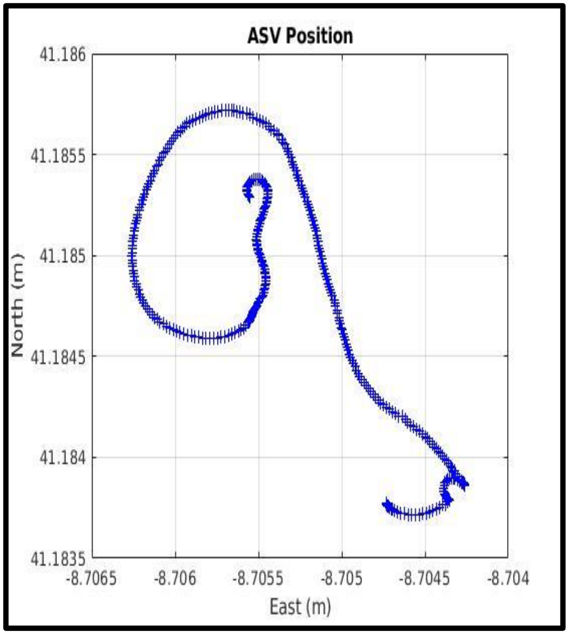


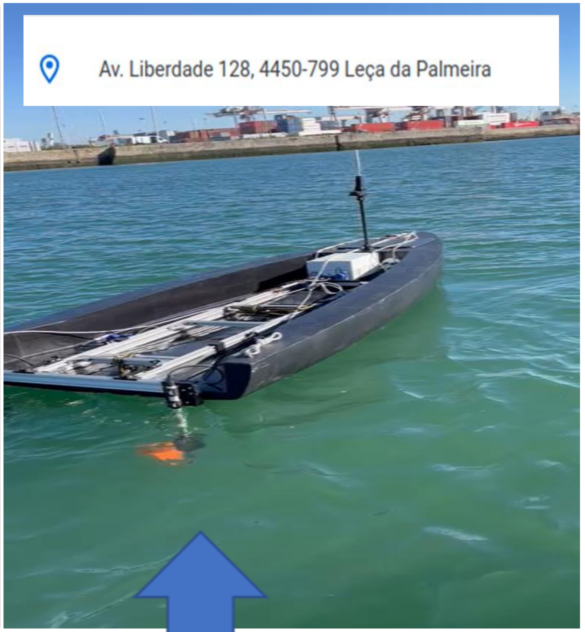
WORKING



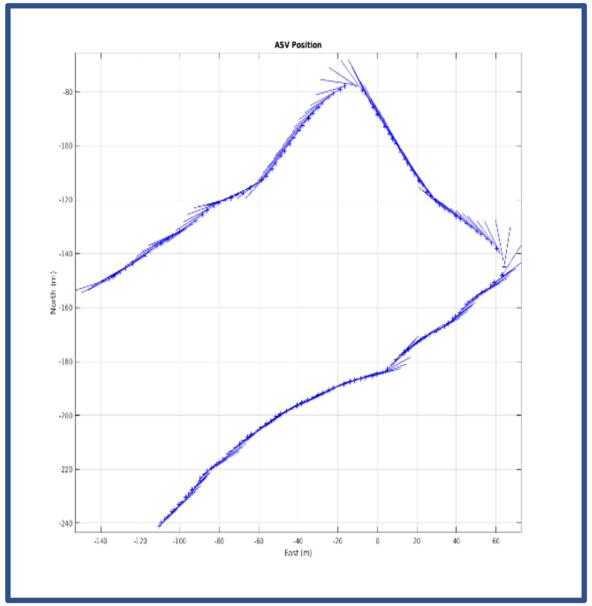
ASV PROTOTYPE TESTING - TELEOPERATION MODE & AUTONOMOUS MODE







10 m/s for7m30s



Useful when

1. Easy Deployment and Recovery Procedures
2. Navigating without Maps of Surrounding Area
3. Navigating through High Traffic Areas

Main Features

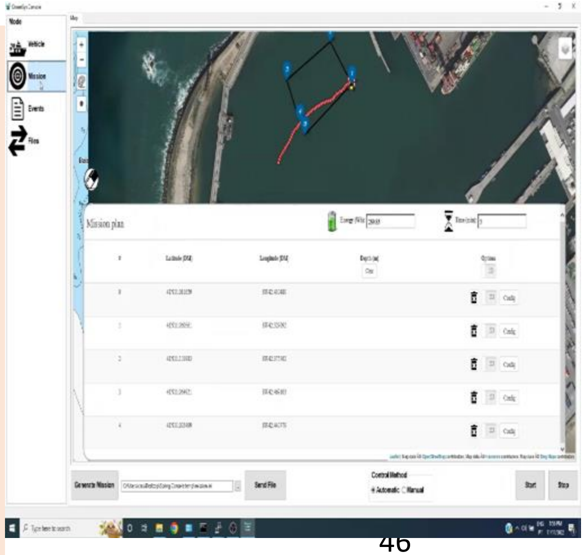
1. Real-Time Data Visualization
2. 600m of Current Line-of-Sight Range

