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

DST - IIT Madras Water Innovation Centre

for

Sustainable Treatment, Reuse and Management for Efficient, Affordable and Synergistic Solutions for Water

DST Sanctioned No: DST/TM/WTI/WIC/2K17/82(G) dated 23rd October 2018

(Water-IC for **SUTRAM for EASY WATER**).

Aims and Objectives

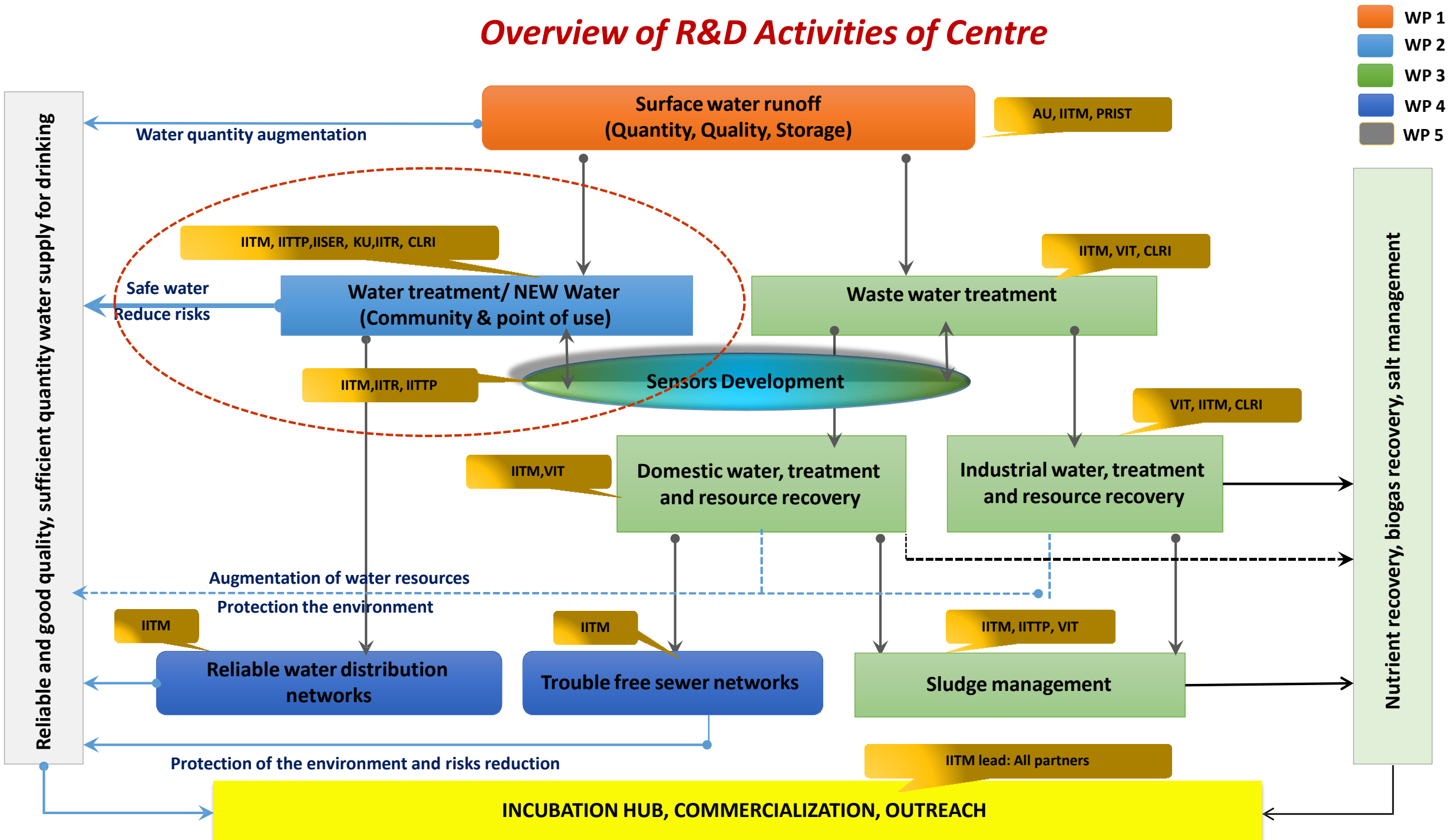
Aims

The overall goal is to ensure adequate, safe, reliable and sustainable sources of drinking water for rural and urban India and process water for highly polluting and water intensive industries through research, technology development and capacity building.

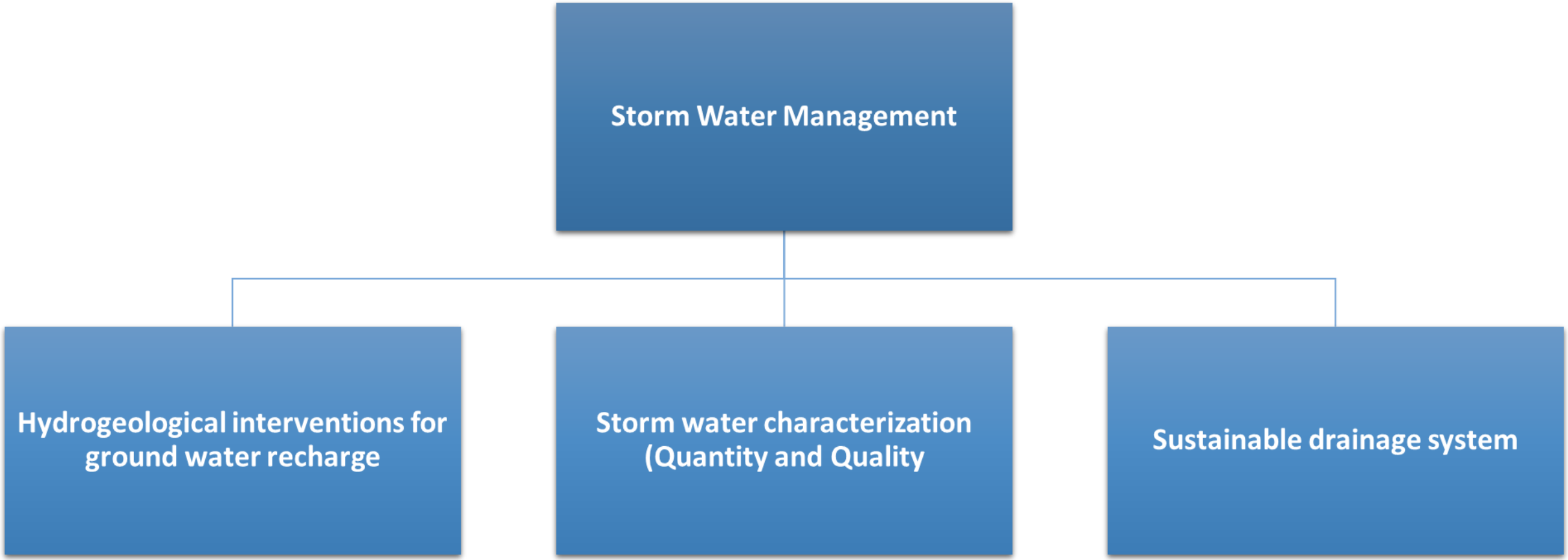
Objectives

- To develop strategies and technologies for sustainable treatment, reuse and management of water.
- To translate the water technologies using the resources, mechanisms and knowledge acquired and close the innovation loop.
- To have active engagement with researchers and the innovators across the country and abroad
- Incubation and commercialization of developed technologies and products

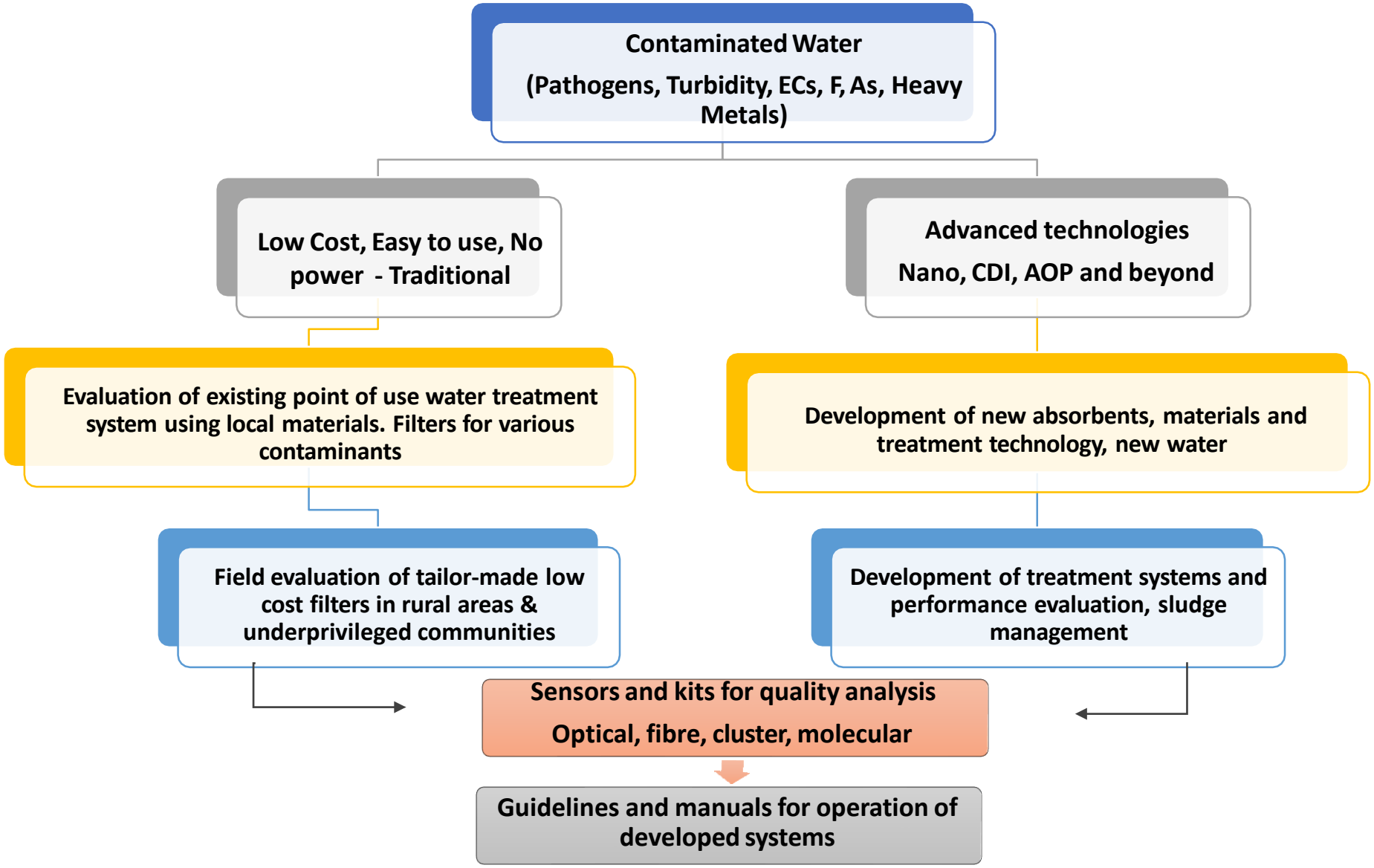
Overview of R&D Activities of Centre



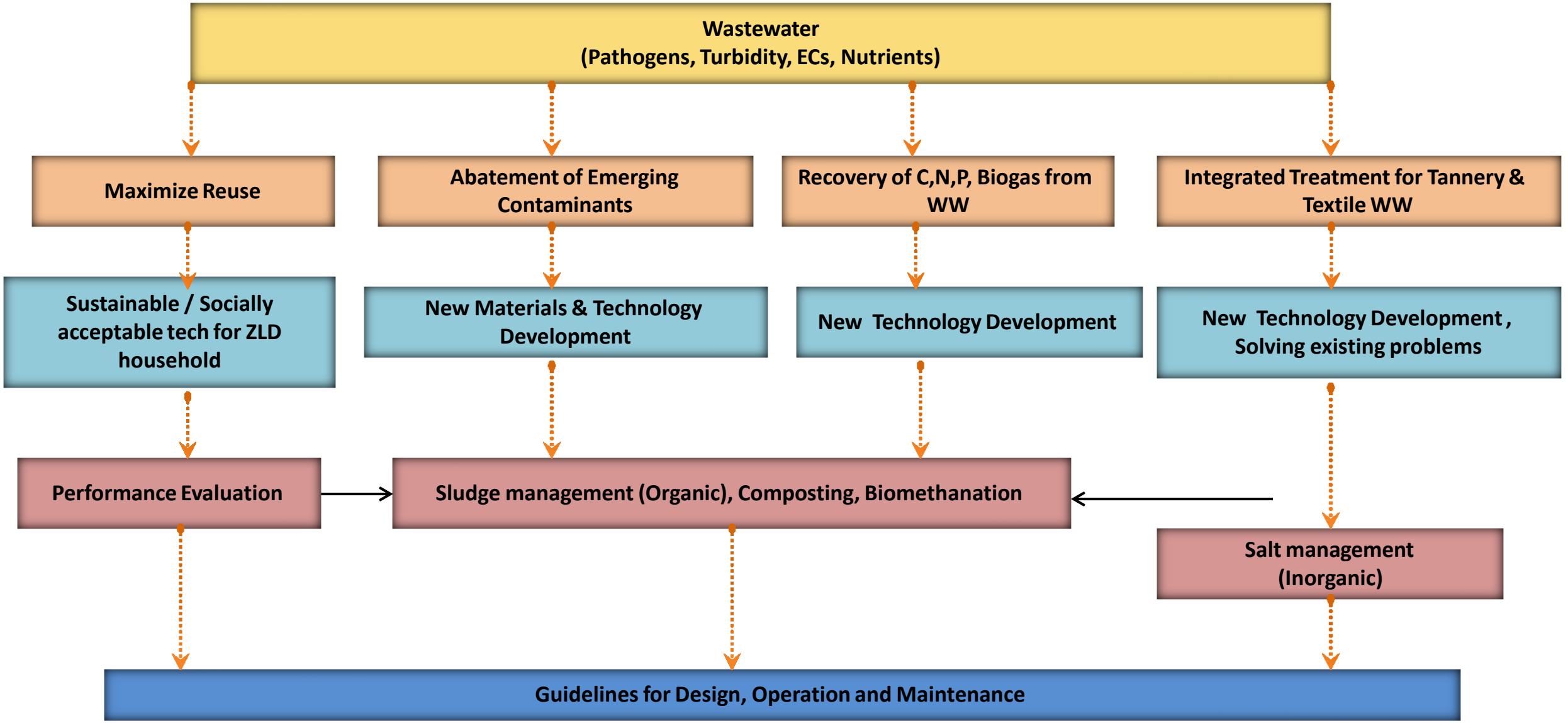
Work Package - 1: Storm Water Management



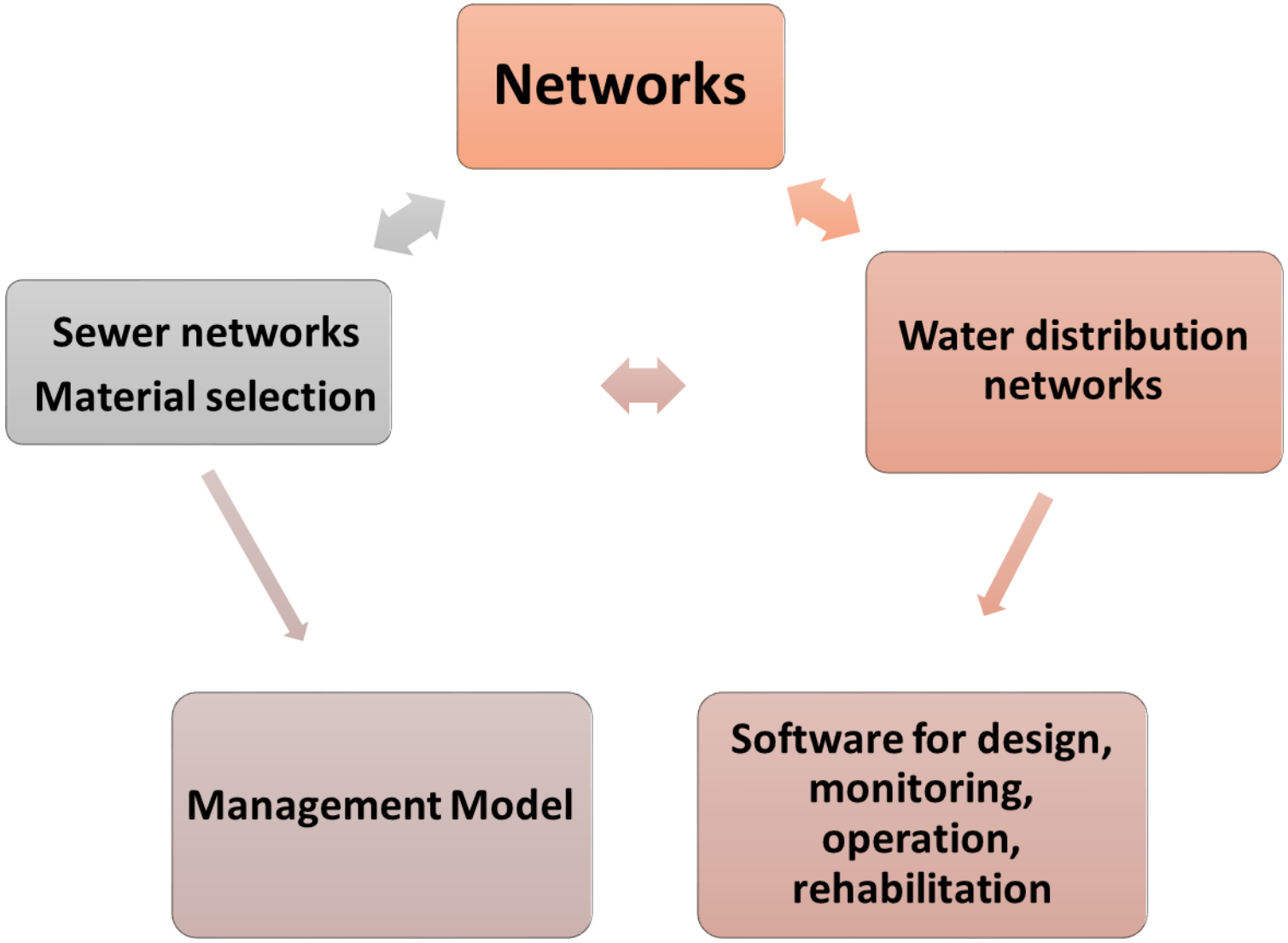
Work Package - 2: Water Treatment



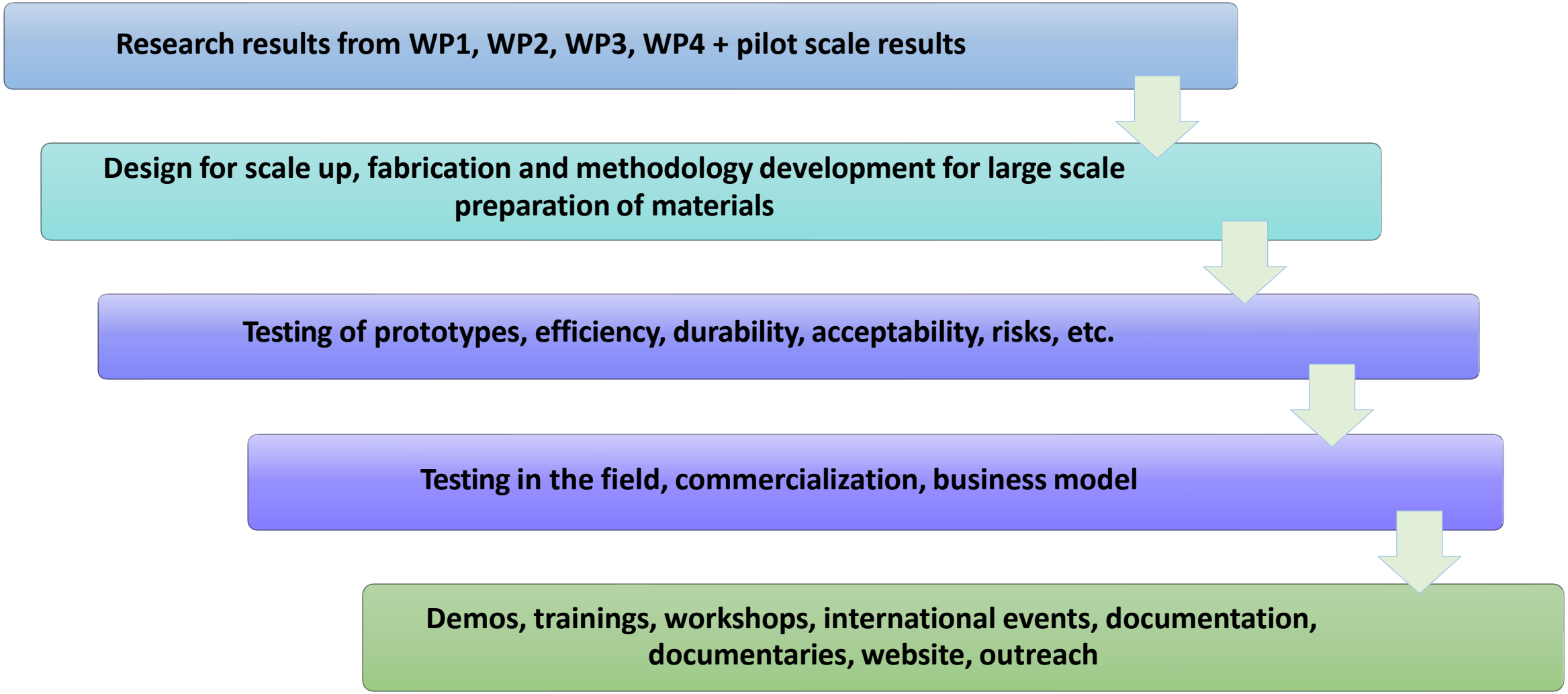
Work Package - 3: Wastewater Management



Work Package - 4: Collection and Distribution



Work Package - 5:
Incubation HUB – Commercialization Outreach



Participants

Principal Investigator (s): Ligy Philip & T. Pradeep

Lead institute: IIT Madras

Co-Investigators

From IITM

- Dr. B.S. Murty
- Dr. Balaji Narasimhan
- Dr. Ravindra Gettu
- Dr. Shankar Narasimhan
- Dr. Sridharakumar Narasimhan
- Dr. Boby George
- Dr. R. Sarathi

- Prof. L. Elango, Anna Univ.
- Dr. J. Raghava Rao, CSIR-CLRI
- Dr. S.V. Srinivasan, CSIR-CLRI
- Dr. S. Easwaramoorthi, CSIR-CLRI
- Prof. P. C. Sabumon, VIT Chennai
- Dr. M. M. Shihabudheen, IIT Tirupathi
- Prof. Alok Dhawan CSIR-IITR
- Dr. Satyakam Patnaik, CSIR-IITR
- Dr. Abhijit Patra, IISER Bhopal
- Dr. Nanda Gopal Sahoo, Kumaun Univ.
- Dr. Ashutosh Das, PRIST Univ.

- Mr. Selvan, Mannarai Common Effluent Treatment Plant Pvt. Ltd.
- Mr. Anshup, InnoNano Resaerch Pvt. Ltd.
- Mr. Vijay Sampath, InnoDI Water Technologies Pvt. Ltd.

Targeted Objectives

1. MANAGING THE WATER SOURCES (Lead: L. Elango, Anna University)

- 1.1 Aquifer Recharge Management (Lead: Dr. L. Elango, Anna University)
- 1.2 Sustainable Urban Drainage Systems (Lead: Dr. Balaji Narasimhan, IIT Madras)
- 1.3 Storm water : Characterization, Surveillance, Modeling and Forecasting (Lead: Dr. Ashutosh Das, PRIST University)

2. WATER TREATMENT (Lead: Dr. T. Pradeep, IITM)

- 2.1 Community based / Point of use Water Treatment units for removal of various pollutants (Lead: Dr. Ligy Philip, IIT Madras)
- 2.2 Point of use Treatment for Rural and Underprivileged Communities (Lead: Dr. Ligy Philip, IIT Madras)
- 2.3.1 Contaminant Removal: Nano-technology based solution (Lead: Dr. Shihabudheen M. Maliyekkal, IIT Tirupati)
- 2.3.2 Removal of Emerging Contaminants: Novel Adsorbents (Lead: Dr. Ligy Philip, IIT Madras
- 2.3.3. Removal of Emerging Contaminants: Advanced Oxidation (Lead: Dr. Ligy Philip, IIT Madras)
- 2.4.1 Sensors and Kits for Water Quality Monitoring: CLRIs component (Lead: Dr. S. Eswaramoorthi, CSIR-CLRI, Chennai)
- 2.4.2 Sensors and Kits for Water Quality Monitoring: IITM component (Lead: Dr. T. Pradeep, IIT Madras)
- 2.4.3 Low -cost microfluidic platform for multi-analyte assessment of water quality (Lead: Dr. T. Pradeep, IIT Madras)
- 2.5 Atmospheric Water Capture (Lead: Dr. T. Pradeep, IIT Madras)
- 2.6. CDI Prototype (Lead: Dr. T. Pradeep, IIT Madras)
- 2.7. Environmental impact (Dr. Satyakam Patnaik and Dr. Alok Dhawan, CSIR-IITR, Lucknow)
- 2.8. New Framework Solids for Water Purification (Lead: Dr. Abhijit Patra, IISER, Bhopal)
- 2.9 Field Testing of Water Filters in Nainital (Lead: Dr. Nand Gopal Sahoo, Kumaun University, Nainital)

Targeted Objectives , Contd.

3. WASTEWATER MANAGEMENT (Lead: Dr. Ligy Philip, IIT Madras)

- 3.1 Zero Liquid Discharge Homes and Apartments (Lead: Dr. Ligy Philip, IIT Madras)
- 3.2 Biological sludge management from onsite, decentralized systems: (Lead: Dr. Ligy Philip, IIT Madras)
- 3.3 Fate of emerging contaminants in treatment plants and remedial measures (Lead: Dr. Ligy Philip, IIT Madras)
- 3.4.1 Process Know-how for Removal/Recovery of Nutrients from Wastewater (Lead: Dr. P.C. Sabumon, VIT, Chennai)
- 3.4.2 N, P, Biogas Recovery from Wastewater using Bio-electrochemical Systems (Lead: Dr. Mukesh Goel, PRIST University)
- 3.5 Tannery Wastewater Treatment (Lead: Dr. S.V. Srinivasan, CSIR-CLRI, Chennai)
- 3.6.1 Integrated treatment of Textile Wastewater using Pulse Power Technology (Lead: Dr. Ligy Philip, IIT Madras)
- 3.6.2 Decolorization of azodyes from textile wastewater (lead: Dr. P.C. Sabumon, VIT, Chennai)

4. WATER DISTRIBUTION AND SEWER NETWORKS (Lead: Dr. Sridharkumar Narasimhan, IIT Madras)

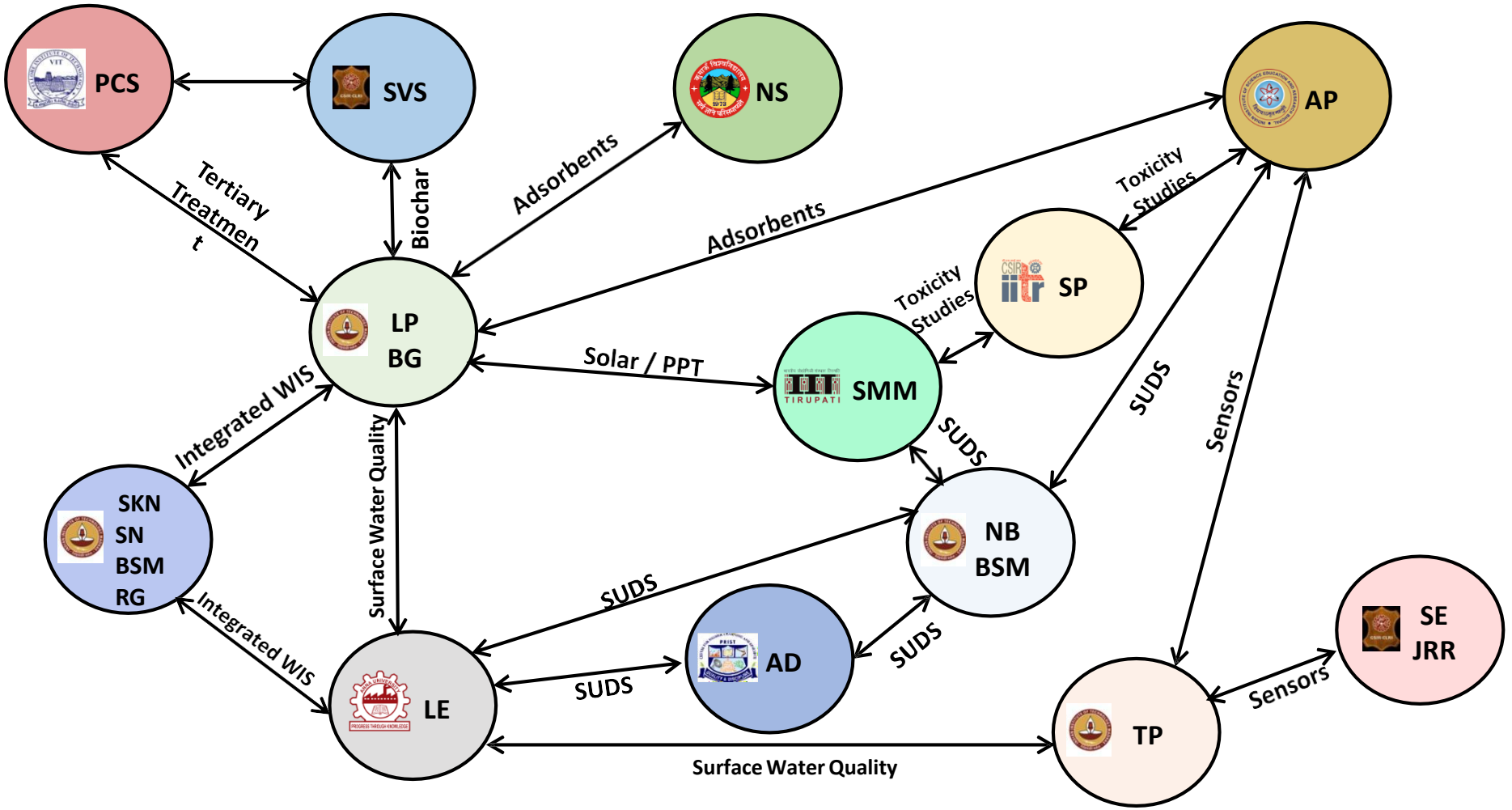
- 4.1 Retrofit Design and Operation of Sewer Networks (Lead: Dr. B.S. Murty, IIT Madras)
- 4.2 Decision Support System for Pipe Material Selection (Lead: Dr. Sridharkumar Narasimhan, IIT Madras)
- 4.3 Design, Monitoring, Operation and Rehabilitation of WDNS (Lead: Dr. Shankar Narasimhan, IIT Madras)

5. INCUBATION HUB (Lead: Dr. T Pradeep, IIT Madras)

Collaborative Research & Group activities

SUTRAM – SYNERGY- ALREADY WORK IN PROGRESS

Identified areas where inter institutional cooperation is possible. Many initiatives are already taken



Collaborative Research & Group activities

Regular Review meetings
All PIs/Co-PIs and project staff attend in person, discuss the action taken, results and way forward in detail

Kick off meeting of SUTRAM Projectheld on 3rd December 2018 at IIT Madras

First Internal Project Review meeting held on 16th March 2019 at IIT Madras

Second Internal Project Review meeting held on 14th September 2019 at IIT Madras

Third Internal Project Review meeting held on 2nd February 2020 at IIT Tirupati

Fourth Internal Project Review meeting (Virtual) held on 27th February 2021

Major Outcomes

Journal / Conference Publications

- **Journal Publications:**
  - **Published / Accepted: 30**
  - **In Review: 16**
- **Conferences/Symposia: 14**
- **Patents Filed**
  Patents/copyrights Filed: 9

Awareness Program /Workshops etc., Knowledge Strengthening Programm or Awareness Camps

- **Half-Day Brain Storming Session on Planning of Water Infrastructure of Chennai" held on 1st July 2019 at IIT Madras**
- **Co-hosted in the State-level Science Exhibition amongst School-students, with support of TNSCST during 2018-19 & 2019-20.**
- **Webinar on "Advanced techniques in groundwater resources management" by KSCSTE-CWRDM, Kozhikode, Kerala**
- **Seminar on "Advances in flood modelling – coastal & inland cities" by DHI**
- **Seminar on "Introduction to river and channel modelling" by DHI**
- **Training on "Impact of climate change on water resources" by Rajiv Gandhi National Ground Water Training & Research Institute, Raipur**

ENAGAGEMENT WITH STAKEHOLDERS

Entire Group is involved in CMWSSB Wastewater Management Projects. At this stage Profs.: Elango, Balaji, Murty and Ligy are involved in helping them preparing the DPR and execution of phase 1 of the project

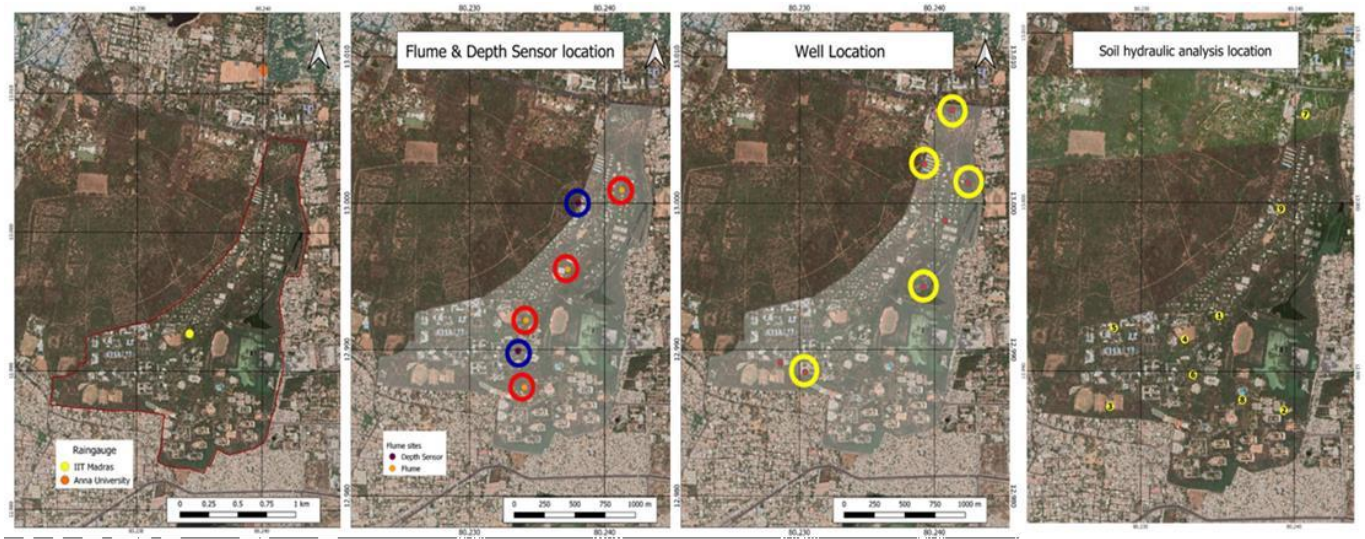
Brain Storming Session with CMWWSB Officials on 1st July 2019

- **MOU signed with M/s: Greenvironment Innovation and Marketing India (P) Ltd. Chennai as Advisory to Greenvironment Innovation and Marketing India (P) Ltd**
- **Saint Gobain-Signed an MoU regarding membrane evaluation and up-gradation**
- **Signed an MoU with international centre for clean water (ICCW) for up gradation and commercialization of greywater treatment system**
- **Going to sign an MoU with Toray International, Japan on wastewater treatment and recycling**

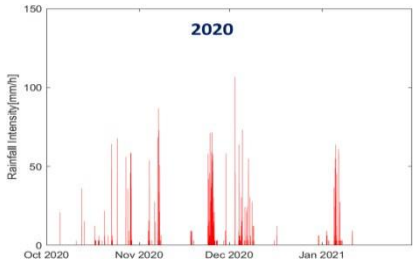
PROGRESS: WP-1: STORM WATER MANAGEMENT (Sustainable Urban Drainage)

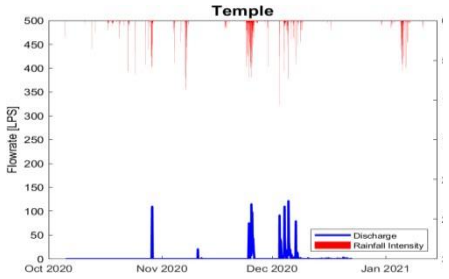
SUSTAINABLE DRAINAGE SYSTEM(Suds) components: design and development methodology (Balaji Narasimhan & B. S. Murty, IIT Madras)

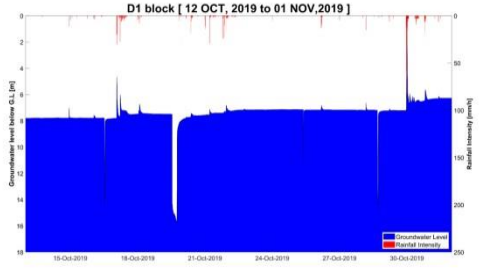
1. Critical Primary Data has been Collected



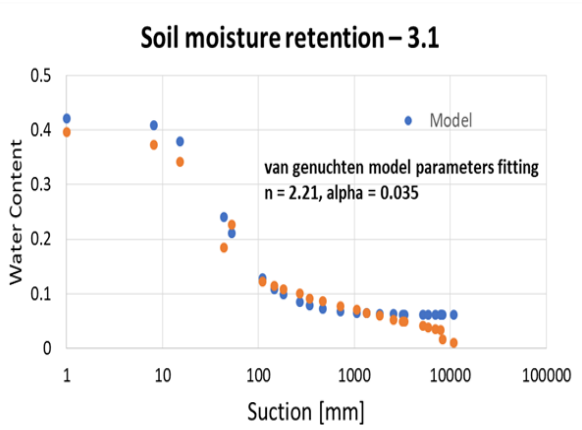
Rainfall Data **Flow Data** **Groundwater**

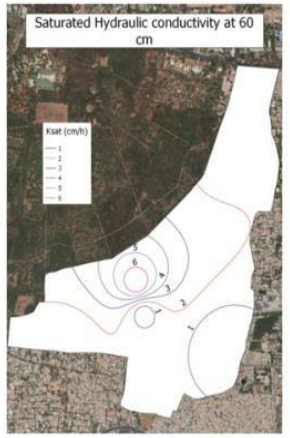


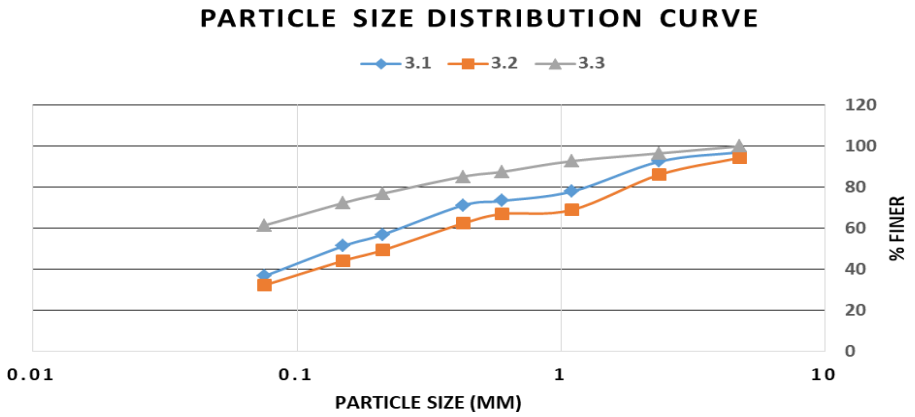




2. Data was used to calculate values of input parameters



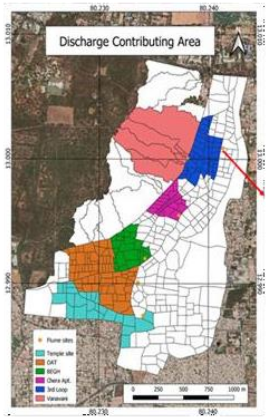


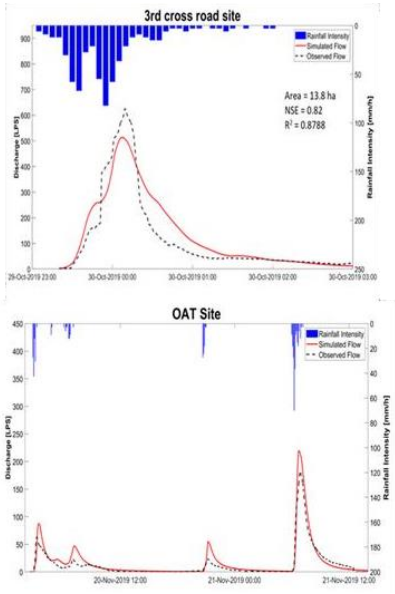


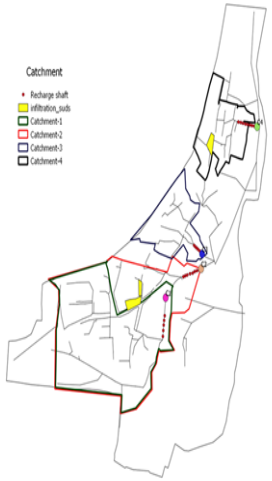
PROGRESS: WP-1: STORM WATER MANAGEMENT (Sustainable Urban Drainage)

SUSTAINABLE DRAINAGE SYSTEM(Suds) components: design and development methodology (Balaji Narasimhan & B. S. Murty)

Calibrated the SWMM Model for SUDS Design



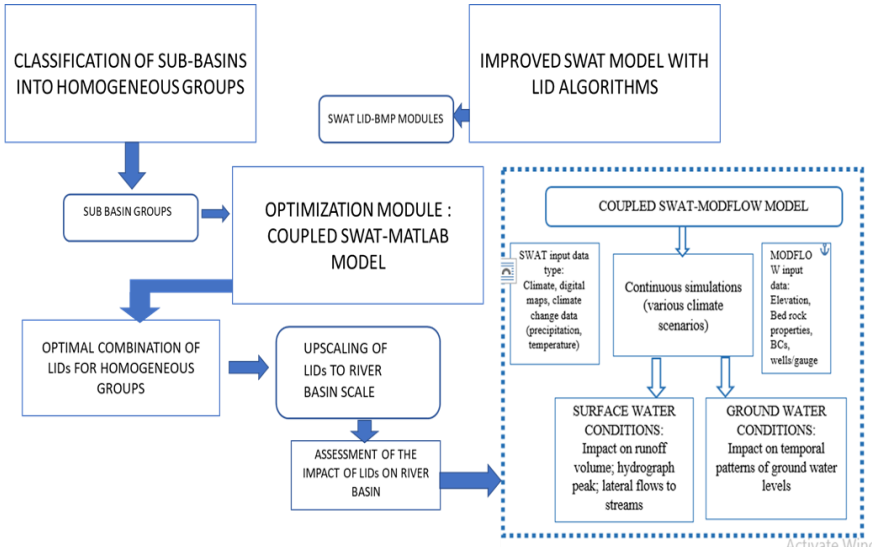




Different SUDS scenarios studied

SUDS Scenarios	Peak runoff reduction %					
	Rainwater harvesting	Infiltration Basin	Recharge shaft	RWH + Infiltration basin	RWH + Recharge shaft	RWH + Infiltration basin + Recharge shaft
Catchment-1	23.7	-	6.5	-	30.92	-
Catchment-2	22	16.1	4.96	37.85	28.25	52.54
Catchment-3	16.35	-	3.1	0.9	16.78	-
Catchment-4	15.8	13.58	6.37	29.35	18.39	34.74

New Framework for SUDs application to Basins



A methodology has been developed to utilize HYDRUS-1D model for parameterizing infiltration based LIDs in SWMM
(Important: Infiltration component in SWMM model is week; it does not contain groundwater recharge)

It is demonstrated how SWMM model can be used to evaluate effectiveness of different SUDs scenarios

A framework has been developed for application of concept of SUDs for managing water at basin level
(Until now, SUDS has been applied only for urban drainage)

PROGRESS: WP-1: STORM WATER MANAGEMENT (Hydrogeological Interventions)

Hydrogeological interventions for flood mitigation and augmentation of groundwater recharge (L. Elango, Anna University)