Useful when

1. Mission with Several Waypoints Distanced Far Apart
2. Several Missions during Same Day's Operations
3. Navigating with Maps of Surrounding Area

Main Features

1. Real-Time Data Visualization
2. Geo-Reference Tag of Sample Collected
3. Operator Assumes Supervision Behavior



Objective

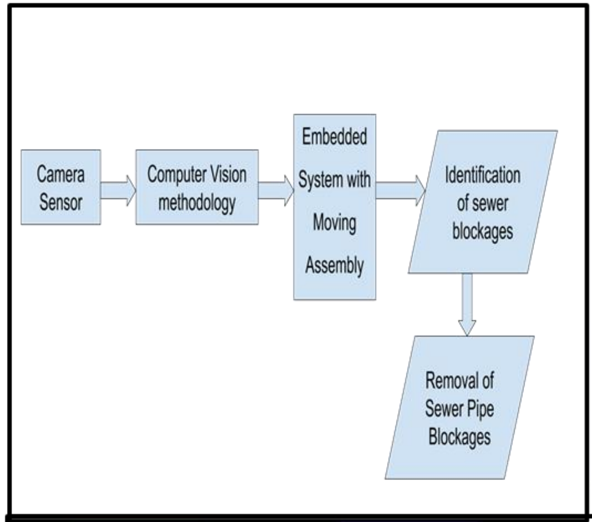
- Development of autonomous robot to detect underground water blockages.
- Algorithm development and testing.
- Payload integration.
- Deliver bio-oxidation system inside the pipelines to the point of blockage.
- Test and validation in realistic environment.

Blockages Occurring in Sewer Lines

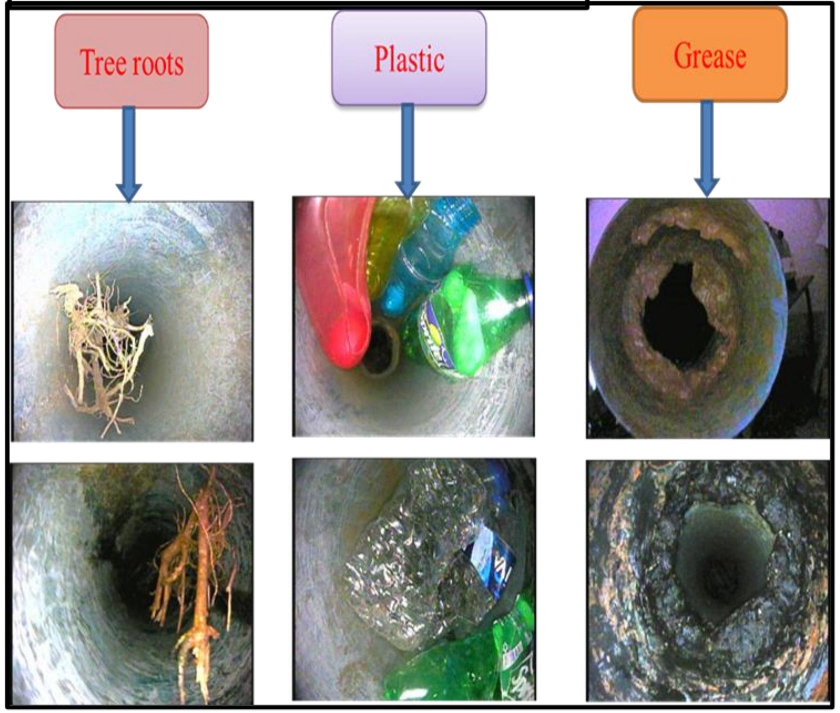
Tree roots, Stones, Grease, Wooden blocks, Plastic bottles, foreign objects, etc.

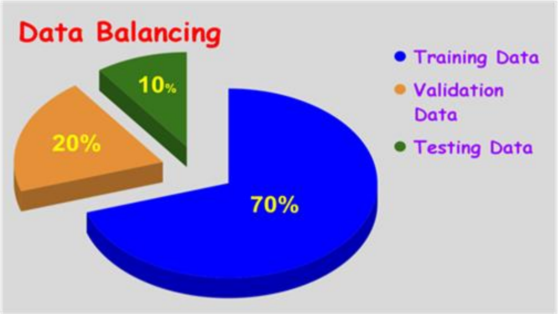
Need of Imagery Dataset

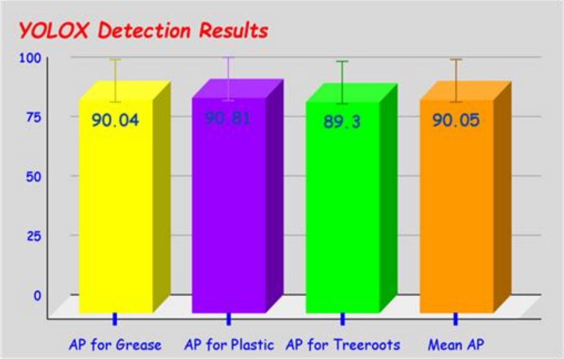
S-BIRD Dataset: The dataset of 7164 images have been created for training of DNN module to detect blockages