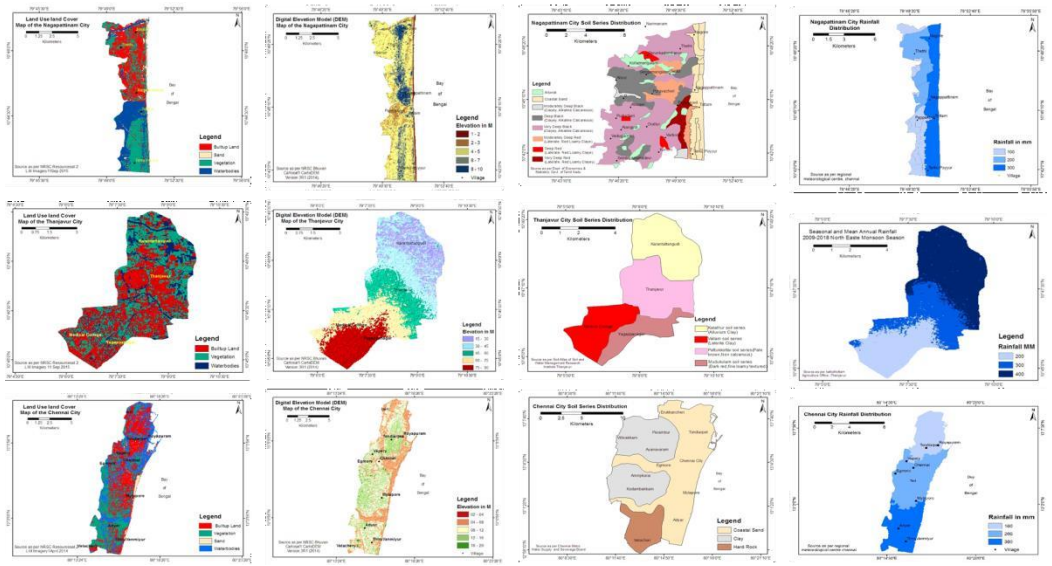
Technological outcomes and achievements

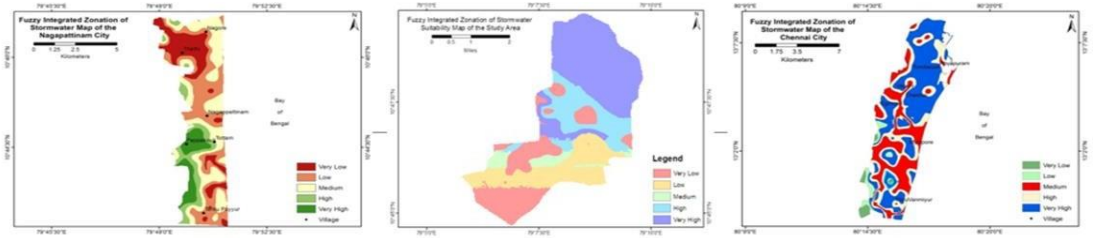
- **Tentative alignment of channels for diverting water from the lake/river to the quarries has been completed**
- **Development of surface hydrological model of the catchment is being developed**
- **Pilot scale percolation pond was constructed and the quantification of recharge were made**

PROGRESS: WP-1: STORM WATER MANAGEMENT (Storm Water Characterization)

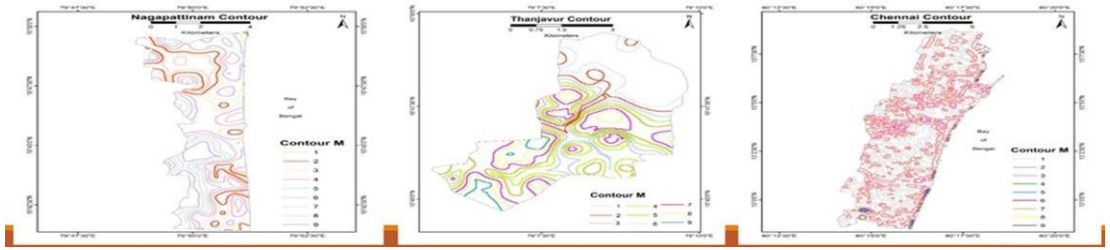
Storm Water Characterization modelling and forecasting (Ashutosh Das, PRIST University)

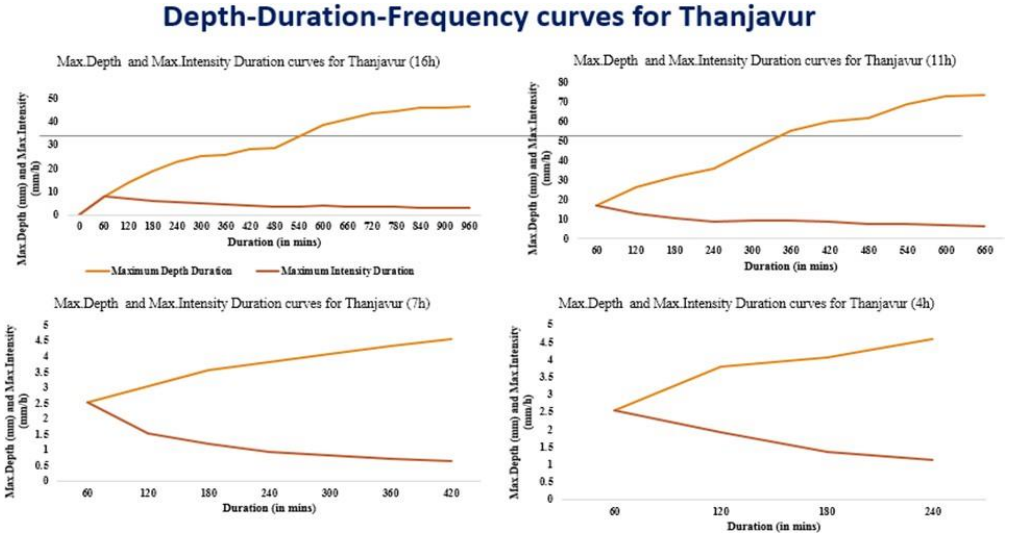
- Preparation of Zone-specific Depth-Duration-Frequency curves
- Development and validation of Unit Hydrographs
- Validation of Water quality-integrated model through representative primary field data of 2019-20





STORM WATER SUITABILITY CONTOURS (Rainfall Calibrated)

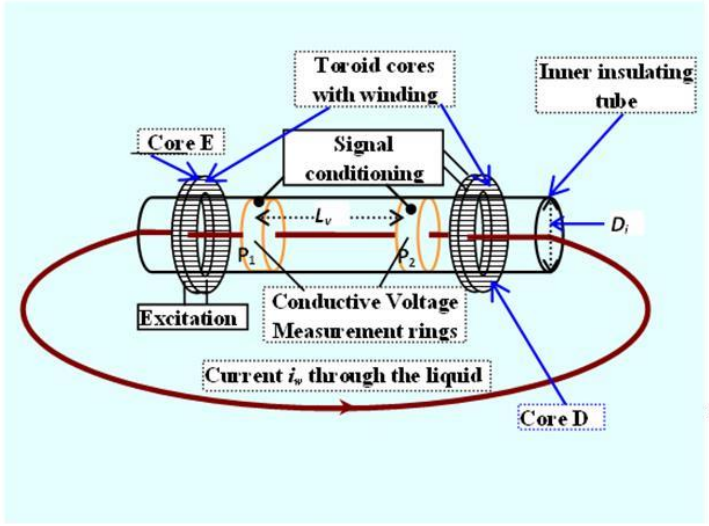


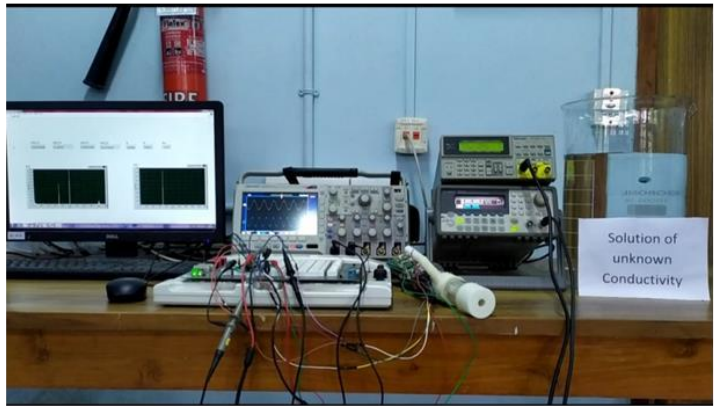


PROGRESS: WP-2: WATER TREATMENT (Sensors)

Conductivity of water -immersion type - Probe (Boby George, IIT Madras)

Objective: Develop an immersion type fully non-contact probe for conductivity measurement of water





-Fully Non-contact

-Corrosive liquid - no problem

-Cell constant - calculable

Tejaswini K. K., George B. and Kumar V. J., "Assay of Inductive-Capacitive Probe for the Measurement of the Conductivity of Liquids", **IEEE Transactions on Industrial Electronics,** 2021. (Accepted, in press), DOI: 10.1109/TIE.2020.3013754

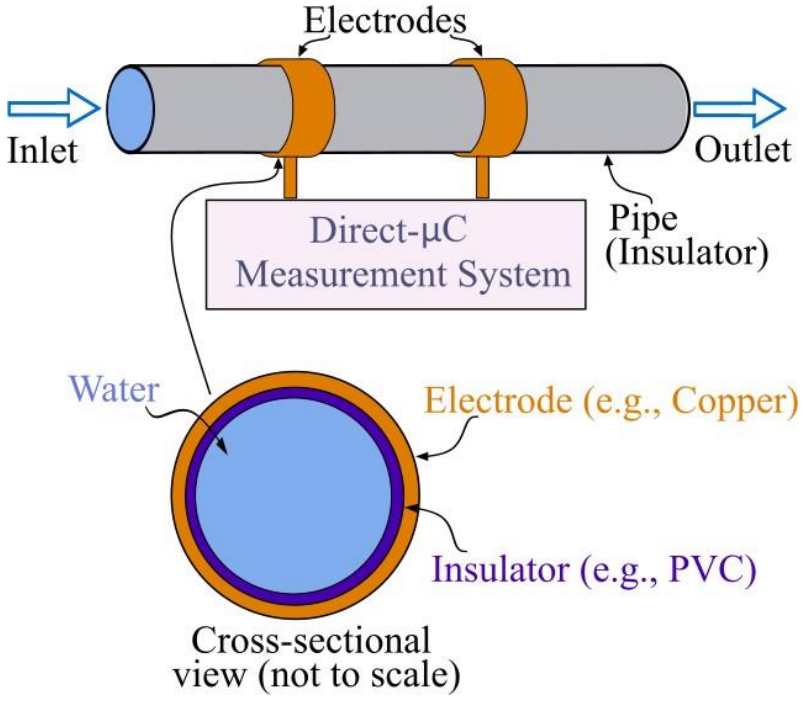
PROGRESS: WP-2: WATER TREATMENT (Sensors)

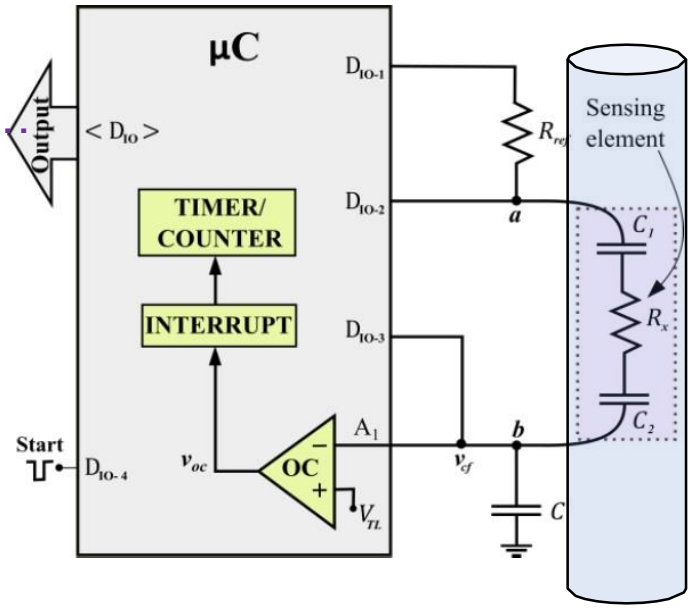
Conductivity of water - pipe – Low Cost, Electronics (Boby George, IIT Madras)

Objective: Develop an low cost electronic unit for non-contact conductivity measurement in a pipe

110101001010 conductivity…

Direct Digital Output





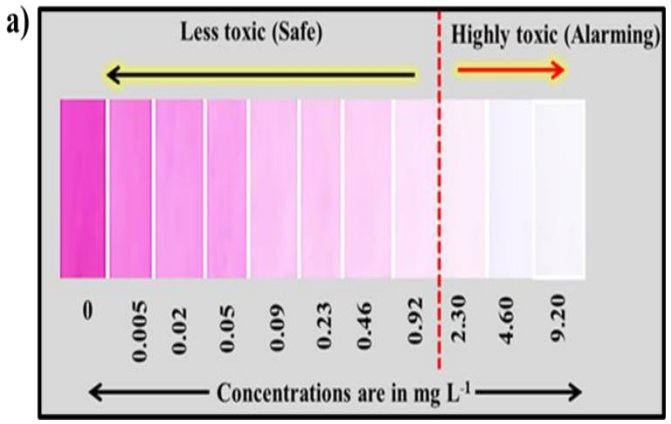
Patent: "Simple Direct Microcontroller Interface for Capacitively-coupled Resistive Sensors", (202041021691, 22-05-2020)

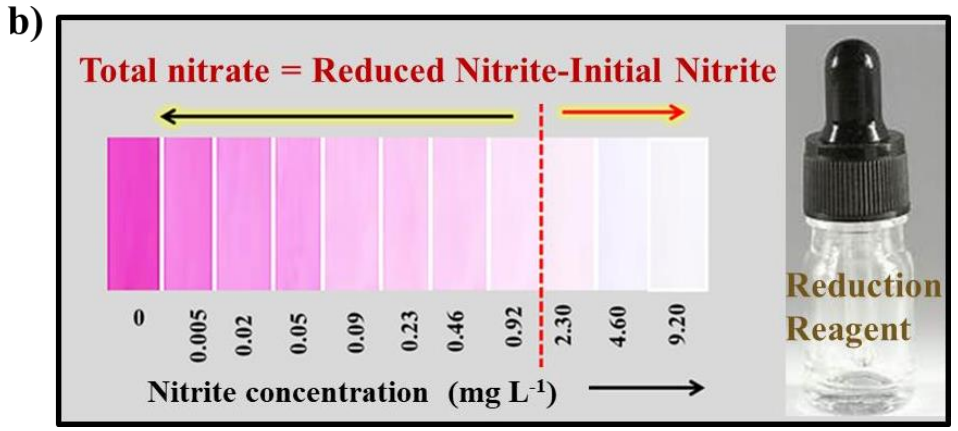
Areekath L., George B. and Reverter F., "Analysis of a Direct Microcontroller Interf ace for Capacitively-Coupled Resistive Sensors," IEEE Transactions on Instrumentation and Measurement, **vol. 70, Art. no. 1501010, pp. 1-10, 2021.**

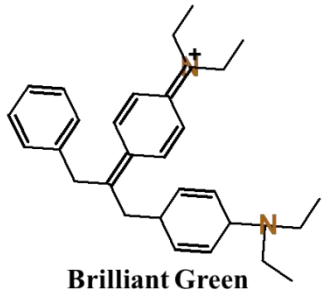
PROGRESS: WP-2: WATER TREATMENT (Sensors)

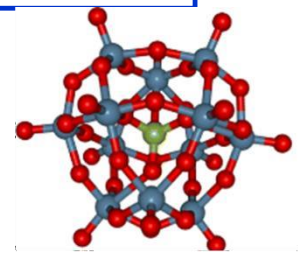
Low-cost colorimetric sensor for the detection of aqueous nitrate, nitrite and phosphate ions (Ligy Philip, IITM) (Patent filed)

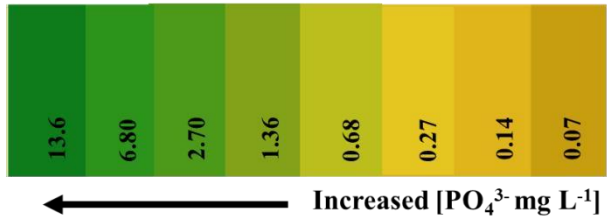
- Fabrication of portable low-cost colorimetric strips for nitrite and phosphate ions and studying the selectivity and sensitivity of the developed sensors against diverse coexisting pollutants
- The detection limit was 0.14 mg/L
- The sensor behaved well in the presence of several cation and anion.
- The sorption mechanism involved was formation of molybdate complex
- The cost of production was $0.25 (including of chemicals)





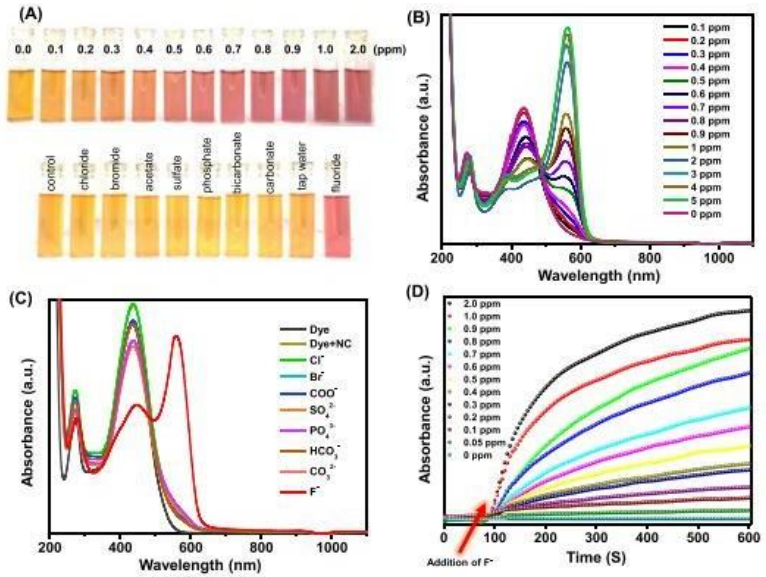




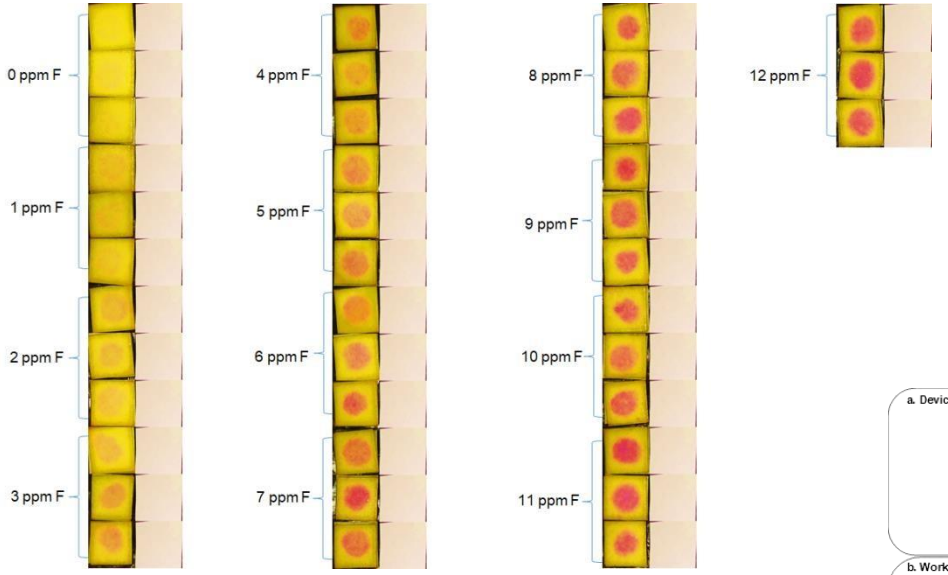


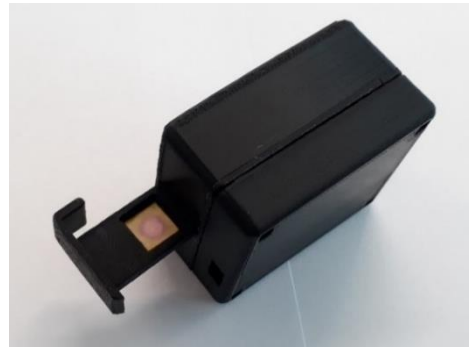
PROGRESS: WP-2: WATER TREATMENT (Sensors)

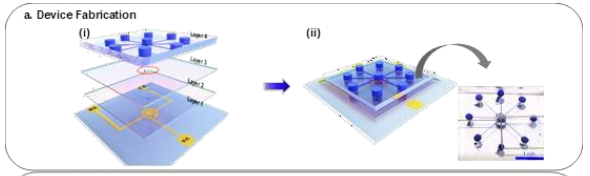
Water quality monitoring and fluoride measurement (T. Pradeep, IIT Madras)



Drop and sense paper strip for fluoride measurement in water







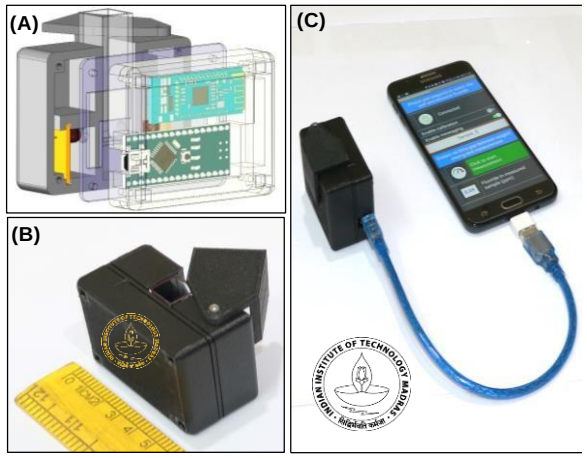
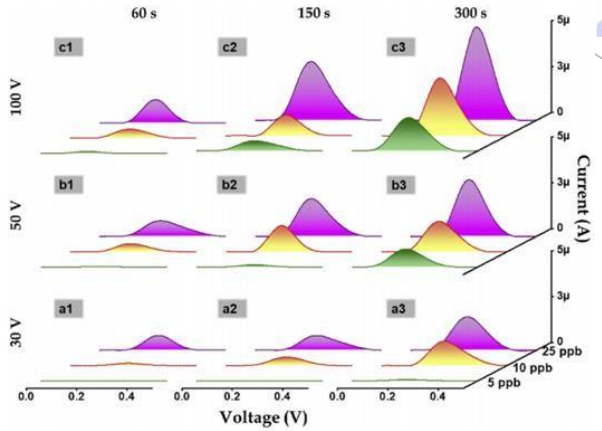


Figure. (A) Optical images of the colorimetric changes showing sensitivity of NC–XO system toward various F– concentrations and its specificity toward F– as compared to other anions.

Schematic of the device fabrication protocol and its working mechanism. Electrochemical characterization of As3+ after ICP.