Object Class	Captured Frames
Treeroots	2295
Plastic	2392
Grease	2353
Total	7040

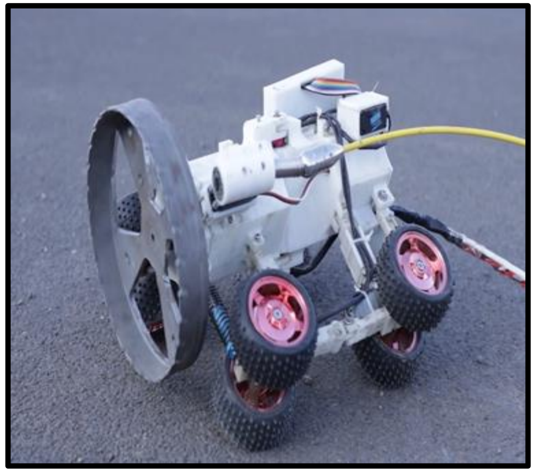


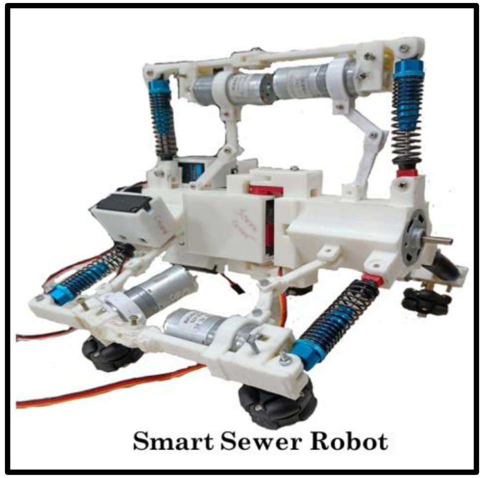


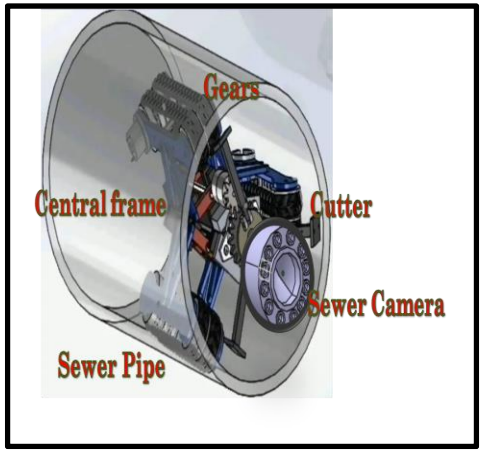


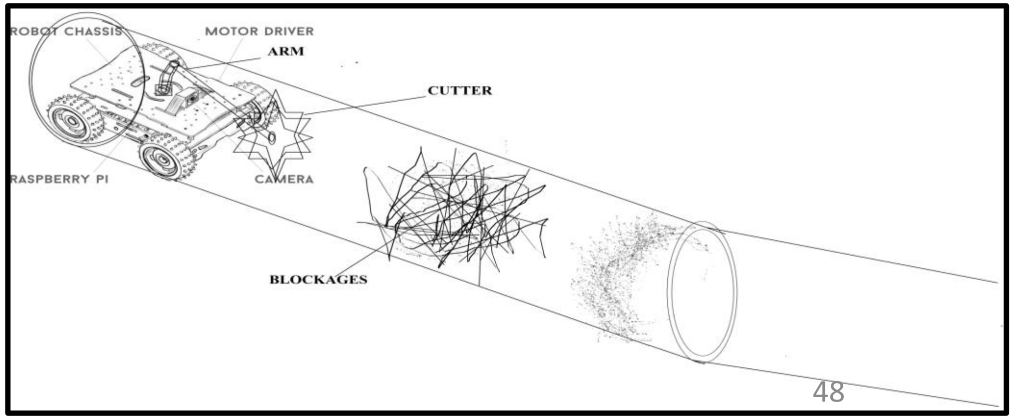
SEWER ROBOTIC SYSTEM

1. Navigates using camera-sensor and embedded vision with ability to deploy the enzymes at identified points.
2. The AI detection algorithm with newly created extensive imagery dataset.
3. **Removes sewer blockages in real time with the help of attached cutter.**
4. **Can work in pipe diameters ranging from 30 cm to 1 m.**
5. Linkage mechanism, cutting tool and three independent crawler modules, central frame
6. **3 crawler's module:** It is arranged in 120-degree angel to contact the sewer pipe surface correctly and make driving reliable.
7. **Semi integral Chassis design:** 2 Central frames structure are used. If the robot meets with accident only damaged frame need to be changed.
8. **Revolute Joint mechanism:** helps to rotate half body of robot and move easily in small diameter pipes.
9. **Easily adaptable:** Wall press mechanism, extendable arms to adjust as per pipe diameter.
10. **Powerful and compact Gearbox:** Worm wheel gear mechanism is used to decrease motor speed and increase torque up to 10 times to make 4x4 driving mechanism
11. **Cutting Assembly:** the 200 mm diameter TCT cutter are used to remove the blockage inside the sewer pipeline. The speed of motor is up to 3000 rpm.
12. It can be used for various **pipeline inspections.**
13. **Solves human scavenging issue.**
14. **Single version cost – Approximately 4.5 L**
15. **Real time working video available.**




Smart Sewer Robot





CASE STUDY - PUNE MUNICIPAL CORPORATION

Terms	Details
Sewer Line	2167 kilometer
Sewer Pipe Diameter	Ranges from 100 mm to 1800 mm
Total Chambers (manhole)	2187
Sewer Pipe Material	• RCC • High-density polyethylene (HDPE) • bid-iron • PVC
Distance Between Chambers	10 to 15 meter
Sewer Cleaning Techniques	• Jetting Machine • Sewer Suction Cum Jetting Machine • Sewer Suction Cum Jetting Machine with a Recycler
Total Generated Sewage	744 MLD
Intermediate pump stations (IPS)	6
Sewage Treatment Plants (STPs)	9
Main Sewer Lines	• Below road • River side • Canal side
Cleaning Tools • Jetting Machine • Sewer Suction Cum Jetting Machine • Sewer Suction Cum Jetting Machine with a Recycler	Charges/Shift (8 hours shift) 5360 INR 6400 INR 37000 INR

Jetting Machine	Perform only single operation
	Costly, More time consuming
	Less efficient
Sewer Suction Cum Jetting Machine with a Recycler	Need of skilled operator and labors
	High maintenance cost
	Need of large space for operation purpose
	Very costly

CONCLUSION

- Autonomous Unmanned Vehicle (AUV) for water quality monitoring was developed.
- Autonomous robot to detect underground water blockages, removal of physical blockage, deliver the Bio-oxidation system inside the pipelines to the point of blockage.
- Robot prototype developed, tested and validated.

Deliverable Reference No.	Deliverable Title
D6.1	Biosensor integrated to Robot system
D6.2	Real-time monitoring system

Autonomous Unmanned Vehicle (AUV) for water quality monitoring with auxiliary system to support its operation: **TRL 6**

SO7: Field trials and testing of prototype(s).

Immobilization Matrices Used

i. TiO2 nanoflowers
ii. Zr MoF
iii. ZnO
iv. Silanised Glass beads (1-2mm Diameter)
v. Sodium Alginate
vi. Kappa Carrageenan,
vii. Cross linked Enzyme crystals

Results

Silanised Glass beads (1-2mm Diameter) with 1% Silane were found to be highly effective in

A. Mechanical strength
B. Enzyme stability (T50 more than 60 cycles)
C. Thermal and pH stability.
D. Storage and Environmental stability

Immobilized Enzyme Bioreactor

- Synthetic wastewater was used to evaluate the efficiency of the enzymes and the generation of hydroxyl radical was evaluated.
- To prevent fouling of the enzymes by the hydroxyl radical, the inclusion of the enzyme beads into PVDF porous membrane bags was found to be effective and removal of hydroxyl radical from the packed porous membrane bag was effective.
- The BOD and COD reduction was found to be above 98%.
- The immobilized bio-oxidation enzyme system was found to degrade the Lignin and organic matter in Paper mill effluent and in pharmaceutical effluents.

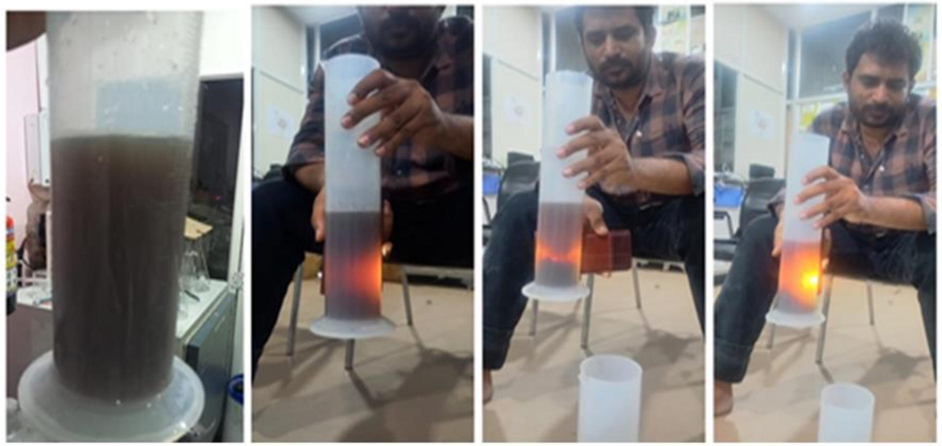
Ammoniacal Nitrogen Reduction

Sample ID	Units	Raw	After Treatment
Aeration 1	PPM	2000	48
Aeration 2	PPM	3000	52
High TDS ET	PPM	3200	45
High TDS conc.	PPM	2800	43
LTDS conc.	PPM	600	40
LTDS collection	PPM	500	35
LTDS Hold	PPM	500	32
2000 KLD	PPM	300	50