Technological outcomes - Low-cost microfluidic platform for multi-analyte assessment of water quality

PROGRESS: WP-2: WATER TREATMENT (Sensors)

Sensors and Kits for Water Quality Monitoring F- sensor (T. Pradeep, IIT Madras)

Online fluoride sensor

- Principle of operation – Online colorimetric sensing
- Detection range – 0-12 ppm with in-built auto-dilutor
- Error - ~10 %
- Calibration – Automatic based on user selection
- Cost per measurement - ~ 2 INR
- Measurement frequency – User defined. Min interval between two measurements is 10 min
- Interface – Any IoT or Bluetooth platform
- Proposed launch date – 30th July, 2021

➢ Other low cost option – Pocket device interfaced with smartphone (Manual operation)

Flow cell for online fluoride measurement

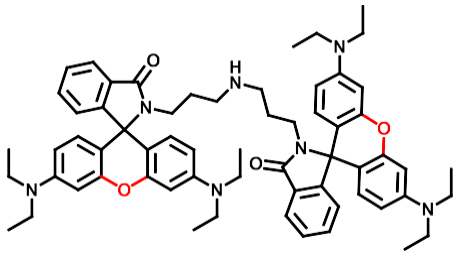
Pocket device for fluoride measurement

Proposed duration of the work: One year
Work will be done at our incubation hub housed at the International Centre for Clean Water

PROGRESS: WP-2: WATER TREATMENT (Sensors)

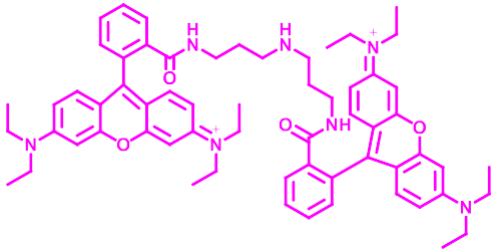
Sensing by optical and fluorescent methods (J. Raghava Rao & S. Eswaramoorthi, CSIR-CLRI)

To detect water contamination in organic solvents



Stimuli

M^{n+}, H_2O



Colourless, weakly fluorescent (shorter wavelength)

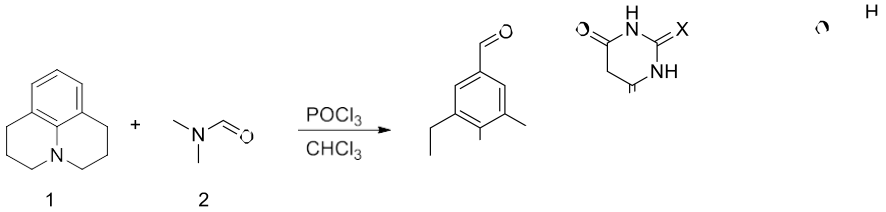
Intense colour, intense fluorescence (visible region)

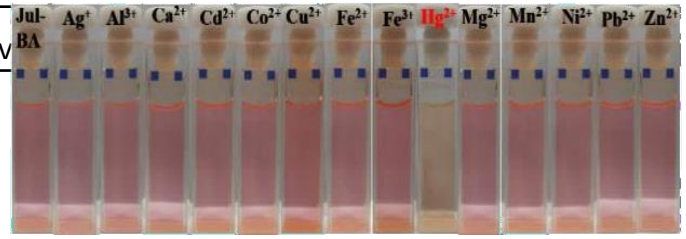
Probe	Solvents	R^2	DL % (v/v
DRh	ACN	0.9988	**0.022**
	DMF	0.9943	**0.077**
	DMSO	0.9966	**0.084**
	THF	0.8763	**0.045**
MRh	ACN	0.9865	**0.013**
	DMF	0.9822	**0.104**
	DMSO	0.9923	**0.085**
	THF	0.9188	**0.056**

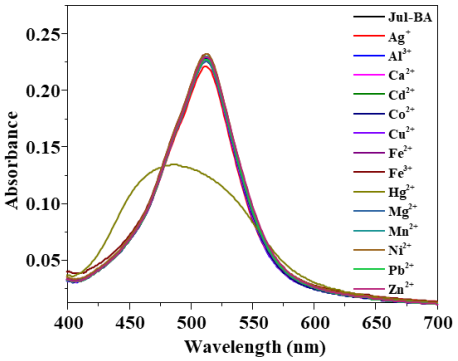
Presence of even trace amount of water in solvents or the humidity initiates the signal

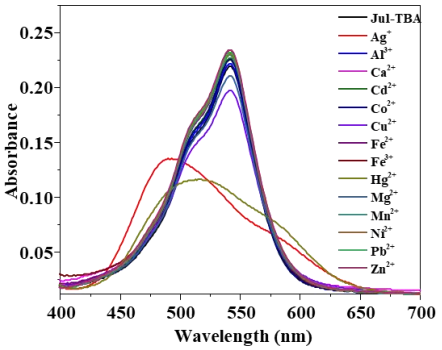
New Journal of Chemistry **2020, *44* (16), 6566-6574**

Detection of Hg(II) and Ag(I) at ppt levels







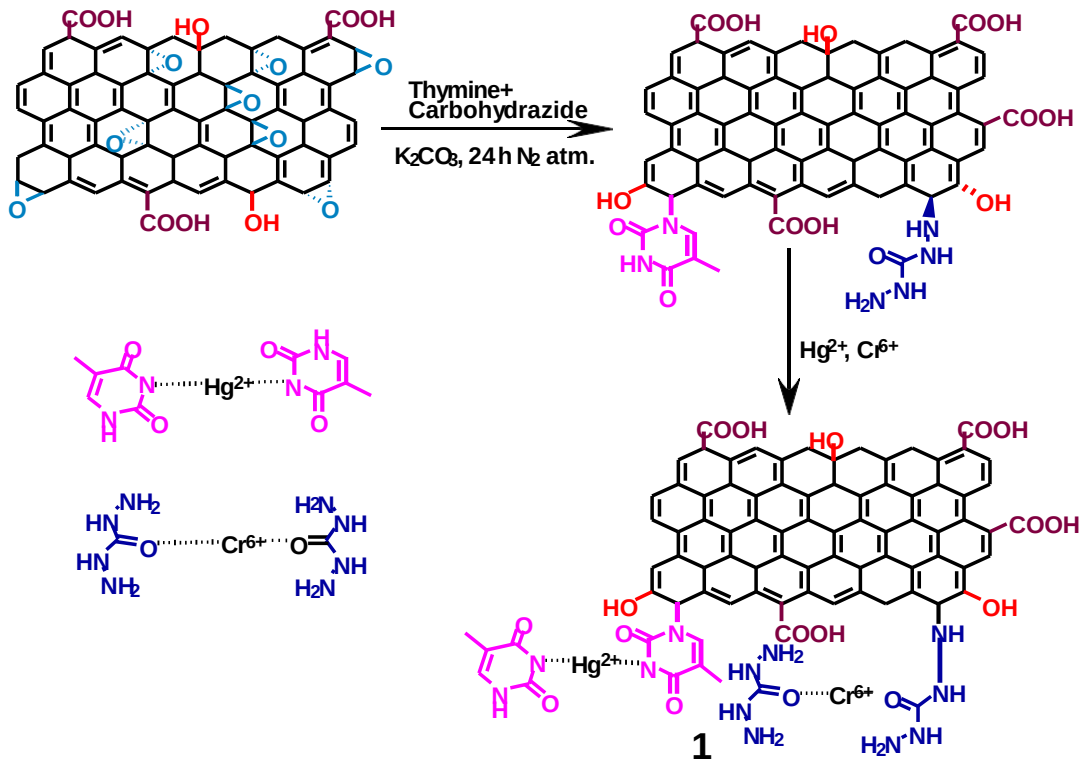


Detection Limit for Hg^{2+} - 2.8 ppt

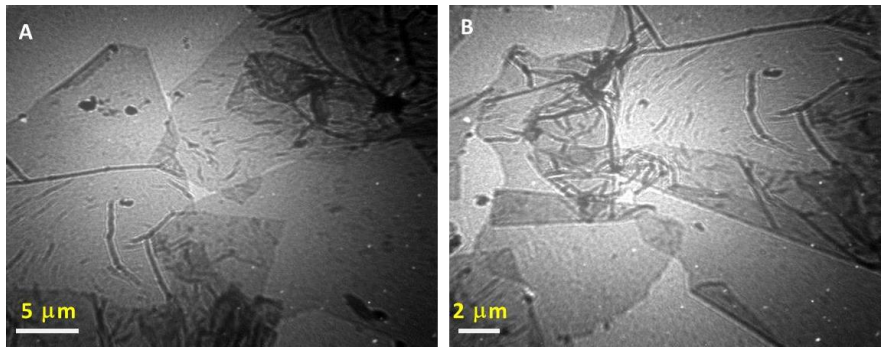
PROGRESS: WP-2: WATER TREATMENT (Sensors)

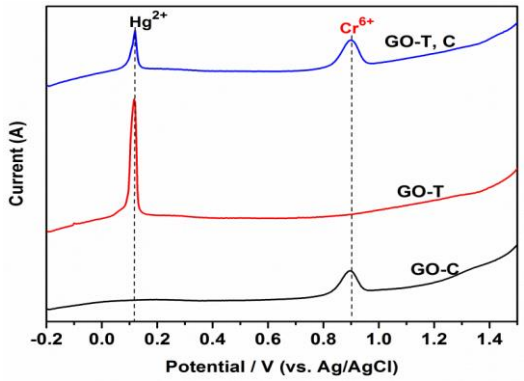
Sensing by electrochemical methods (J. Raghava Rao & S. Eswaramoorthi, CSIR-CLRI)

Functionalization of graphene



Detection of Hg(II) and Ag(I) at ppt levels





Linear sweep voltammetry of GO-T,C/GCE, GO-T/GCE, and GO-C/GCE recorded in the presence of Hg^{2+} and Cr^{6+} in acetate buffer pH 4.5

- **Several target compounds were synthesised and the evaluation of sensing properties are in progress**
- **Reporter having more than one receptor was synthesized and it responds to Cr^{6+} and Hg^{2+} with different signals**
- **Efforts are on to make a device based on the modified electrode**

PROGRESS: WP-2/3: WATER TREATMENT (Tailor made adsorbents for ECs)

Assessment of adsorption of pharmaceuticals and personal care products on carbonized adsorbent derived from waste (Ligy Philip, IIT Madras)

- Selection of low cost material for adsorbent
- Development of adsorbent using thermal treatment
- Identification of target pollutants (emerging contaminants).

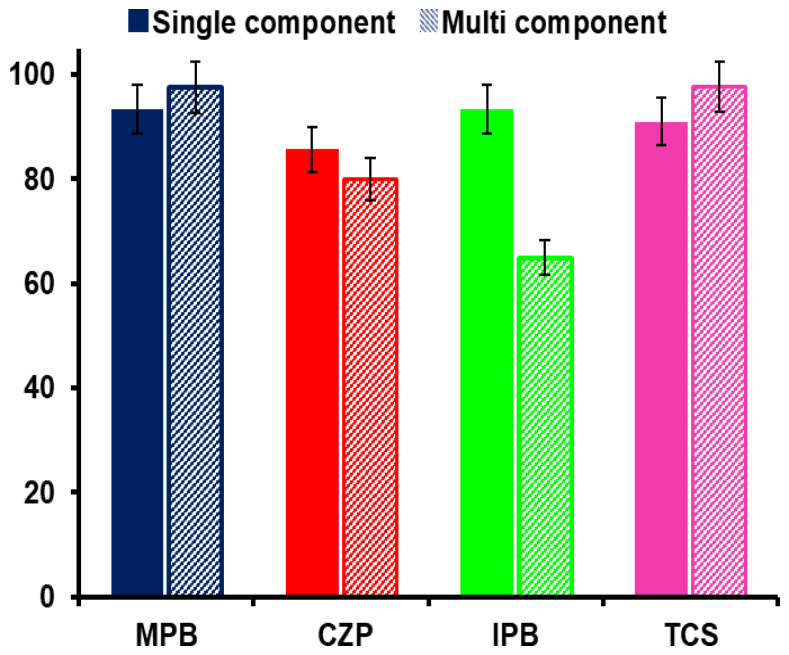
  (Methyl paraben, Ibuprofen, Carbamazepine, Triclosan)
- Batch scale verification of adsorbent for removal of PPCPs.

Empty palm fruit bunch

Pyrolysis
T (250,450, 750
10 °C/ min RT 30
min

PF biochars (BC) (250, 450,750 °C

Development of adsorbent



Behaviour in the real wastewater

PROGRESS: WP-2/3: WATER TREATMENT (Low Cost Adsorbents)

Assessment of sorption behavior of pharmaceutical compounds and nutrients by various porous low-cost adsorbent (Ligy Philip, IIT Madras)

Identification of eight different low-cost, readily available materials-Matrices for Constructed wetland


Autoclaved Aerated Concrete (AAC) blocks


Brickbats


Blast Furnace slag


Lightweight Expanded Clay Aggregate (LECA)


Pyrite


Sand

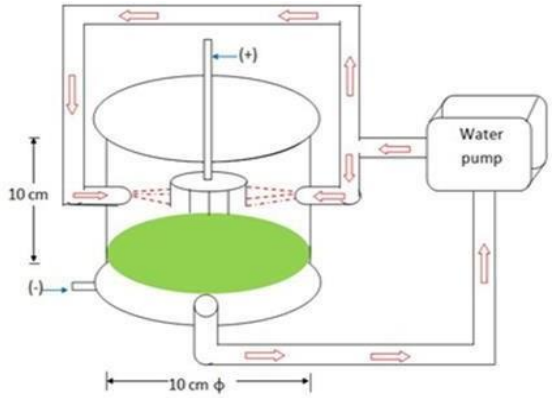

Wood charcoal


Zeolite

Experiments		CBZ	DCF	IBU
Kinetics		1 mg/L	1 mg/L	1 mg/L
Effect of pH		pH 2, 3, 4, 5, 7, 8, 10 and 12		
Effect of organics		20 mg/L of Humic acid + 1 mg/L pharmaceutical compounds (PhC)		
Effect of nutrients		25 mg/L of Ammonia, 10 mg/L of Phosphate, 5 mg/L of nitrate + 1 mg/L PhC		
Equilibrium	**Single pollutant**	10, 5, 2.5, 1, 0.5 and 0.1 mg/L individually		
	Multi-pollutant	10, 5, 2.5, 1, 0.5 and 0.1 mg/L		
Nutrient removal		25 mg/L of Ammonia, 10 mg/L of Phosphate and 5 mg/L of nitrate		

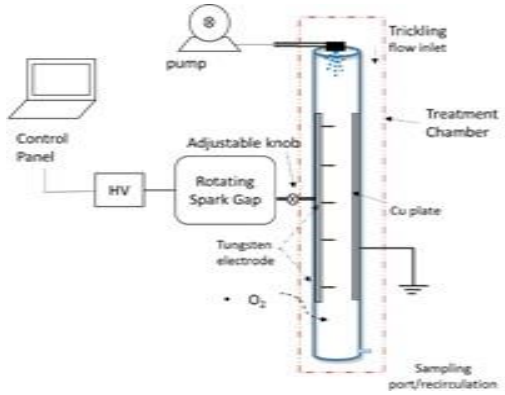
PROGRESS: WP-2/3: WATER TREATMENT (Pulsed Power Plasma Technology)

Development of pulsed power plasma technology for water and wastewater Treatment (Ligy Philip, IIT Madras)



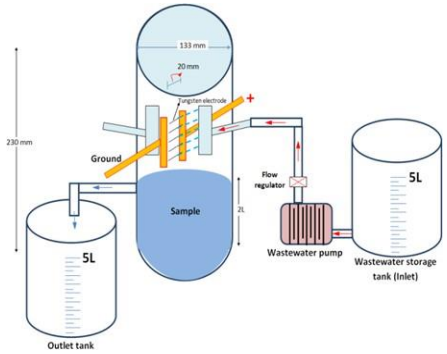
SFR advantages

- Working capacity: 1 L
- Increased mass transfer
- Reduced nitrate concentration by 80%
- Specific electrical energy consumption (EEO) 4.54 kWh/m³
- Operating cost: 9 $/year



TDPR advantages

- Working capacity: 3 L
- Increased mass transfer
- Reduced nitrate concentration by 90%
- No water jacket is required
- Specific electrical energy consumption (EEO) 7.9 kWh/m³
- Operating cost: 11.1 $/year



SDPR advantages

- Working capacity: 2 L
- Enhanced mass transfer
- Reduced nitrate concentration by 94%
- No water jacket is required
- Specific electrical energy consumption (EEO) 3.26 kWh/m³
- Operating cost: 6.4 $/year

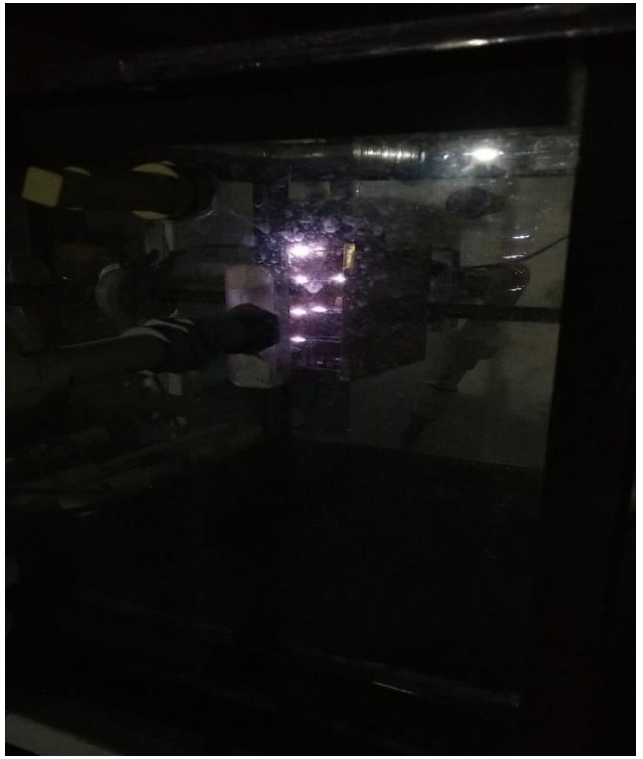
PROGRESS: WP-2/3: WATER TREATMENT (Pulsed Power Plasma Technology)

Development of pulsed power plasma technology for water and wastewater Treatment (Ligy Philip, IIT Madras)

Pilot Scale Plasma Reactor: IIT Madras STP

Complete pilot scale reactor with tanks

Photograph of Plasma formation

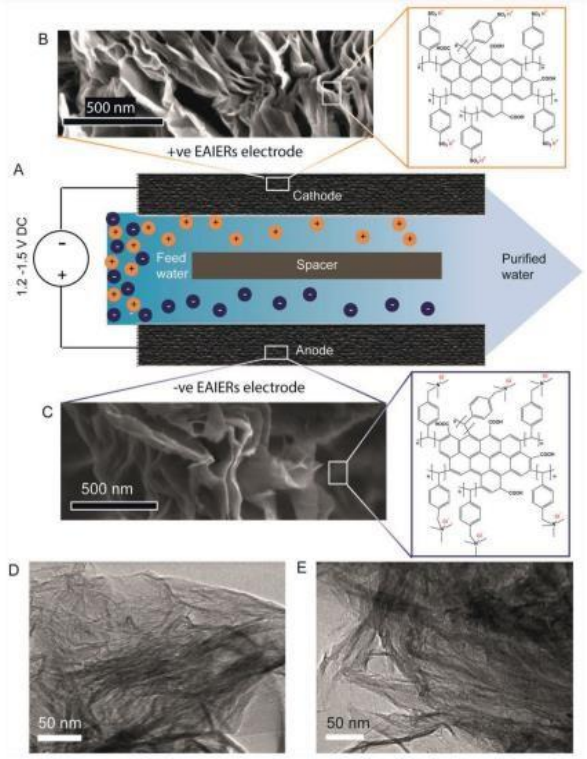


Plasma formation: Close view

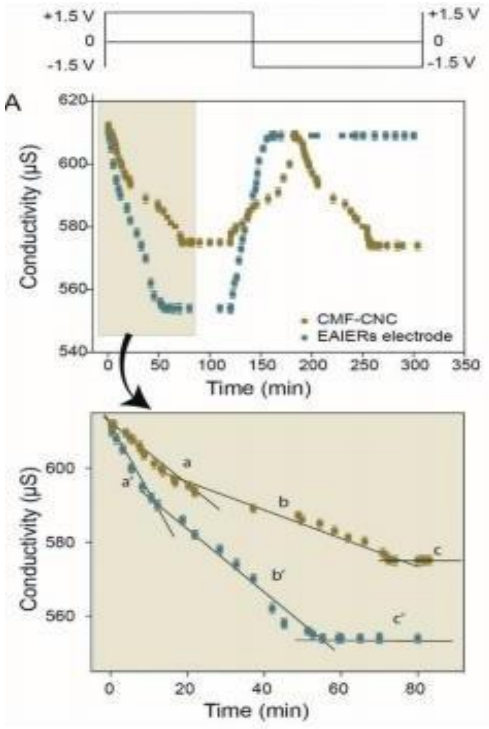
PROGRESS: WP-2: WATER TREATMENT (CDI Prototype & Atmospheric Water Capture)

(T. Pradeep, IIT Madras)

Technology Outcome: CDI Prototype

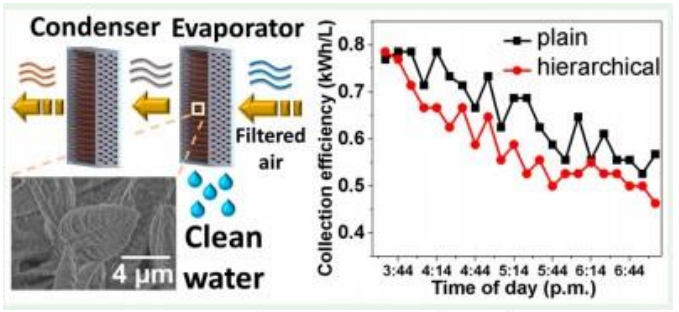


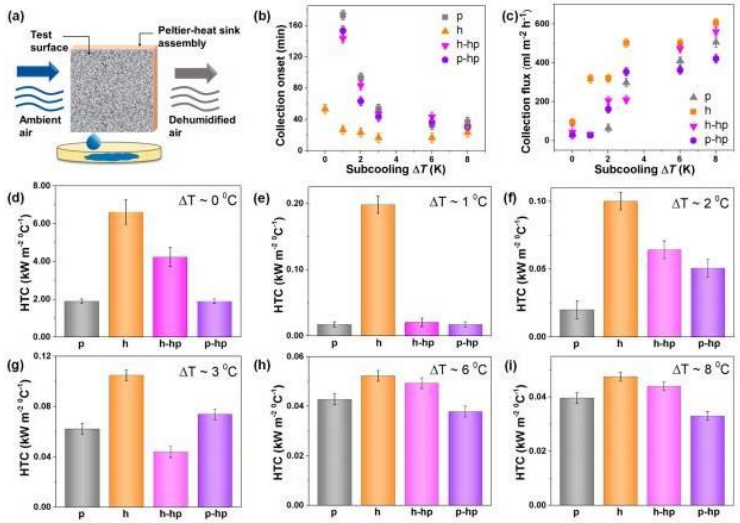
Schematic design of a cell with integrated EAIERs (molecular construct) for capacitive deionization (CDI). The rGO sheets have -COOH functionalization. Expanded views show the HRSEM images (B and C) of +ve and –ve EAIERs, respectively. . TEM image of D) +ve EAIERs and E) –ve EAIERs materials. The scale bars are 500 and 50 nm for HRSEM and TEM, respectively



Comparison of CDI performance between covalently integrated EAIERs (rGO–PS functionalized) electrode and melamine-functionalized carbon nanocellulose (CMF-CNC) derived electrode in 610 µS NaCl solutions.