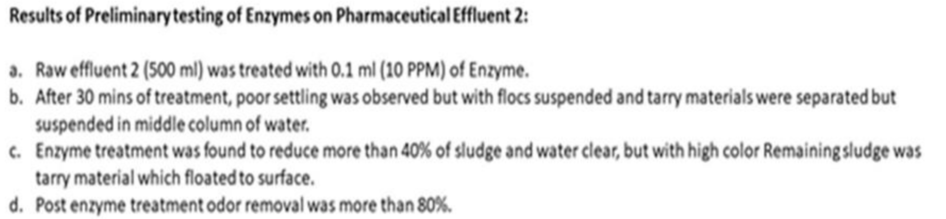
COD and Ammoniacal Nitrogen Removal from Pharmaceutical Effluent

S. No.	Parameter	Units	Permitted limits	Initial Concentration	Final after treatment
1	COD	mg/L	< 250	8000	197
2	TDS	mg/L	< 1200	2654	673
3	pH	---	7.00 – 8.00	8.9	7.2
4	Color	Hazen Units	Less than 10 HU	56	7
5	Turbidity	NTU	Less than 10	164	8
6	TSS	mg/L	Less than 20	51	5
7	Ammoniacal Nitrogen	mg/L	<50	2379	36
8	Odor	--	Nill	Pungent Pyridine odor	Mild fermented odour

Method of analysis: As per APHA (American Public Health Association) method

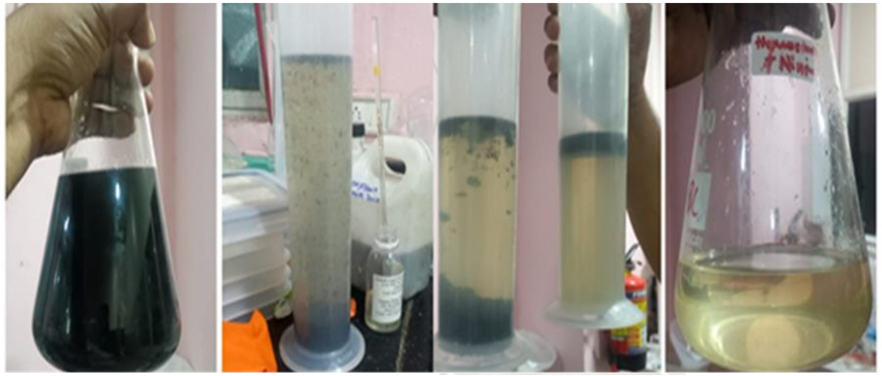


Raw Effluent **Post enzymatic treatment (30 min)** **Post enzymatic treatment (45 min)** **Post enzymatic treatment (1h)**

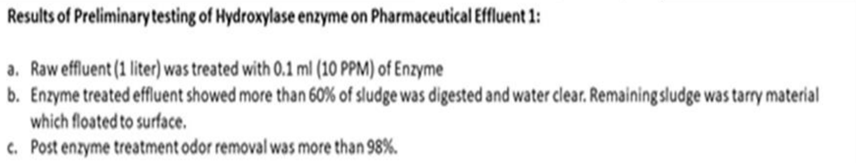


Results of Preliminary testing of Enzymes on Pharmaceutical Effluent 2:

a. Raw effluent 2 (500 ml) was treated with 0.1 ml (10 PPM) of Enzyme.
b. After 30 mins of treatment, poor settling was observed but with flocs suspended and tarry materials were separated but suspended in middle column of water.
c. Enzyme treatment was found to reduce more than 40% of sludge and water clear, but with high color Remaining sludge was tarry material which floated to surface.
d. Post enzyme treatment odor removal was more than 80%.



Raw Effluent **Post enzymatic treatment (30 min)** **Post enzymatic treatment (45 min)** **Post enzymatic treatment (1h)**



Results of Preliminary testing of Hydroxylase enzyme on Pharmaceutical Effluent 1:

a. Raw effluent (1 liter) was treated with 0.1 ml (10 PPM) of Enzyme
b. Enzyme treated effluent showed more than 60% of sludge was digested and water clear. Remaining sludge was tarry material which floated to surface.
c. Post enzyme treatment odor removal was more than 98%.

CONCLUSION

A bio-oxidation system to treat pollutants in wastewaters.

Deliverable Reference No.	Deliverable Title
D7.1	Prototype system
D8.1	Report and field data
D8.2	Commercially viable product

A completely autonomous bio-0xidation system with onboard sensors, electronics, actuation systems, auto-diagnostics and communication with remote control center: **TRL 6 (at the end of project tenure)**

SO8: Developing stakeholders decision making and management framework (Municipality and NGOs, State Water Board) to apply the developed remediation system.

INDO-NORDIC WATER FORUM ESTABLISHED

Mission and Vision

INWF acts as a joint network and platform for water stakeholders in India and the Nordics, aiming to solve water management challenges with a multi-stakeholder approach.

INWF
Indo Nordic Water Forum

Scaling up of multistakeholder cooperation on water management

Supporting and developing the EU-India Strategic Partnership

Achieving SDG 6: Clean Water and Sanitation

Facilitate networking

Joint project development

White Paper development

October 2021
INWF founded in Delhi by Nordic Ambassadors

April 2022
MoU Gujarat Water Supply and Sewerage Board

March 2023
SPRING Water Summit in Delhi

September 2023
Indo Nordic Water Seminar Delhi/Online

January 2024
Commercial project with State of Haryana

January 2024
EU-India Water Tech Event

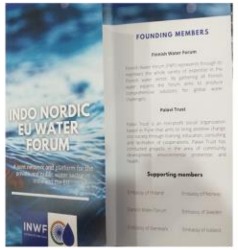
March 2024
SPRING Water Summit in Delhi

June 2024
Annual Board Meeting, Review of 2025 strategy

October 2024
Nordic Pavilion IFAT Mumbai

1. ORGANISED **INTERNATIONAL WATER DAY SEMINAR** IN DELHI ON 21-22 MARCH 2022 AND WORLD ENVIRONMENT DAY IN JUNE 2022
2. **MOU WITH GUJRAT JAL(WATER) BOARD** AS PARTNER INEUWF IN 2022-2023
3. **MOU WITH MIT, PUNE** IN 2022-23
4. MOUs WITH ALL STAKEHOLDERS OF SPRING PARTNERS
5. ORGANISED **INTERNATIONAL SEMINAR CUM TECHNOLOGY DEMONSTRATION** (MIT, FWF,DYP, ELIX, PAL) ON MUTHA-MULA RIVER, PUNE ON 25 MAY 2022
6. ORGANISED **INTERNATIONAL WATER SUMMIT** IN NEW IN DELHI ON 09 TO 11 MARH 2023
7. ORGANISED AN **INTERNATIONAL SEMINAR CUM TECHNOLOGY DEMONSTRATION** (MIT, FWF,DYP, ELIX, PAL) ON SUKHRALI LAKE, GURGAON ON 02 OCT 2023
8. PUBLICATIONS REVIEWS AND NEWS IN MEDIA CARRIED OUT

Dissemination and Outreach Activities	
04 research articles, 07 book chapters, 01 patent filed, Research articles from all Institutes in pipeline	**Outreach**
> 20 manpower trained, several PhDs from India jointly supervised	Online/personal consortium/stakeholder meeting – Palavi Trust, SRKREC
Seminars/Workshops	Demo sites – keen interest from water sector in India – Palavi Trust
International Water Day Webinar – Palavi Trust	INEUWF pilot launch - >1000 contacts – FWF/Palavi
Research/student seminars – Research partners	Mapping EU/India water/wastewater actors – FWF/Palavi
Stakeholder workshop (hybrid) - SRKREC	Webinars – Ministries, Embassies, water industries – FWF/Palavi Trust
International Conference on River Health – IIT BHU	Social media, press releases, website https://en.uit.no/project/springeuindia-eu




WORLD WATER DAY- 23 March 2022
WEBINAR ON
GROUND WATER - MAKING THE INVISIBLE VISIBLE

PALAVI TRUST, PUNE

Speaker
Mr. Kirk Johnson, Finland

Speaker
Mr. Peeyush Gupta
NMCG, Ministry of Jal Shakti, New Delhi

Hon'ble Sh. Ramveer Tanwar
(Pond Man)
Keynote Speaker

Horizon 2020
Indo-EU Cooperation

Col (Dr) S S Malik
Director & Chief Organiser

Speaker
Mr. Antti Herlevi, Finland

Speaker
Dr. Jaya Dubey
PGIMER, Chandigarh

Time: 4:00-5:00 pm
Date : 23rd March 2022
JOIN ZOOM ID-9196981707
ZOOM PASSCODE- 12345
Contact info: 8698101562
Email-palavitrust@gmail.com