Technology Outcome :Atmospheric Water



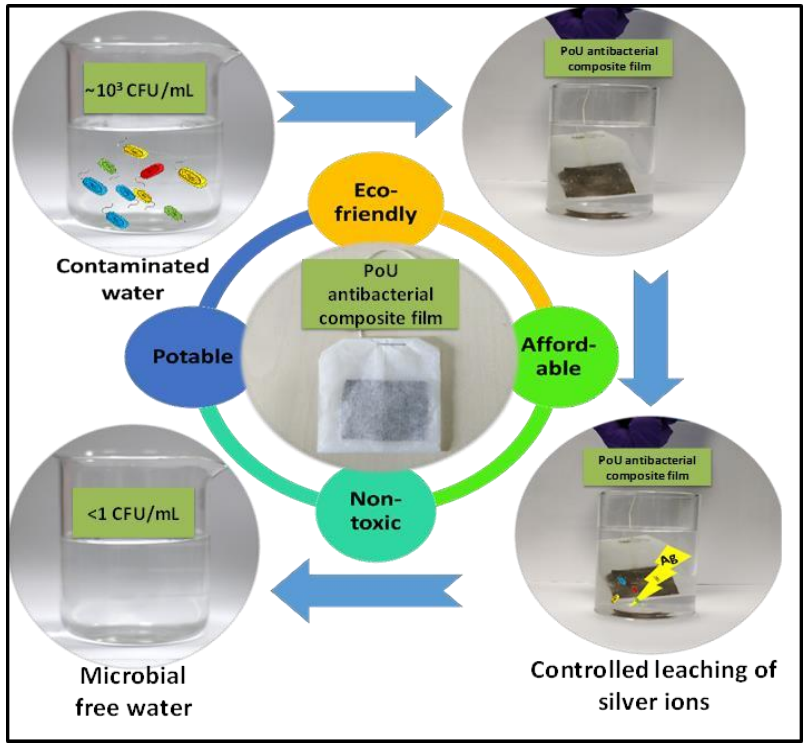


(a) Schematic of the setup for testing water collection performance of the test surfaces. (b) Plot of onset of water collection against subcooling. (c) Cumulative water collected plotted as water collection flux against subcooling. (d–i) Latent heat transfer coefficients for all test surfaces corresponding to water collection experiments performed on the test surfaces across the subcooling range of ~0–8 °C.

PROGRESS: WP-2: WATER TREATMENT (Disinfection)

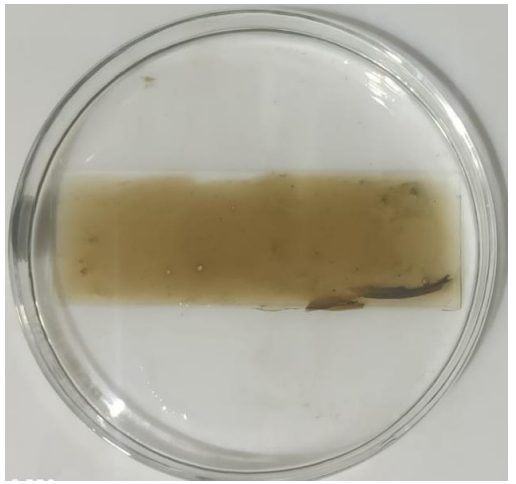
A point-of-use disinfection system for low-income communities (M. M. Shihabudheen, IIT Tirupati)

A reusable Dip & Sip type point-of-use disinfection system is developed and evaluated for its performance under laboratory conditions.



Process Safety and Environmental protection, 148, 104-113, 2021.

Photograph of nanocomposite bead for disinfection



Glass slide coated with nanocomposite followed by crosslinking for disinfection

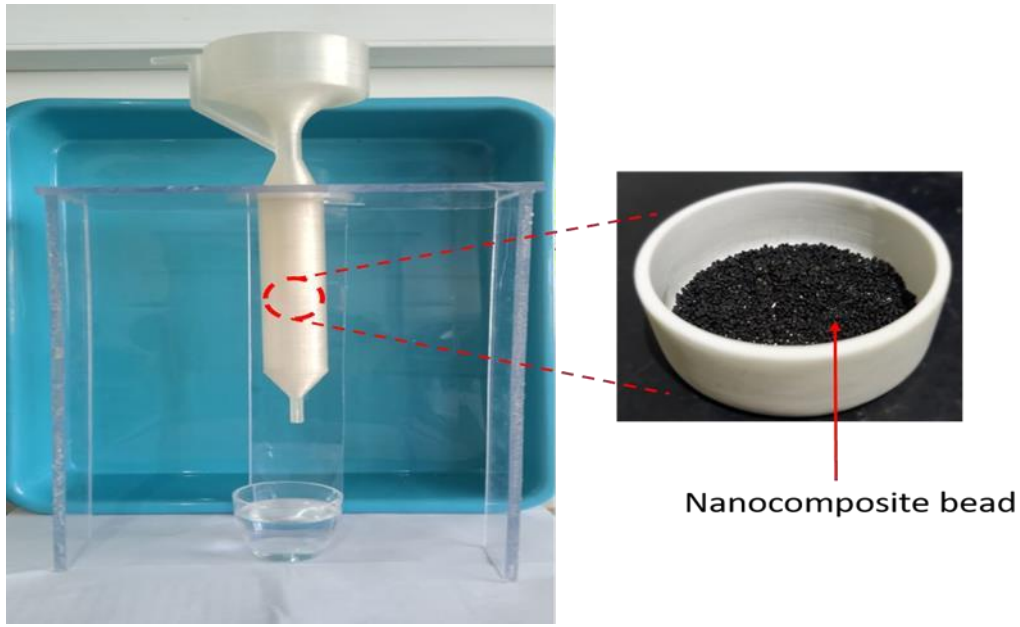
Patent Grant No.: IN 345400 (Granted on: 28.08.2020)

PROGRESS: WP-2: WATER TREATMENT (Disinfection)

Nanoscale materials for the removal of the pathogenic organism and heavy metals in water

(M. M. Shihabudheen, IIT Tirupati)

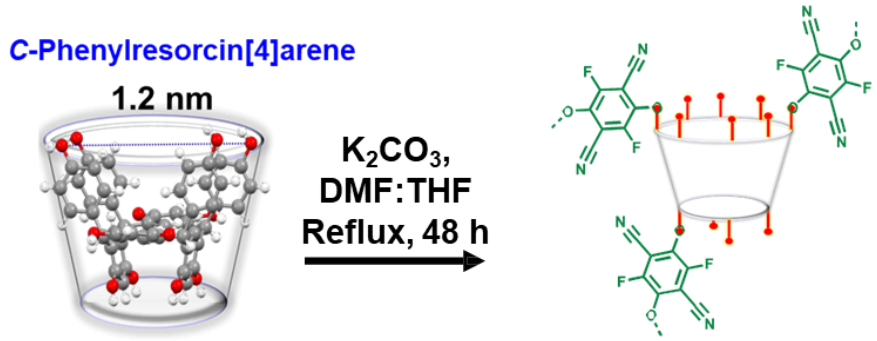
A packed-bed point-of-use disinfection was developed using the immobilized nanocomposite as the supporting medium. Preliminary evaluation shows that the nanocomposite beads produced 3 log_{10} reductions in 30 min contact time against E.coli in the batch reactor.

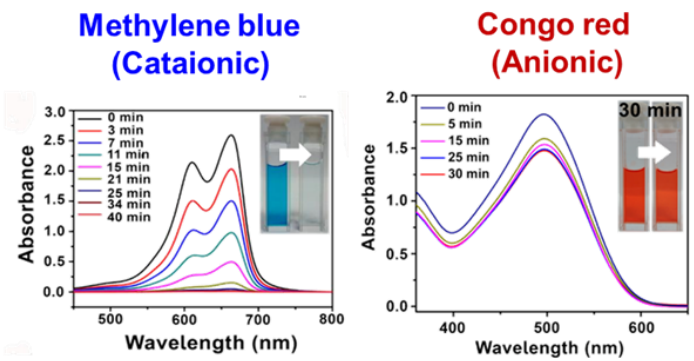


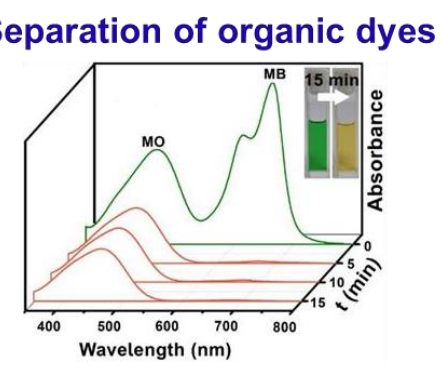
Lab-scale packed-bed reactor filled with nanocomposite bead for disinfection

PROGRESS: WP-2: WATER TREATMENT (New Framework Solids for Water Purification)

Cavitand-based Porous Organic Framework for Charge-specific Size-selective Micro-pollutant Separation (Abhijit Patra, IISER, Bhopal)



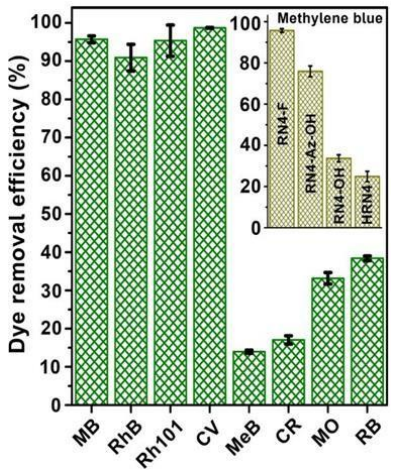




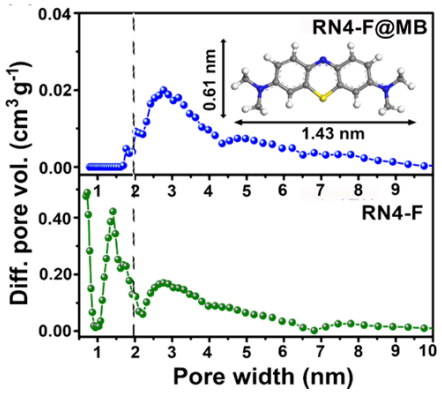
RN4 (156 ± 5 $m^2 g^{-1}$) **RN4-F** (925-1230 $m^2 g^{-1}$)

- Fluoride groups effectively interact with cationic guest (fluorine-cation interaction)
- Pores around 0.7 nm and 1.4 nm of RN4-F leads to size selective adsorption of dyes

Entry	Size		Charge	% of dye remove d#
	X (nm)	Y (nm)		
Methylene blue (MB)	1.55	0.73	+1	96
Rhodamine B (RhB)	1.50	1.44	+1	91
Cresyl violet (CV)	1.48	0.83	+1	99
Congo red (CR)	2.74	0.87	-2	17
Methyl blue (MeB)	2.38	1.76	-3	14
Methyl orange (MO)	1.59	0.55	-1	33
p-Nitrophenol	0.79	0.55	0	80
2-Napthol	0.82	0.62	0	76



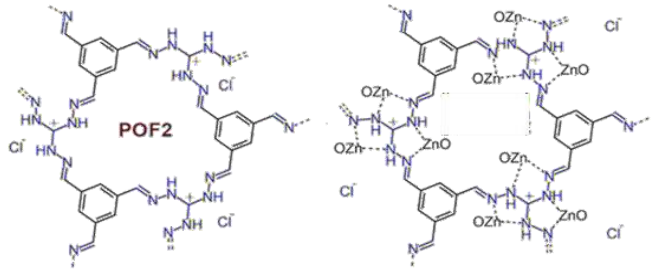
Pore size distribution of RN4-F before & after MB adsorption



Giri, A.; Hussain, W. MD. ; Sk, B.; Patra, A. *Chem. Mater.* 2019, *31*, 8440−8450

PROGRESS: WP-2: WATER TREATMENT (New Framework Solids for Water Purification)

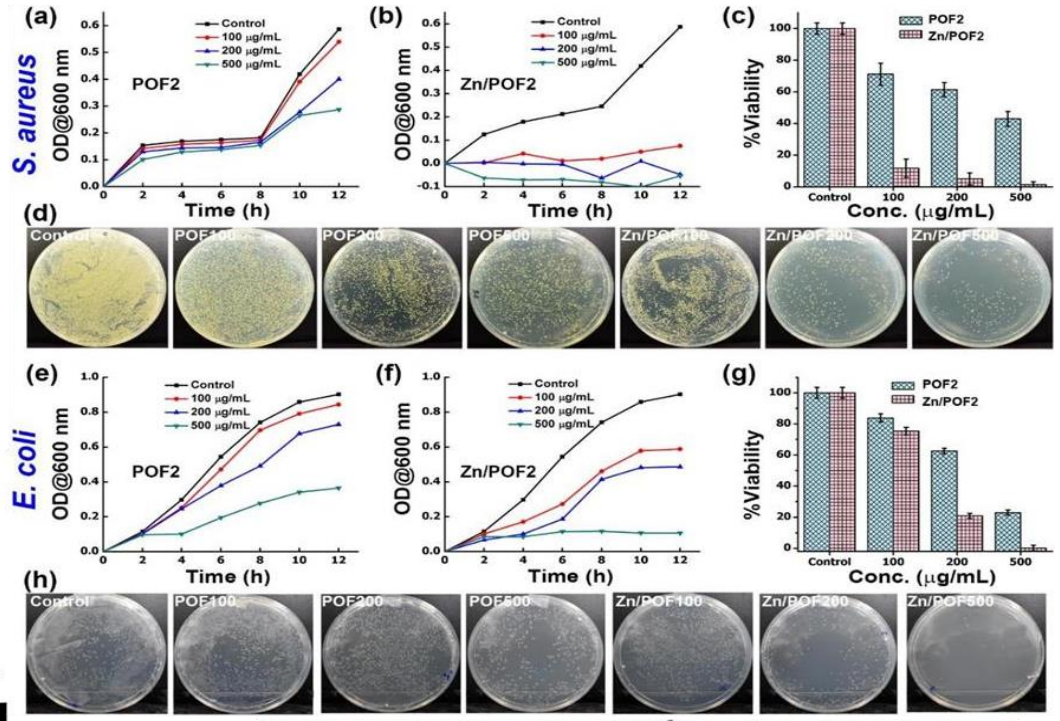
Ionic Porous Organic Frameworks for Antimicrobial Activity (Abhijit Patra, IISER, Bhopal)



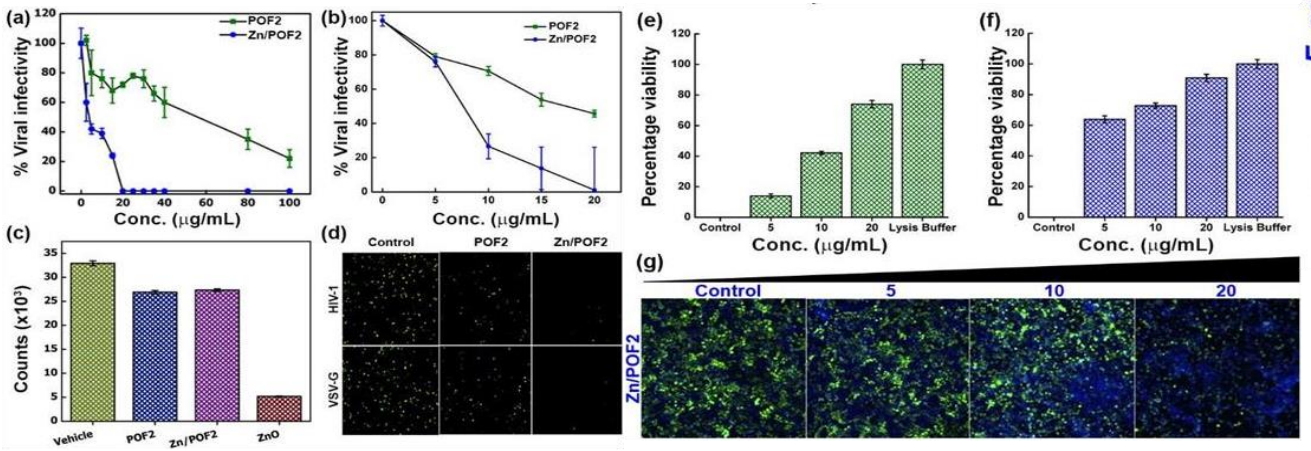
POF: 450 ± 50 $m^2 g^{-1}$ Zn/POF : 105 ± 20 $m^2 g^{-1}$

- High metal chelating ability
- ZnO loadings: 57.5 ⍰ 0.8%
- Heterogeneous catalyst for CO_2 conversion
- Antimicrobial coating (Zn/POF@PVA film)

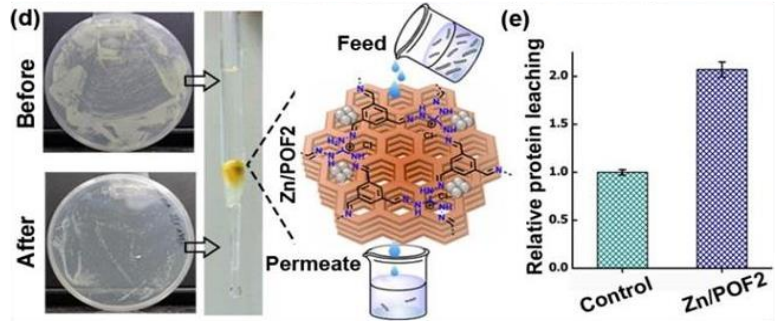
Antibacterial activity



Antiviral activity (HIV-1, VSV-G lentivirus particles)



Decontamination of water

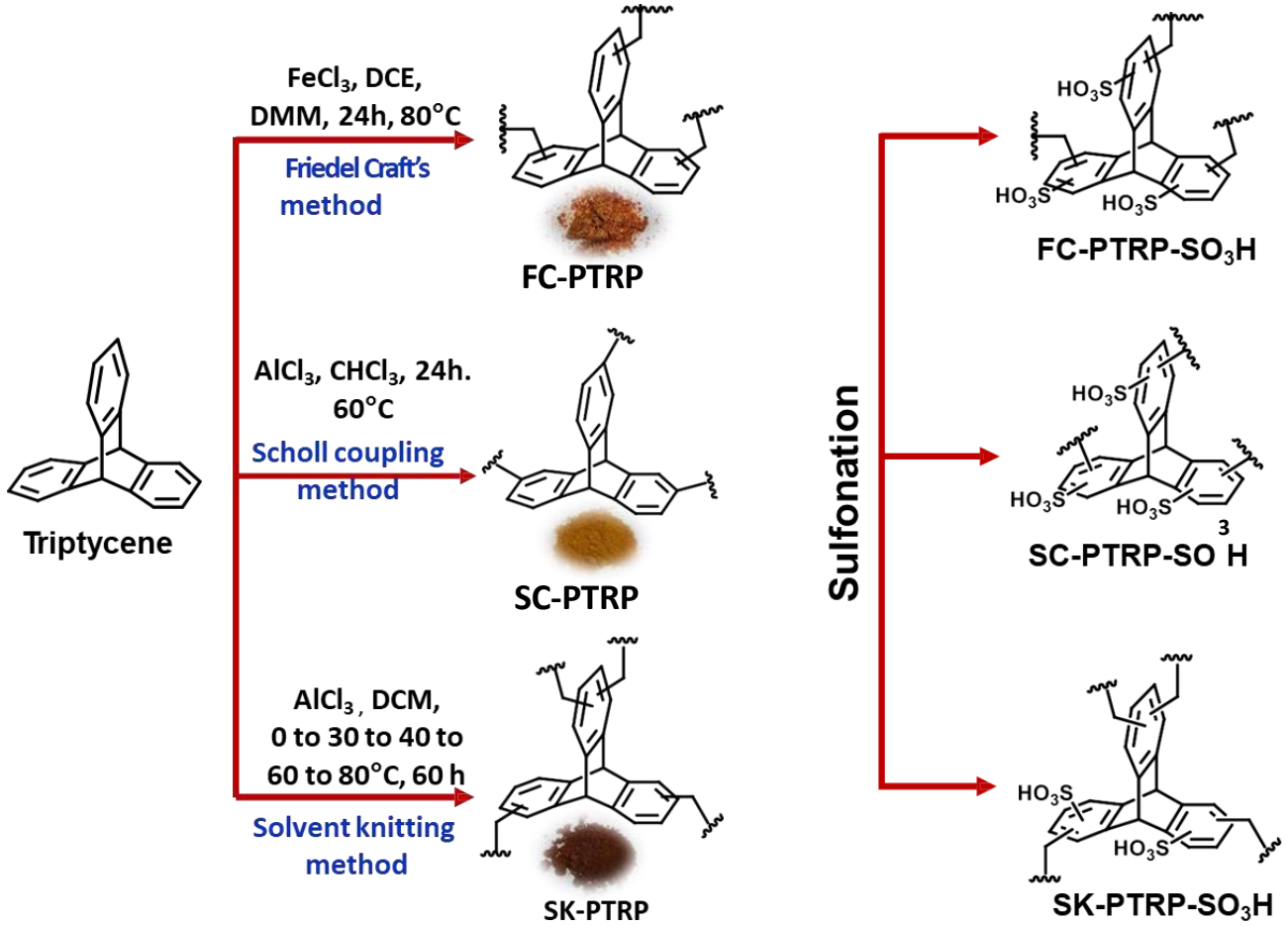


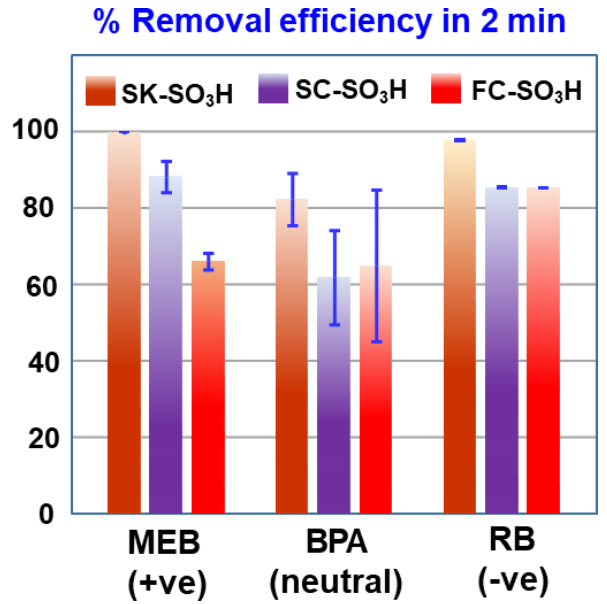
Patent application filed: Nanoporous organic frameworks for efficient CO_2 fixation, antibacterial and antiviral applications *Application No.201921010663 A*

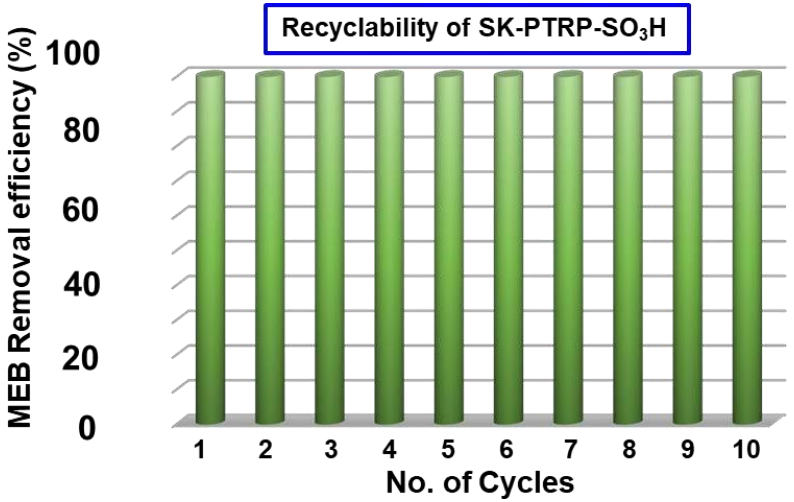
PROGRESS: WP-2: WATER TREATMENT (New Framework Solids for Water Purification)

Triptycene-based Hypercrosslinked Polymers (HCPs) (Abhijit Patra, IISER, Bhopal)

Fabrication of HCPs through three different reaction pathways



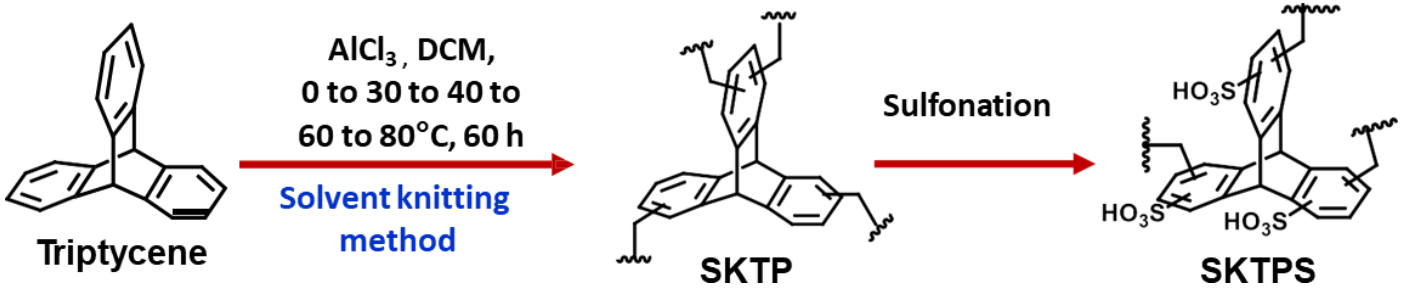


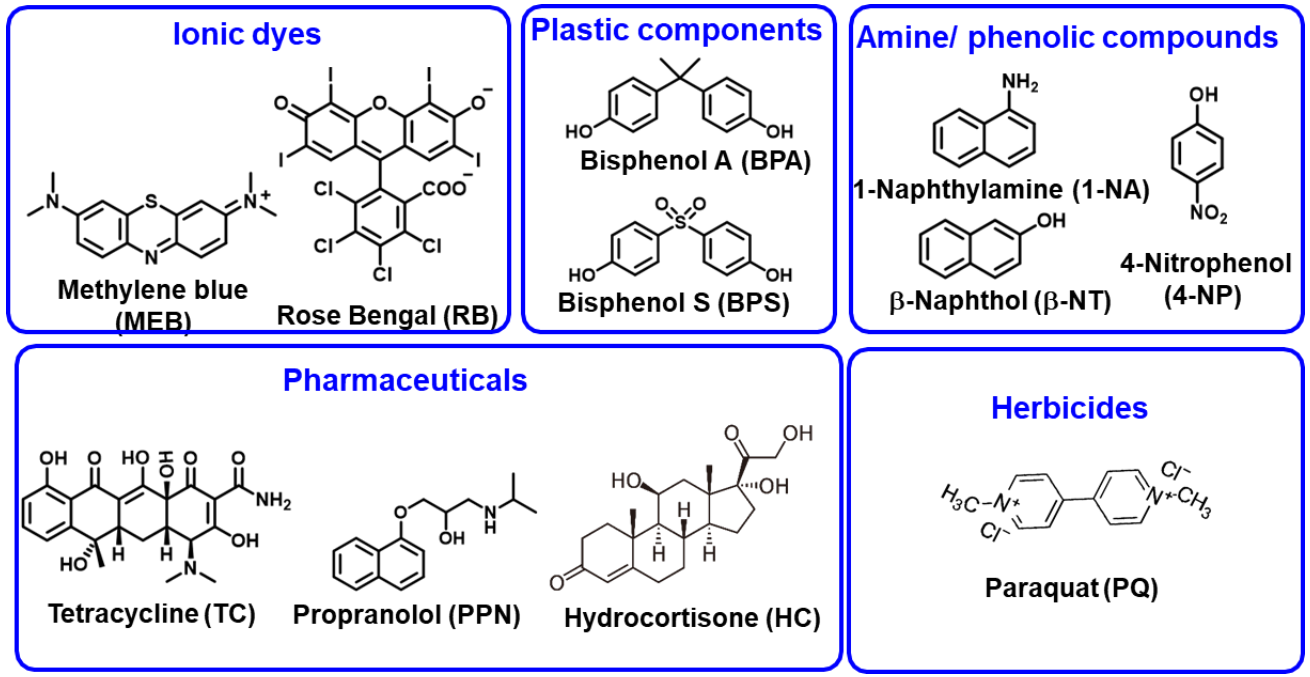


All the HCPs are scaled up and physical properties are reproduced

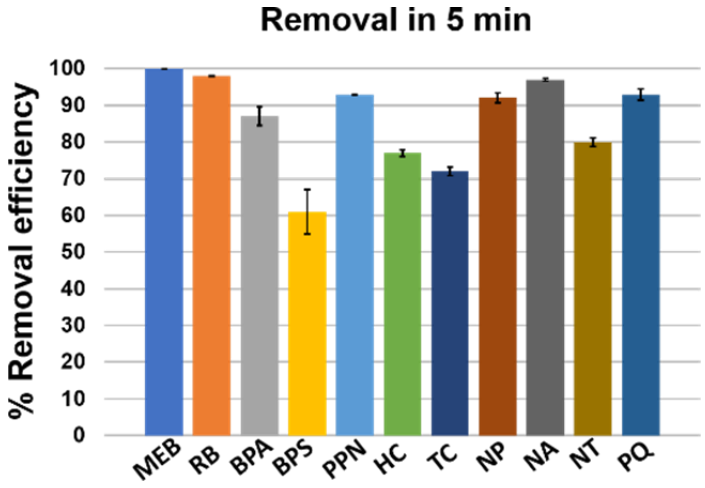
PROGRESS: WP-2: WATER TREATMENT (New Framework Solids for Water Purification)

Triptycene-based Hyper crosslinked Polymers (HCPs) for Broad-spectrum Micropollutant Removal (Abhijit Patra, IISER, Bhopal)





Manuscript submitted

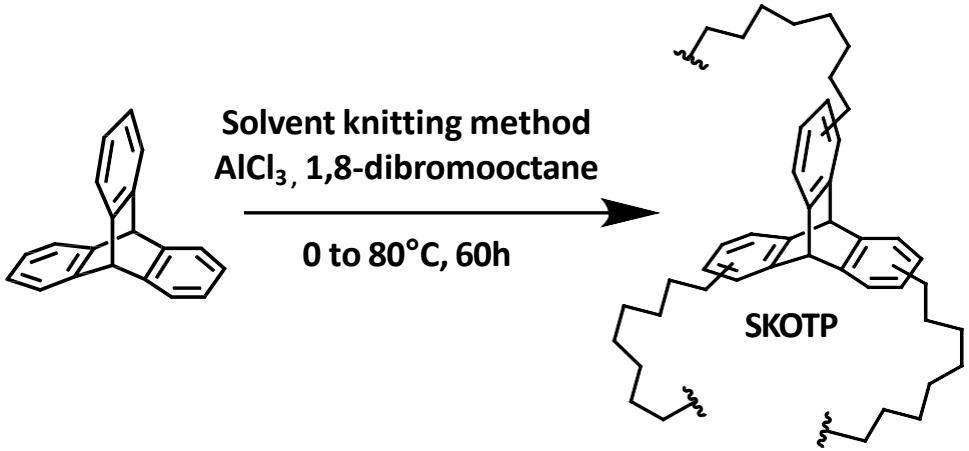


Gram Scale synthesis of Benzene-based HCP

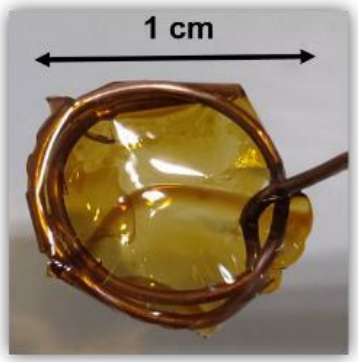
Optimization is going on

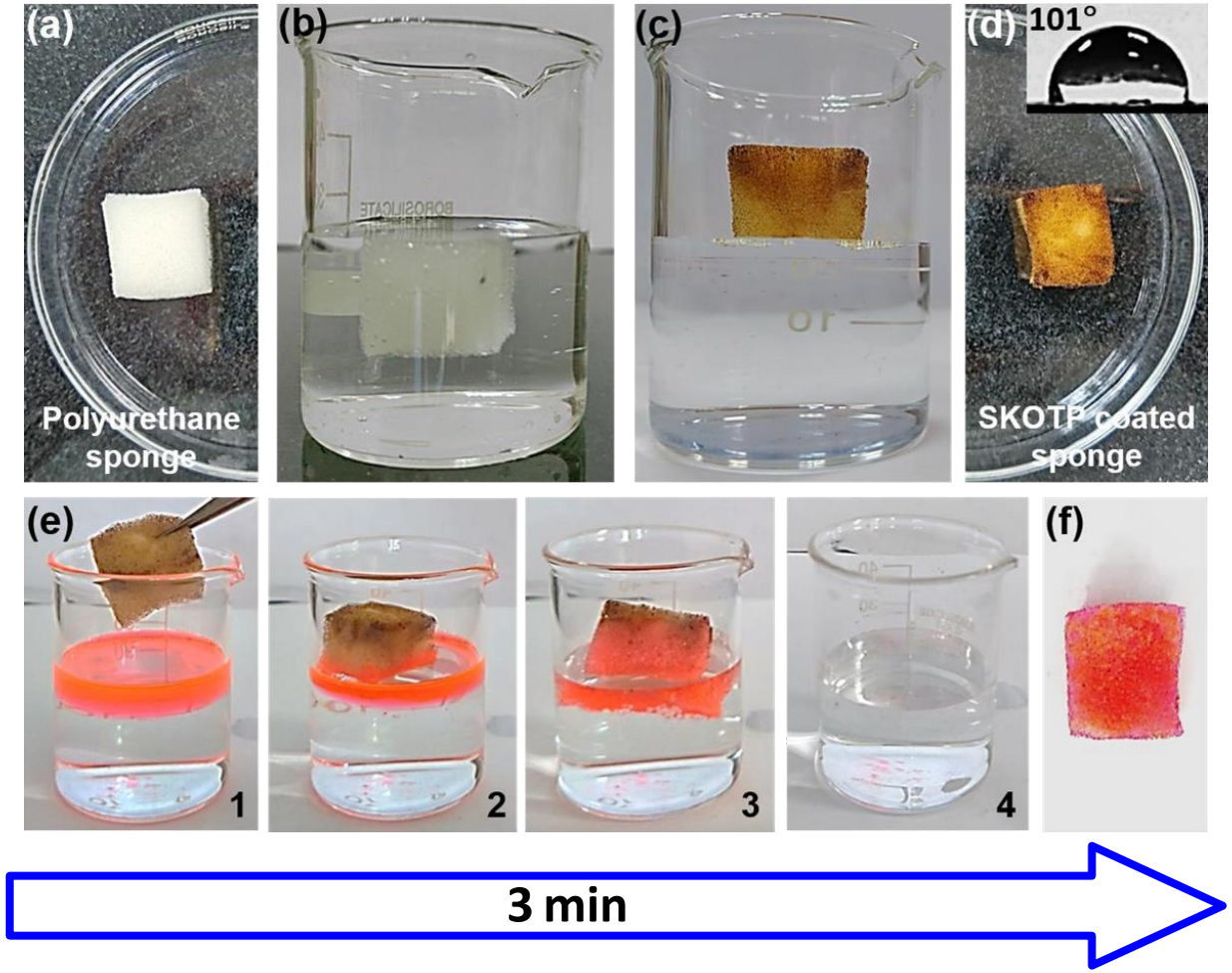
PROGRESS: WP-2: WATER TREATMENT (New Framework Solids for Water Purification)

Triptycene-based Solution Processable Hypercrosslinked Polymers for Oil/Water Separation (Abhijit Patra, IISER, Bhopal)



- Soluble in DCM, DMSO
- Robust semi-transparent thin film fabrication

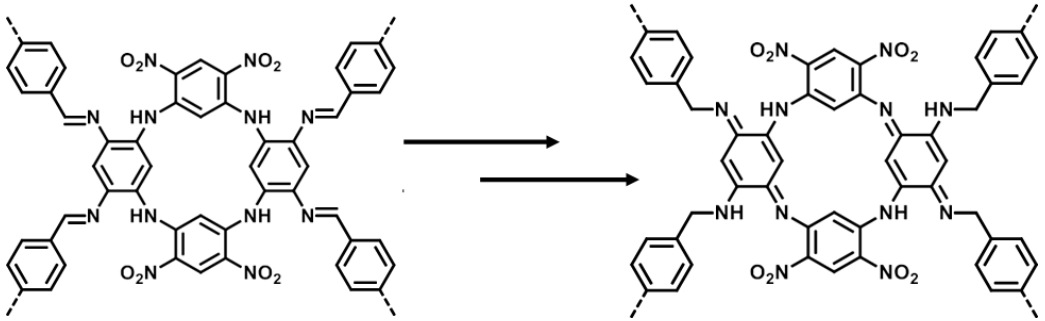




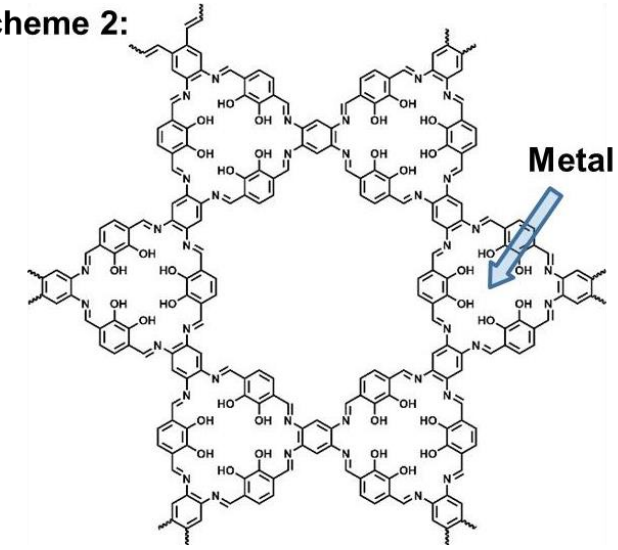
PROGRESS: WP-2: WATER TREATMENT (New Framework Solids for Water Purification)

Macrocycle/cage-based Covalent Organic Frameworks for Nanofiltration (Abhijit Patra, IISER, Bhopal)

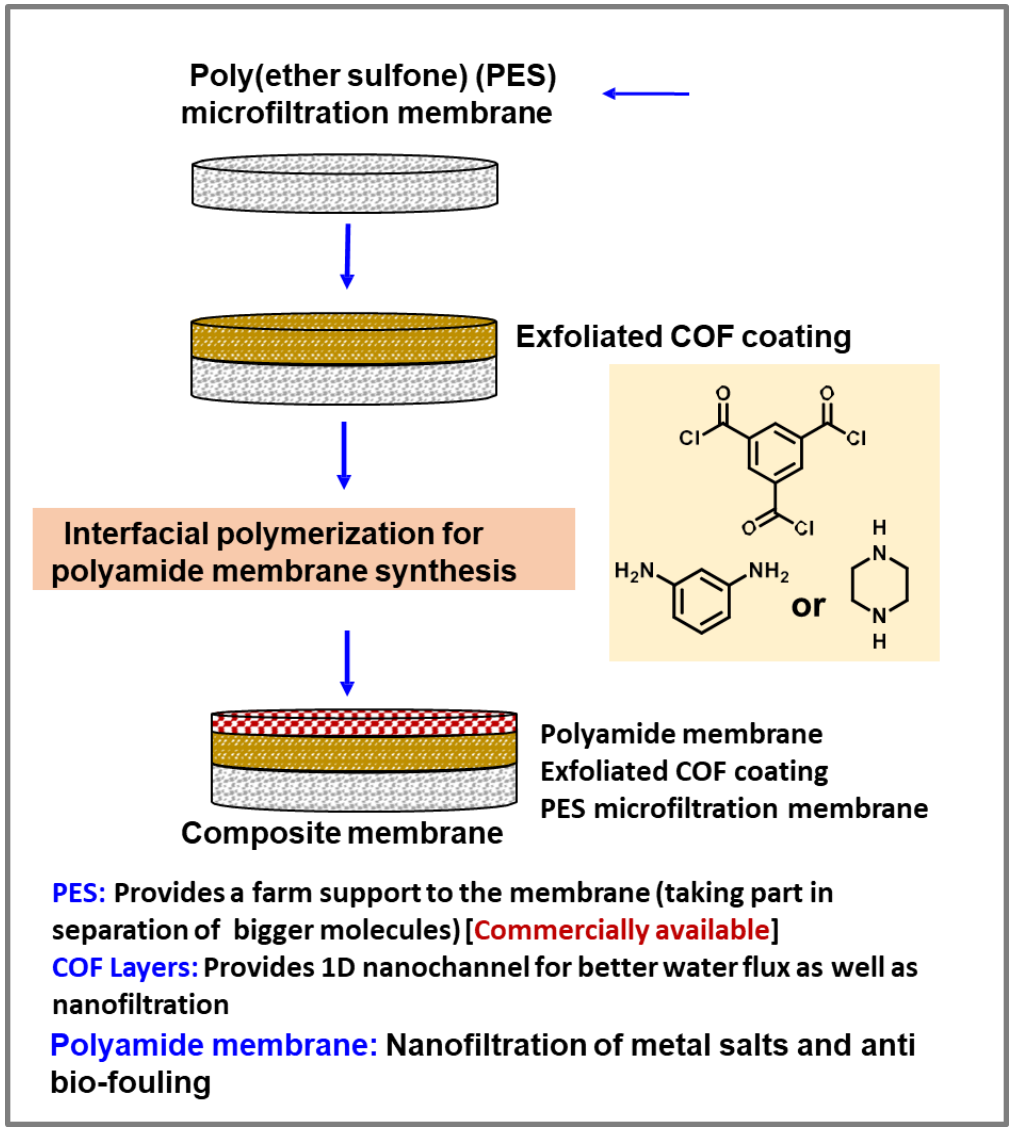
Scheme 1:



Scheme 2:



- Synthesis and characterization of monomers
- Optimization of the fabrication condition for the COFs are going on



PROGRESS: WP-2: WATER TREATMENT (Environmental Impact)

Toxicity assessment of various samples (Satyakam Patnaik & Alok Dhawan, CSIR-IITR)

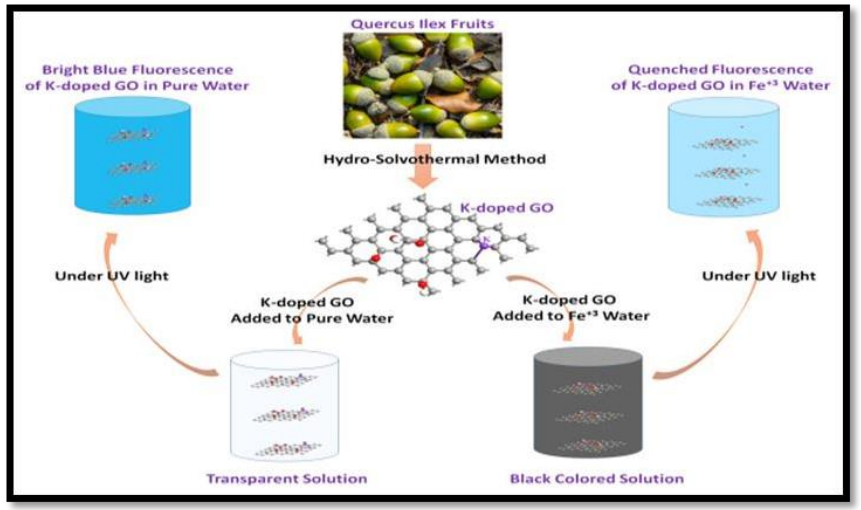
Targeted Timelines (Institution wise)-CSIR-IITR **Mar 2020-Feb 2021-IInd Yr**	**WP:2.6 -Environmental impact (Dr. Satyakam Patnaik)** **2.6.7- Evaluation of effects of various environmental parameters-16-18th Q** **2.6.8- Toxicity and TOC studies of the treated water-16-18th Q**
Achievement	**Discussion with partners of SUTRAM network regarding the toxicity assessment of various samples completed. Samples from Kumaon University and IISER Bhopal will be tested once received.**

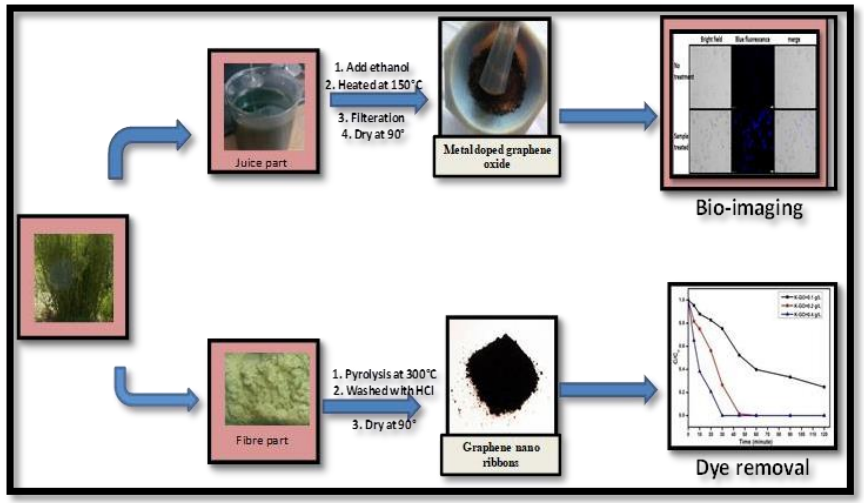
PROGRESS: WP-2: WATER TREATMENT (Nano Composite Based Water Filtration Units)

Development of Cost Effective Nano Composite Based Water Filtration Units for the Efficient Removal of Hazardous Impurities Found in the Lakes of Nainital, Uttarakhand (N. G. Sahoo, Kumaun University)

- **Synthesis of potassium doped graphene oxide has been done successfully by using *Quercus ilex*. The synthesized material demonstrates its utility as a heavy metal ion sensor with detection limit of $0.345*10^{-7}$ M iron ions.**

- **Synthesis of 2D/3D nanomaterials i.e. metal doped graphene oxide and 3D graphene nano ribbons have been done successfully by using Ringal bamboo's extract and synthesized 3D-graphene ribbons utilize in the field of water treatment for removal of methylene blue and brilliant green dyes.**





PROGRESS: WP-2: WATER TREATMENT (Nano Composite Based Water Filtration Units)

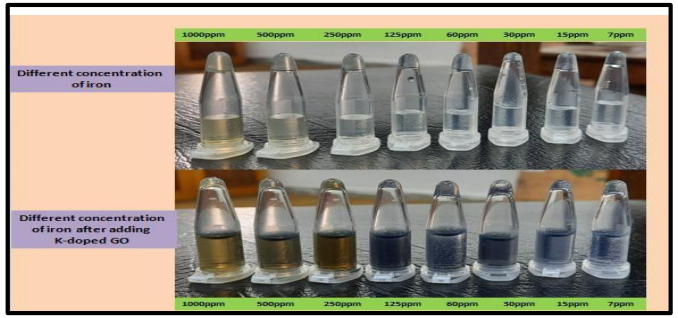
Development of Cost Effective Nano Composite Based Water Filtration Units: Achievements (N. G. Sahoo, Kumaun University)

- Pilot plant "SWAYAMBHU/WRM-2021" with the capacity of 100kg/batch, for upcycling of different solid waste (waste plastic, agricultural waste, waste paper etc) into carbon based nanomaterials for water treatment.