Era Sahai Jasra
Moderator


दैनिक भास्कर झज्जर भास्कर 21-09-2023

विभिन्न संस्थाओं से आए वक्ताओं ने देश के प्रति अपनी जिम्मेदारियों का एहसास कराया

चौ. रणबीर सिंह इंजीनियरिंग कॉलेज में अमृतकाल विमर्श: 2047 का आयोजन

Prof. Rajnish Kaur Calay, UiT-Norway Visit to WET Centre, SRKREC-India


ఎస్ఆర్‌కేఆర్ కళాశాలలో రీసెర్చ్ సెంటర్ ప్రారంభం

భీమవరం: విద్యార్థులతో ప్రజలు సమాజంలో ఎదుర్కొంటున్న సమస్యలపై పరిశోధనలు నిర్వహించాలని నార్వేలోని ఆర్కిటిక్ యూనివర్సిటీ ప్రొఫెసర్ రజనీష్‌కౌర్ కాలె అన్నారు. బుధవారం భీమవరం ఎస్.ఆర్.కె.ఆర్. ఇంజినీరింగ్ కళాశాల సందర్శించి సందర్భంగా కళాశాలలో నూతనంగా ఏర్పాటుచేసిన సస్టేయినబుల్ హేబిటేట్స్ అండ్ రెనియబుల్ ఎనర్జి ఇంజినీరింగ్ రీసెర్చ్ సెంటర్‌ను ఆమె ప్రారంభించారు. అనంతరం వెట్ సెంటర్‌లో నిర్వహించిన కార్యక్రమంలో ఆమె మాట్లాడుతూ యూరోపియన్ యూనియన్ దేశాలతో భారతదేశం 2020 నాటికి పూర్తయ్యే విధంగా 72 ప్రాజెక్టులు చేపట్టిందని ఆమె చెప్పారు. కళాశాల స్థాయిలో రెండు, మూడు డిపార్ట్‌మెంట్లు కలిపి ఒక ప్రాజెక్టు చేయాలని రజనీష్‌కౌర్ కాలె సూచించారు. అందుకు నార్వే యూనివర్సిటీ తమ వంతు సహకారం అందిస్తుందన్నారు. కళాశాల వెట్ సెంటర్ ఆర్‌అండ్‌డి డాక్టర్ పి.ఎ.రామకృష్ణంరాజు మాట్లాడుతూ వెట్ సెంటర్ ఆధ్వర్యంలో జరుగుతున్న ప్రాజెక్టులు వివరించారు. భారతదేశంలో ఐఐటీలు వంటి ప్రతిష్ఠాకరమైన సంస్థలతో కలిసి విదేశీ విశ్వవిద్యాలయాలతో కలిసి ప్రాజెక్టులు చేయడానికి ఎస్ఆర్‌కేఆర్ కళాశాలకు అవకాశం రావటంపై ఆయన ఆనందం వ్యక్తం చేశారు. కళాశాల సెక్రటరీ అండ్ కరస్పాండెంట్ సాగి విఠల్ రంగరాజు, ప్రిన్సిపాల్ డాక్టర్ ఎం.జగపతిరాజు, వెట్ సెంటర్ రీసెర్చ్ అసోసియేట్ ఎస్.శివకిషన్ తదితరులు పాల్గొన్నారు.

ఎస్ఆర్‌కేఆర్ కళాశాలలో రీసెర్చ్ సెంటర్‌ను ప్రారంభిస్తున్న రజనీష్‌కౌర్ కాలె

సాక్షి Thu, 21 November 2019
https://epaper.sakshi.com/c/45980653

Dissemination Activities/Information to Policy Makers


Prof PARK Raju Presenting SPRING activities at District collectorate


Dissemination of SPRING activities to the Policy Makers/ Ministers


Public representatives visit our Laboratories and appreciating our efforts


Prof PARK Raju interacting with Public representatives, showcasing the importance of SPRING Project


MLA seeks experts' advice on construction of barrages

Grandhi Srinivas strives for building two barrages downstream of Dhowleswaram Barrage for protecting the delta area from salt water from sea as well as to fully utilise Godavari waters

HANS NEWS SERVICE
BHIMAVARAM

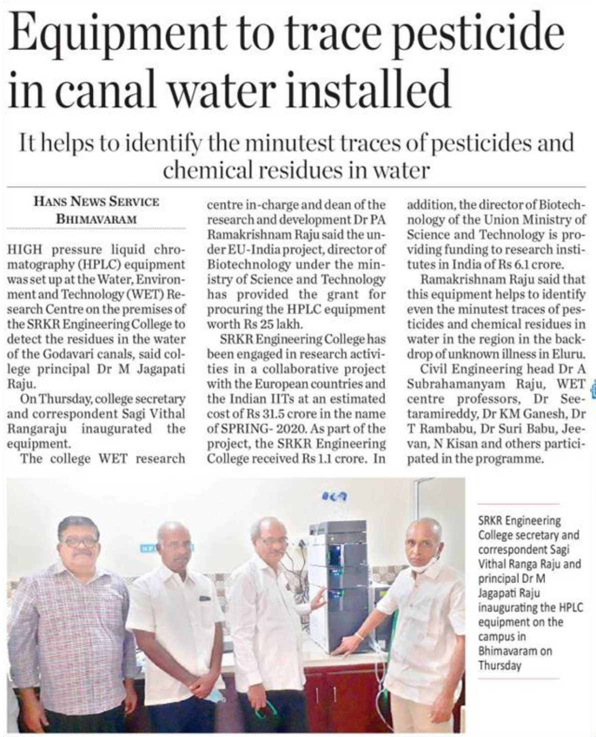
BHIMAVARAM MLA Grandhi Srinivas has asked for the experts' advice on construction of two barrages downstream of Dhowleswaram Barrage for protecting the delta area from salt water from sea as well as to fully utilise Godavari waters.