- Bulk synthesis of graphene oxide from waste plastic for development of graphene based water filter "Naulaus". (In progress)

- Synthesis of graphene oxide from agricultural waste for iron sensing and water treatment applications.

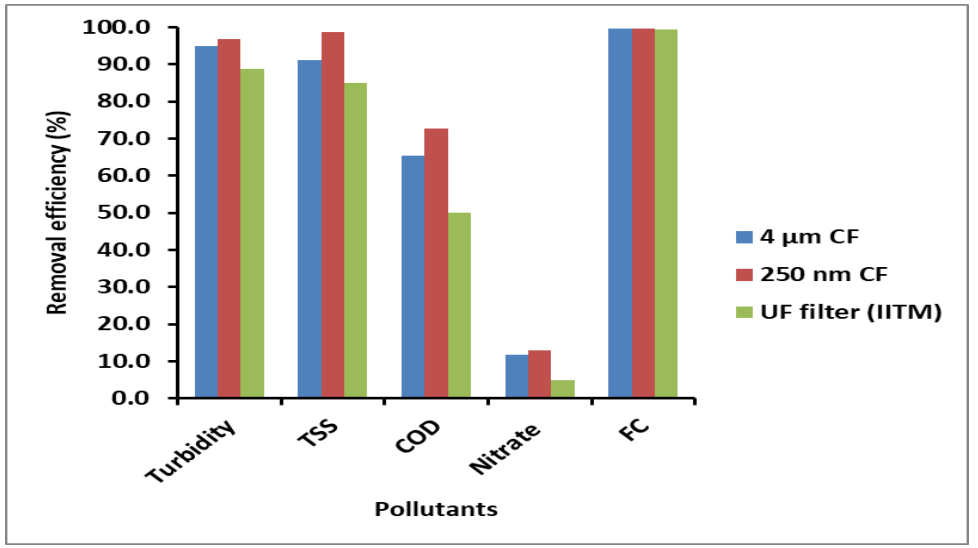
- Bulk synthesis of naturally doped Silicon, Magnesium and Calcium Graphene nanosheets from Paper Waste for water purification.



PROGRESS: WP-3: WASTE WATER MANAGEMENT (Domestic Waste Water)

Performance evaluation of ceramic membrane as tertiary treatment systems for domestic wastewater (Ligy Philip, IIT Madras)

Comparison of quality of treated water for 4µm, 250nm ceramic filter and UF

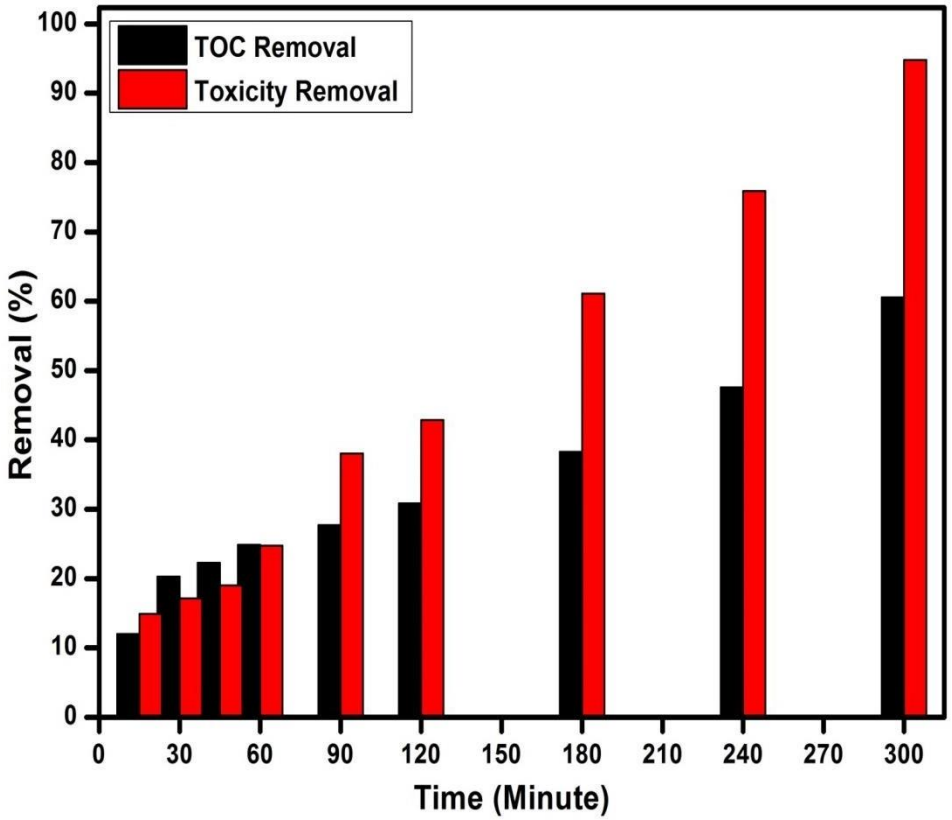


Pollutants	250 nm	4µm	UF filter
Turbidity	96.8%	95%	88.8%
TSS	98.8%	91.1%	85%
COD	72.8%	65.5%	50%
Nitrate	13.8%	11.7%	4.86%
FC	99.8%	99.6%	99.5%

PROGRESS: WP-3: WASTE WATER MANAGEMENT (Textile Wastewater)

Simultaneous removal of cationic and anionic dyes in adsorptive and oxidative treatment system using plastic waste carbon/persulfate system (Ligy Philip, IIT Madras and Prof. Sahoo, Kumaun University)

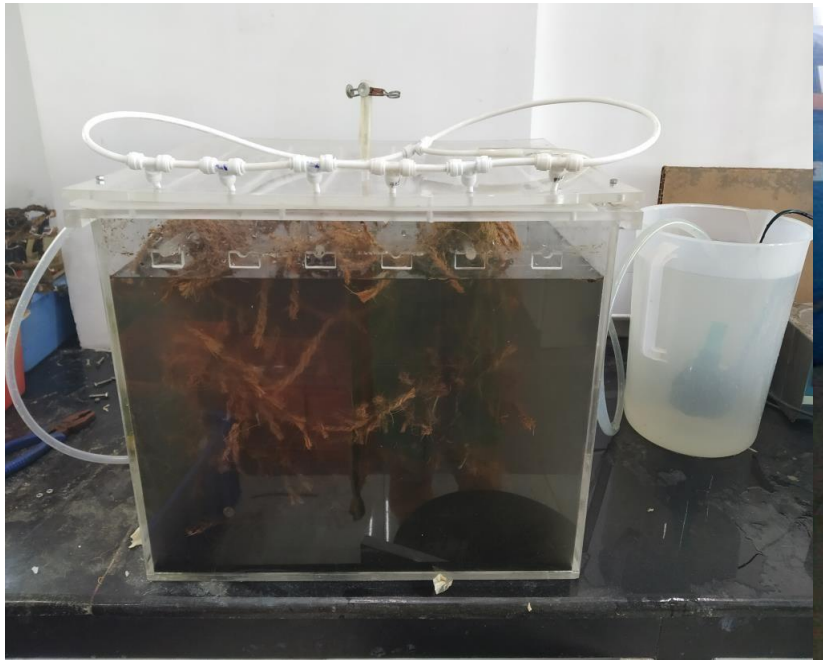
- Plastic waste to carbonaceous material synthesis will be value addition to waste and minimise the waste burden
- Low cost carbonaceous material could be a replacement for metal based catalyst
- Persulfate treatment proved to be more viable than hydroxyl radical towards industrial wastewater treatment like textile industry
- Carbocatalysed persulfate treatment is cost effective system than any other AOPs due to its energy extensive nature
- Metal leaching can be avoided in treated water to meet environmental regulations effectively

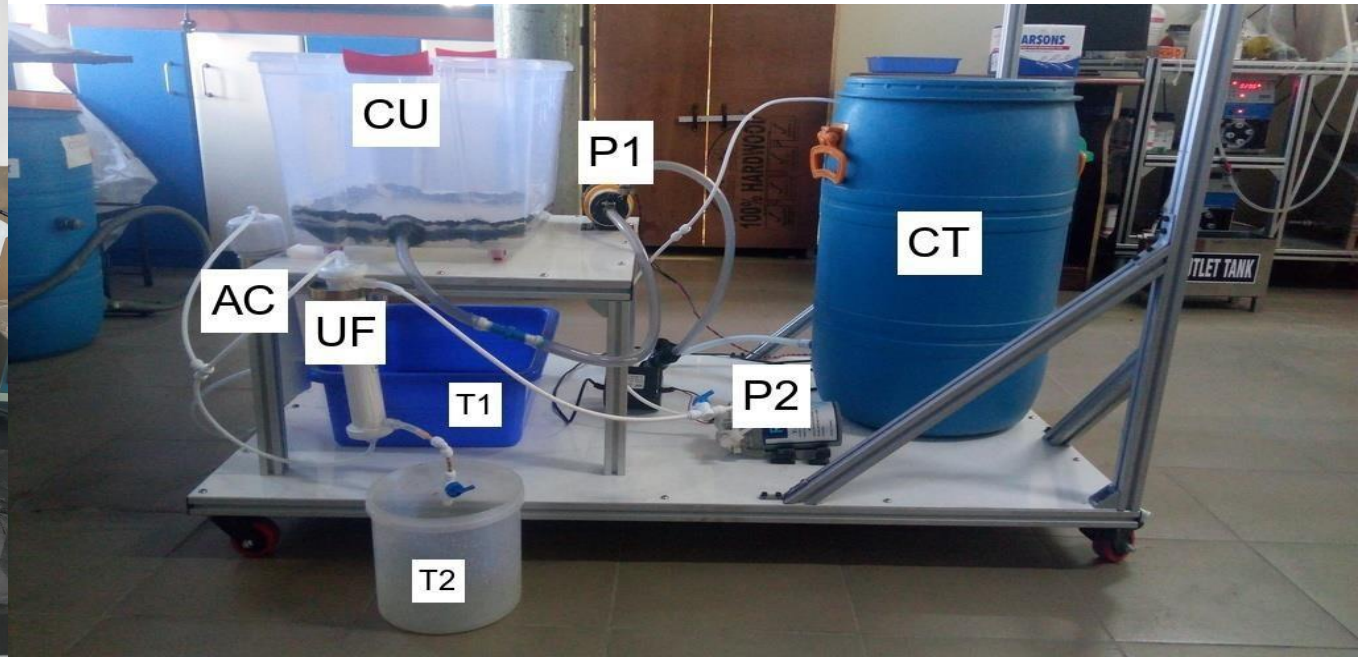


TOC and Toxicity reduction at different reaction time

PROGRESS: WP-3: WASTE WATER MANAGEMENT (Grey Water)

Modified Bathroom Greywater Recycling Unit(BGRU) (Ligy Philip, IIT Madras)





Anaerobic attached coir reactor (AACR) for greywater treatment

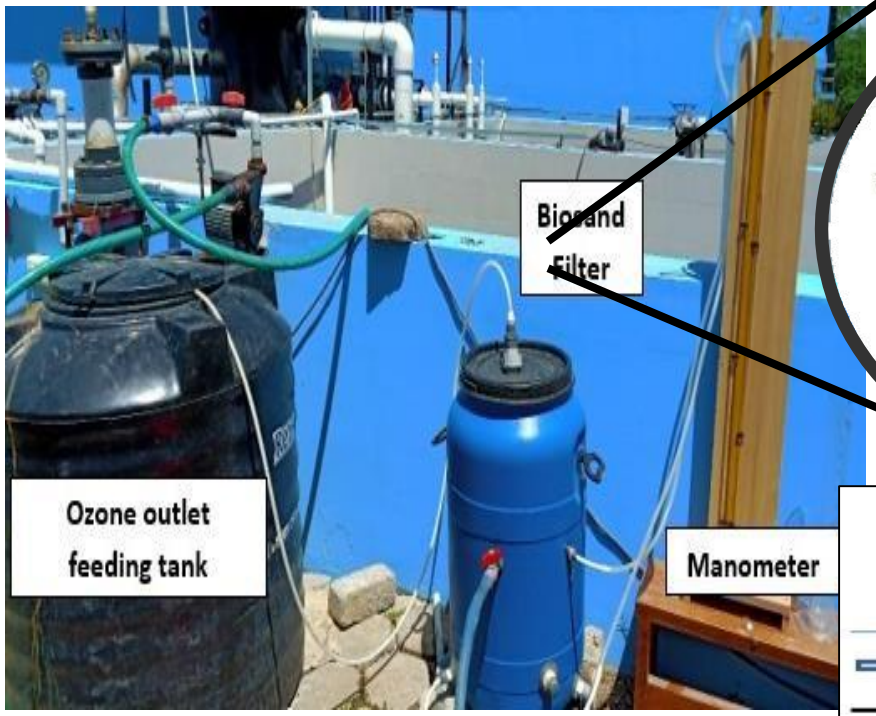
Day	Initial COD (mg/L)	Final COD (mg/L)	Removal efficiency (%)
1	320	150	53.1
2	290	132	54.4
3	340	140	58.8%
4*	360	138	59%

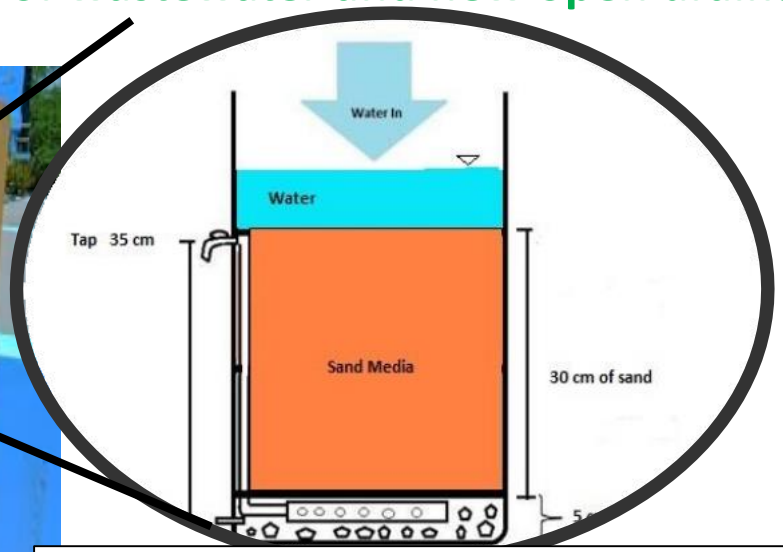
Performance of AACR

- **CU- Raw water collection unit**
- **CT- Coagulation Tank**
- **UF- Ultrafiltration module**
- **T1- Permeate after treatment**
- **P1- Pump connecting CU and CT**
- **P2- Pump connecting CT and UF**
- **AC- Adsorption column**
- **T2- Reject from ultrafiltration unit**

PROGRESS: WP-3: WASTE WATER MANAGEMENT (Tertiary treatment)

Biosand filter for tertiary treatment of wastewater and new open drainage treatment system (Ligy Philip, IIITM)



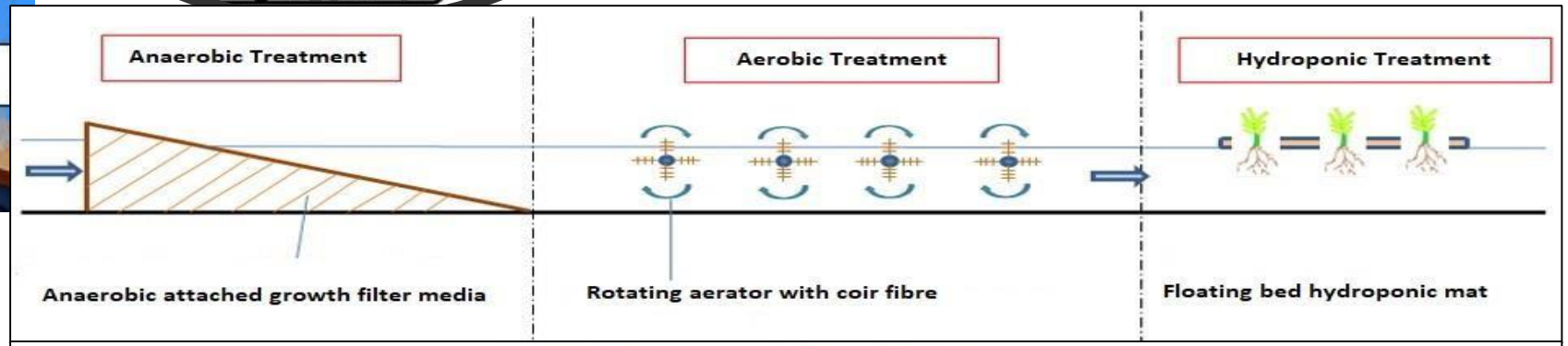


Biosand filter :

a sustainable and effective polishing treatment method for nutrient and pathogen removal

Drainage treatment:

A sustainable and natural treatment train approach for organic and nutrient removal in drainage systems



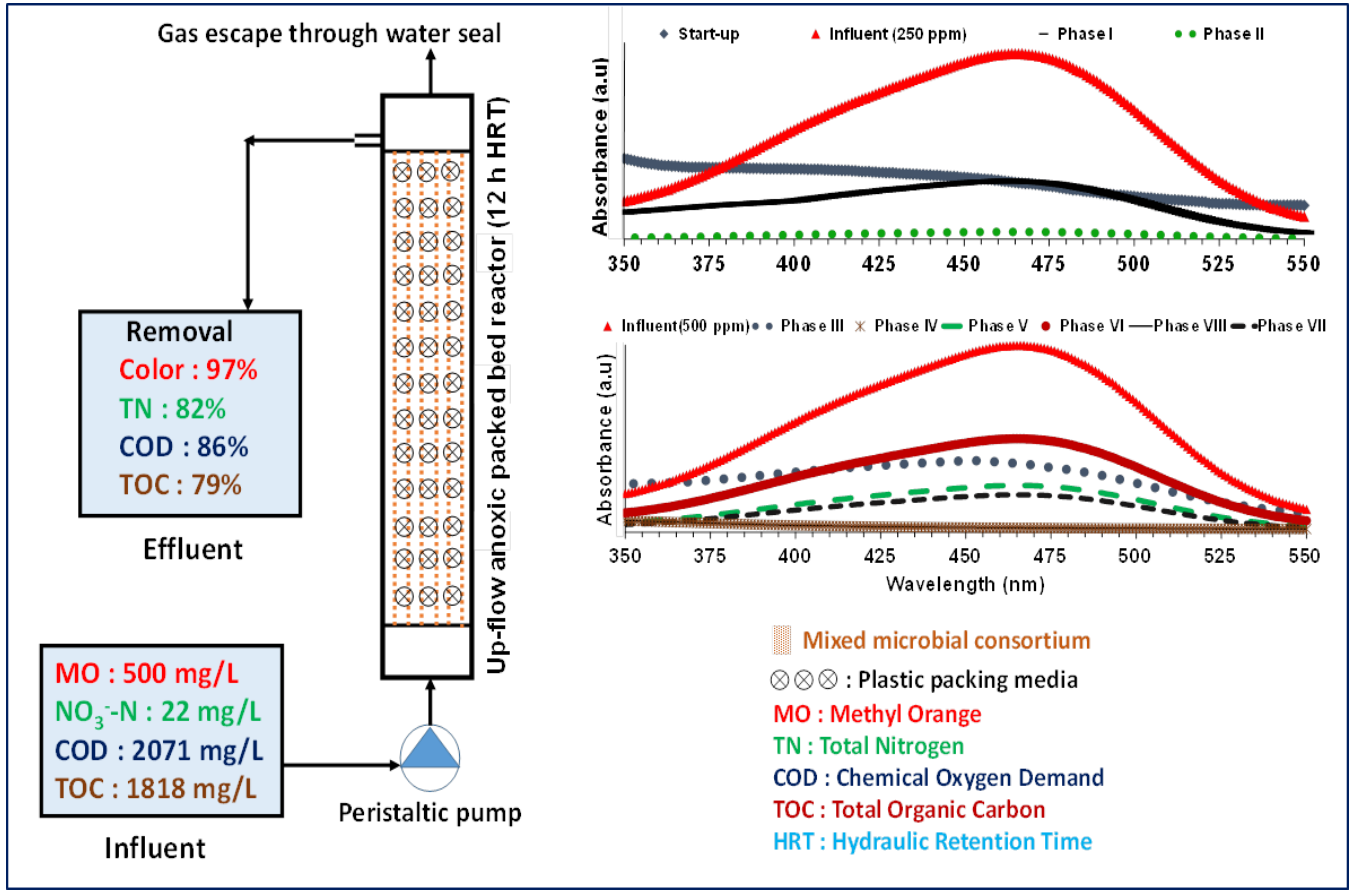
ANAEROBIC TREATMENT UNIT SET-UP

AEROBIC TREATMENT UNIT SET-UP

HYDROPONIC TREATMENT UNIT SET-UP

PROGRESS: WP-3: WASTE WATER MANAGEMENT (Textile Wastewater)