While visiting the Water and Environment Testing (WET) centre at SRKR Engineering College here on Sunday, the MLA expressed concern over the wasteful flow of water into the sea during the monsoon season. He assured the experts that he would take the issue to the notice of Chief Minister YS Jagan Mohan Reddy if they suggested for the two barrages downstream.

He recalled that the Chief Minister took a right decision to stop water from Prakasam Barrage in Vijayawada flowing into the sea by ordering construction of two barrages downstream of Prakasam Barrage.

The WET centre head Dr PA Ramakrishnam Raju explained to the MLA that the centre had developed vast data with the help of satellite images to clearly identify land use and rainfall in different areas in the district, wet lands, canals, drains and entire data is available in the centre. Recently, SRKR College signed the MoU with EU-India project to analyse entire district canals and drain water quality to develop one tool in European Union research centres to purify the polluted water. College principal Dr M Jagapati Raju and secretary and correspondent Sagivithal Ranga Raju assured the MLA that SRKR research centres are always ready to serve society.

The head of the WET Centre of SRKR Engineering College, Dr PA Ramakrishnam Raju explaining the data map to MLA Grandhi Srinivas in Bhimavaram on Sunday


Equipment to trace pesticide in canal water installed

It helps to identify the minutest traces of pesticides and chemical residues in water

HANS NEWS SERVICE
BHIMAVARAM

HIGH pressure liquid chromatography (HPLC) equipment was set up at the Water, Environment and Technology (WET) Research Centre on the premises of the SRKR Engineering College to detect the residues in the water of the Godavari canals, said college principal Dr M Jagapati Raju.

On Thursday, college secretary and correspondent Sagi Vithal Rangaraju inaugurated the equipment.

The college WET research centre in-charge and dean of the research and development Dr PA Ramakrishnam Raju said the under EU-India project, director of Biotechnology under the ministry of Science and Technology has provided the grant for procuring the HPLC equipment worth Rs 25 lakh.

SRKR Engineering College has been engaged in research activities in a collaborative project with the European countries and the Indian IITs at an estimated cost of Rs 31.5 crore in the name of SPRING- 2020. As part of the project, the SRKR Engineering College received Rs 1.1 crore. In addition, the director of Biotechnology of the Union Ministry of Science and Technology is providing funding to research institutes in India of Rs 6.1 crore.

Ramakrishnam Raju said that this equipment helps to identify even the minutest traces of pesticides and chemical residues in water in the region in the backdrop of unknown illness in Eluru.

Civil Engineering head Dr A Subrahamanyam Raju, WET centre professors, Dr Seetaramireddy, Dr KM Ganesh, Dr T Rambabu, Dr Suri Babu, Jeevan, N Kisan and others participated in the programme.

SRKR Engineering College secretary and correspondent Sagi Vithal Ranga Raju and principal Dr M Jagapati Raju inaugurating the HPLC equipment on the campus in Bhimavaram on Thursday


జల గరళం


ఈనాడు

కలిస్తే కడలికి చేటు!

Date : 10/12/2021 EditionName : ANDHRA PRADESH(WEST GODAVARI) PageNo : 01

Deliverable Reference No.	Deliverable Title
D9.1	Public Web Portal
D9.2	Business Plan & Extension Activities

TECHNOLOGY OUTCOME

1. **Spatial maps** of the River Ganga and Godavari delta region to identify pollutant hot spots and type of pollutants.
2. **River Health Index** indicator analysis tool.
3. Enzyme for **advanced bio-oxidation process** and **scale-up process** for mass production.
4. **Integrated advanced bio-oxidation system** for remediation of wide spectrum of pollutants in point and non-point sources.
5. Development of a **low-cost ESP32-based real-time water monitoring system** with hybrid power management and remote data accessibility (Ready prototype).
6. **Microbial sensory platform** for BOD and toxic compound detection.
7. **Automated smart technology for river environmental analysis** and mobile enzyme release.
8. **Automated smart technology for blockage detection** and cleaning of underground pipes.

SUSTAINABILITY CHALLENGES AND MAINTENANCE OF ON-FIELD ACTIVITIES POST PROJECT COMPLETION

1. Overarching goal of SPRING: **A long term consistent solution** to the contaminated Indian and European water bodies as **part of a green sustainability strategy**.
2. Beyond the project period, efforts towards **multi-stakeholder learning alliances** will be institutionalized in the SPRING community of practice (CoP) for dissemination of the developed viable technology (that will be covered by IPR).
3. **SME partner** ELI shall take the responsibility of the continued demonstration while having made necessary financial and resource arrangements from either the local governing bodies or the Government bodies.
4. **BMC** shall extend its resource support for sites at Bhimavaram Municipality.
5. A **technology action plan** to identify other small water suppliers for undertaking the maintenance through the technology developed in association with the respective Municipalities will be undertaken.

Thank You

सत्यमेव जयते
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