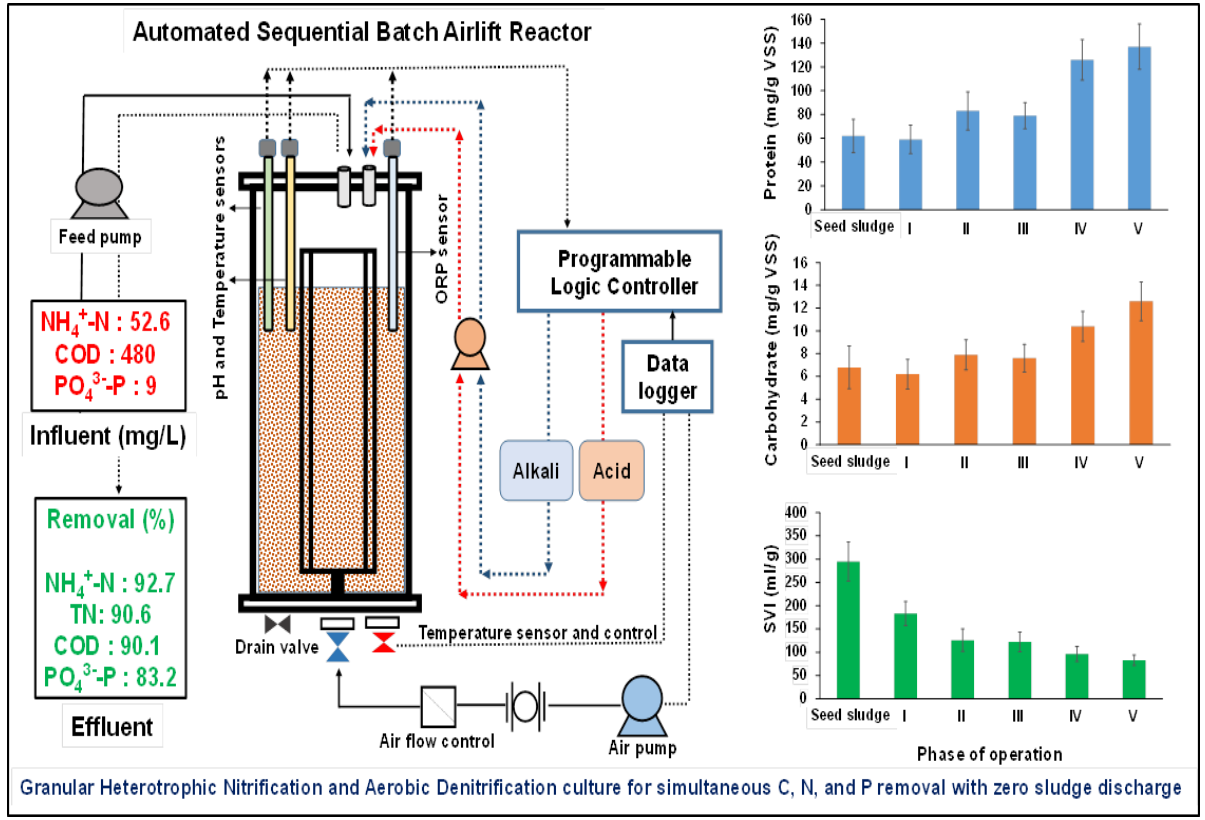
Decolorization of azodyes from textile wastewater (P. C. Sabumon, VIT, Chennai)



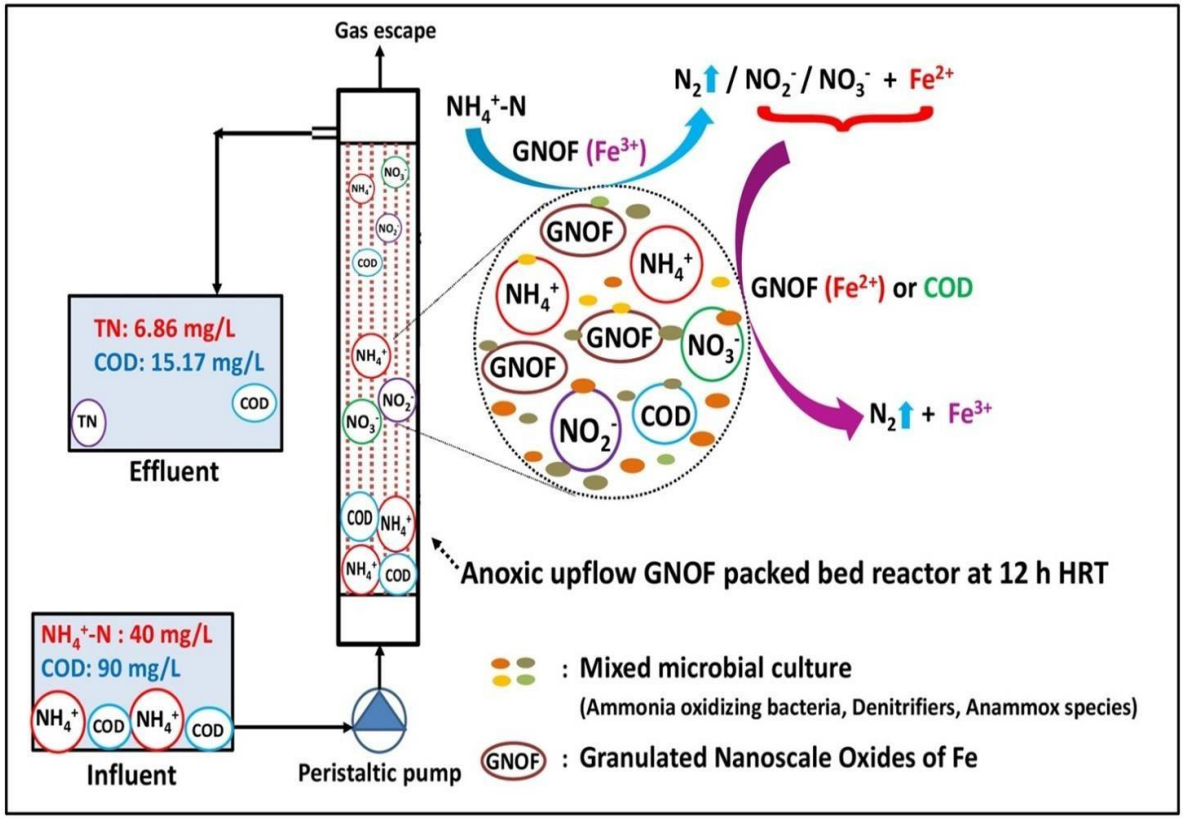
Up-flow anoxic packed bed reactor for Methyl Orange (MO) decolourisation and mineralization in denitrifying environment

PROGRESS: WP-3: WASTE WATER MANAGEMENT (Removal/Recovery of Nutrients)

Process Know-how for Removal/Recovery of Nutrients from Wastewater (P. C. Sabumon, VIT, Chennai)



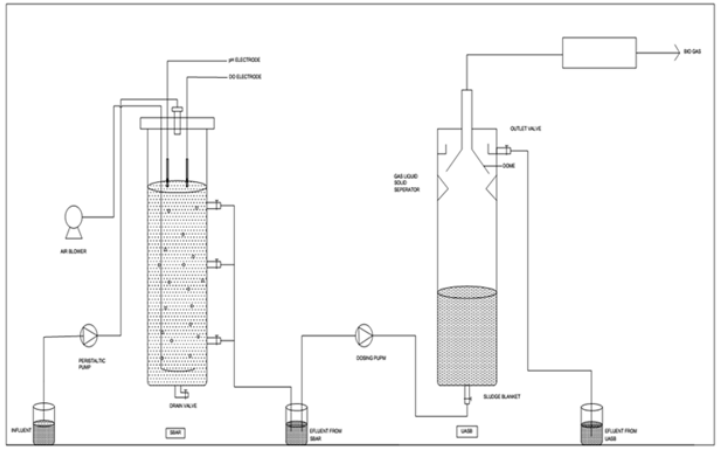
Patented C,N,P removal process in SBR



A cost-effective anoxic ammonia removal process for meeting discharge standards of NH_4-N from low C/N wastewaters , (Indian Patent No. 360373)

PROGRESS: WP-3: WASTE WATER MANAGEMENT (Tannery Waste Water)

Technology for treating tannery waste water (S. V. Srinivasan, CSIR-CLRI)



Process flow scheme

$$2\,NH_{4+} + 3\,O_2 \xrightarrow{Nitrosomonas} 2\,NO_{2-} + 2H_2O + 4H^+ + New$$

$$2\,NO_{2-} + 2O_2 \xrightarrow{Nitrobacter} 2NO_{3-} + New$$

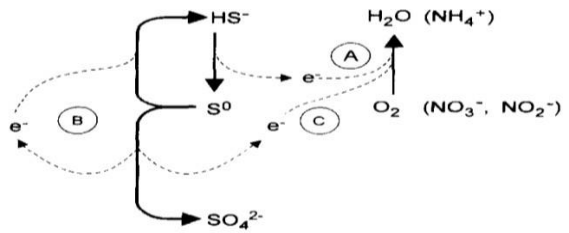


Fig. 4. Model of the common pathway of sulfide oxidation in sulfate-reducing bacteria. First, sulfide is oxidized to elemental sulfur with oxygen (or nitrate or nitrite) as electron acceptor (A). In a second step, elemental sulfur is disproportionated (B). Strains, starting sulfide back-formation after oxygen reduction, reduce oxygen only with electrons released during sulfide oxidation to elemental sulfur. Strains, which start sulfide back-formation during oxygen reduction, reduce oxygen also with the electrons released during elemental sulfur oxidation to sulfate (C).

- As per the proposed process scheme Aerobic process (reduction of COD and Ammonia) followed by anaerobic (Denitrifying sulfide removal) is performed.
- During the course of aerobic process in Sequential Batch Reactor (SBR), Ammoniacal nitrogen is converted to nitrite through nitrification process with nitrifiers, where Ammonia oxidizing Bacteria plays a major role.
- Further, microbial community like nitrobacter convert nitrite into nitrate via nitrification

- SBR is followed by Upflow Anaerobic sludge blanket reactor for the conversion residual COD into methane & Carbon-di-oxide and Nitrate into Nitrogen gas (N_2).
- In UASB, Sulfur reducing bacteria plays a major role in conversion of Sulfate into Sulphide, where this Sulphide can be converted into elemental Sulphur in the presence of NO_3. The process is called Denitrifying sulfur removal.

PROGRESS: WP-3: WASTE WATER MANAGEMENT (Tannery Waste Water) CONTD....

Technology for treating tannery waste water (S. V. Srinivasan, CSIR-CLRI)

Technological achievements during April 2020 – March 2021

- **Stabilization of inoculum for the treatment of Synthetic tannery wastewater for carbon and nitrogen removal was achieved**
- **Sequential batch studies shows better removal than ideal batch reactor for the removal of COD, Ammoniacal nitrogen, TKN and NO_x – N were carried out for over a period of 150 days in a lab scale reactor with the working volume of 5 Litres with the cycle time of 36 hrs.**
- **Removal of COD with more than 87 % and ammoniacal nitrogen with the maximum removal of 75 %. Over 50 % conversion of Ammonical nitrogen into nitrate was observed.**
- **Development and enrichment of Sulfur reducing bacteria using Modified Baar's medium for the denitrifying sulfur removal process was achieved.**
- **Further optimization of COD/SO_4 and F/M ratio was performed in batch anaerobic condition.**
- **Based on the results from the experiments, the continuous studies will be performed with SBR and UASB.**

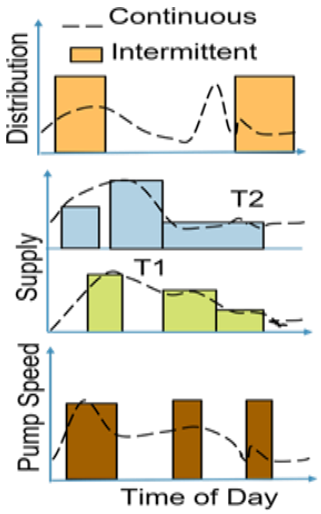
- **The process flow scheme has been proposed with Aerobic process (reduction of COD and nitrification) followed by anaerobic (Denitrifying sulfide removal)**
- **Lab scale : Aerobic process (reduction of COD and nitrification) for synthetic tannery wastewater has been established**
- **Lab scale : Fabrication and start-up of UASB with the capacity of 4 L has been achieved and operation of reactor is under progress**

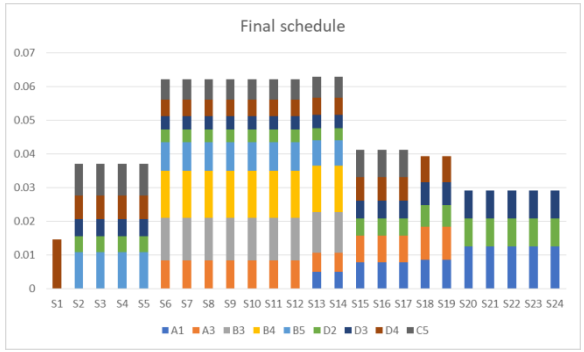
PROGRESS: WP-4: NETWORKS (Water Distribution Networks)

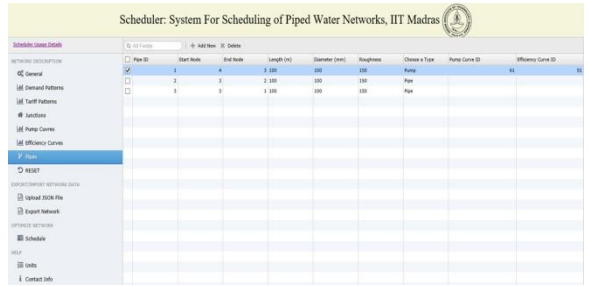
Integrated Methodology & Software for Water Network Design, Monitoring and Rehabilitation (S. K. Narasimhan, S. Narasimhan & B.S. Murty, IIT Madras)

1. Software for scheduling of WDNs operated with On/Off valves is developed

- Scheduling of WDNs is required for optimal supply policies
- Heuristics to identify the optimal or near optimal solution
- Data driven techniques based on On/off valve operations & available measurements are developed for scheduling problem
- Hydraulic or network model not needed!

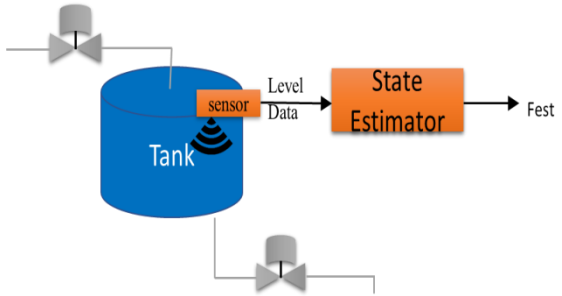




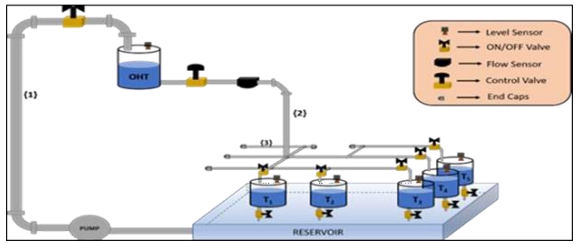


2. Methodology is developed for network calibration

- Customized simulator
- Graph theoretic reduction for computational efficiency
- Experimentally validated & software under development



Experimental rig to prove the software



3. Methodology is developed for estimating flow rates from level measurements at demand nodes

PROGRESS: WP-4: NETWORKS (Sewerage Networks)

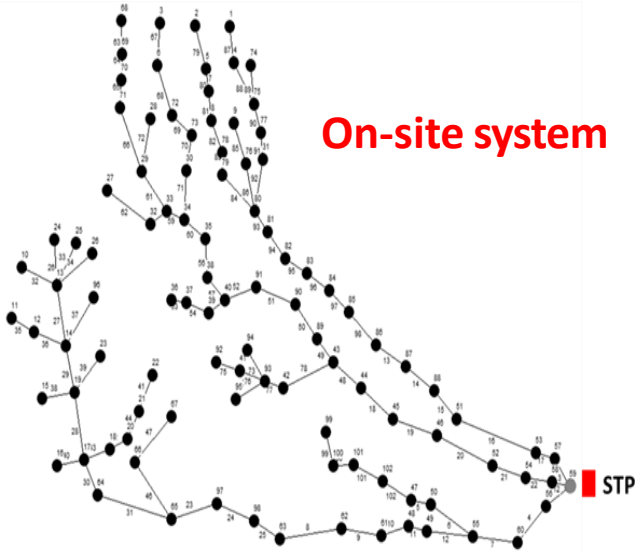
Retrofitting of sewerage networks for recycling of treated wastewater(B.S. Murty, IIT Madras)

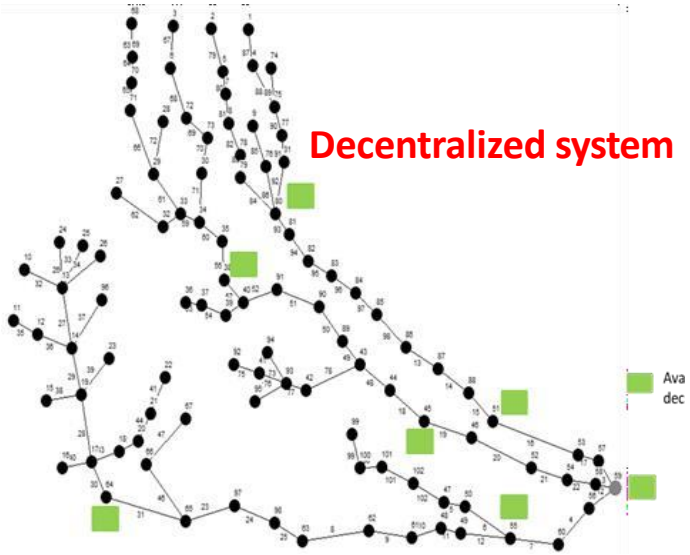
Software is developed for optimal implementation of on-site grey water treatment and recycling in existing sewerage systems

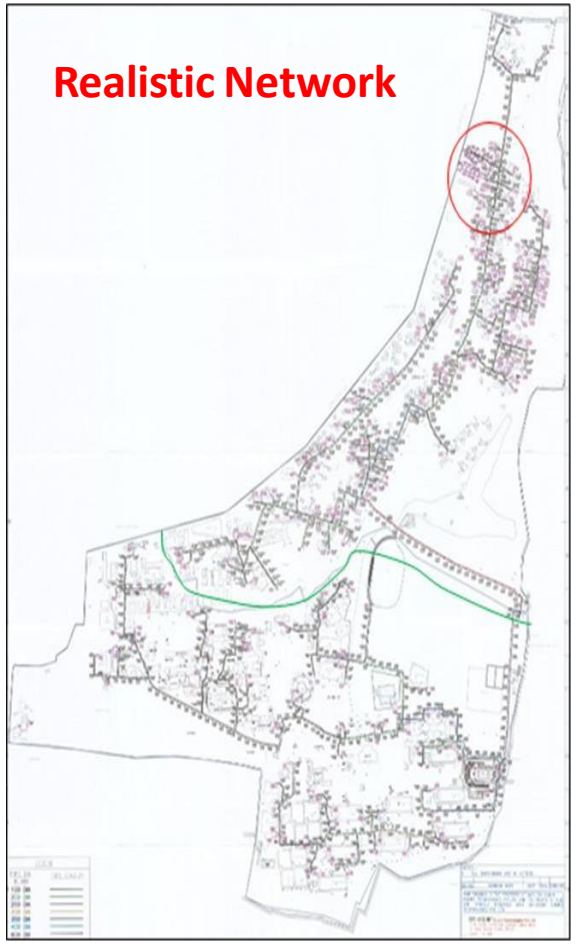
Software is developed for optimal implementation of wastewater treatment and recycling in existing sewerage systems through decentralized wastewater treatment

Minimization of cost

1. Cost of providing fresh water
2. Cost of treatment plants
3. Cost of providing treated wastewater
4. Cost of dual piping system
5. Cost of pumping of treated wastewater
6. Increased cost of flushing of sewer system







Shortfalls in Achievements during the Review Period

Activity	Shortfall (if any) in Specific Terms	Responsible Organization
Planned field work	**The delay in release of funds and the lockdown period posed great difficulty in carrying out the planned field work during this financial year.**	Anna University
Mixed azo dye decolorization studies	**Unable to start due to lockdown**	VIT, Chennai
Feasibility studies for recovery of nutrients from wastewater	**Unable to start due to lockdown**	VIT, Chennai
Coating of nanocomposite for applicability in reactor; Running the reactor for studies	**Complete suspension of lab activities during the period from March to September 2020 due to COVID-19 lockdown. Work was resumed mid of October 2020**	IIT Tirupati
Results obtained in SBR and UASB studies with synthetic wastewater on CNS removal	**Results with respective SBR have been completed. However the overall performance of Continuous UASB reactor as the second stage followed by SBR treatment is pending and same is under progress**	CLRI
Quantitative real time (RT-PCR) data analysis of nitrifiers, denitrifiers and sulphur reducers	**Gene expression studies on Nitrifiers, ammonia oxidizers and sulfur reducers after stabilization of SBR and UASB could not be completed and will be initiated shortly.**	CLRI
Laboratory experiments and field data collection	**CoVID induced disruptions, closure of laboratory facilities has severely affected the progress of the work.**	IIT Madras
Manpower recruitment	**Funds allocated are too small for the purpose. Need to release more funds in this head**	IIT Madras

TECHNOLOGIES DEVELOPED

S. No.	Technology Developed	Patent No.	TR Level
1.	Gray water treatment system for apartments	Copy Right: IDF:1883, 18/7/2019	6
2	Colorimetric sensors of Detection of Eutrophying pollutants (Vaishali Choudhary, Kowsalya Vellengiri, Ligy Philip)	IDF:2070 Filed on 22/3/202	6
3.	Pulse power system for any organic contaminant removal	Patent No:349146 Granted-13/10/2020	6
4.	Composting methodology for septage and biosolids		6
5.	Carbonized adsorbent derived from waste for pharmaceuticals and personal care products (Ligy Philip)		3
5.	Simple direct microcontroller interface for capacitively-coupled resistive sensors(Lakshmi A., Boby George, and Ferran R)	22/05/2020 202041021691	5
6.	Immersion type fully non-contact probe for conductivity measurement of water (Boby George)		4
7.	A green method for preparing robust and sustainable cellulose polyaniline based nanocomposite for effective removal of fluoride from water and a purifier thereof, (Thalappil Pradeep; Sritama Mukherjee; Haritha Ramireddy)	15/11/ 2019 201941046691	8
8.	CDI Prototype (T. Pradeep)		8

TECHNOLOGIES DEVELOPED

S. No.	Technology Developed	Patent No.	TR Level
9.	Triaminoguanidinium-based ionic porous organic frameworks (POFs) for heterogeneous catalysis and broad-spectrum antimicrobial application (A. Patra, A. Chande, MD. W. Hussain and V. Bhardwaj)	19/03/2019 No.201921010663 A	3-4
10.	Hydro-Solvo Thermal Graphene Oxide Synthesis Method1. (Nanda Gopal Sahoo, Chetna Tewari, Sandeep Pandey, Manoj Karakoti, Sunil Dhali, Himani Tiwari, Gaurav Tatrari, Anand B. Melkani	17/03/2020 202011011434	3-4
11.	Process of preparation of naturally doped Silicon, Magnesium and Calcium Graphene nanosheets from Paper Waste for Energy Applications (Australia Innovation Patent) (Sandeep Pandey, Manoj Karakoti, Sunil Dhali, Chetna Tewari, Nanda Gopal Sahoo)	28/01/2021 2021100550	3-4
12.	Metal Oxyhydroxide mediated anoxic ammonia removal from aqueous solutions (P.C. Sabumon, Shihabudeen M.M & Desireddy Swathi)	2021, No. 360373	3-4
13.	Zero sludge and aerobic granulation system for simultaneous removal of C,N and P in sequencing batch airlift reactor (P.C. Sabumon & Desireddy Swathi	2020, 202041032265	3-4
14.	Online Fluoride sensor (T. Pradeep)		
15.	A reusable Dip & Sip type point-of-use disinfection system (S.M. Maliyekkal)	28/08/20 IN 345400	3-4

TECHNOLOGIES DEVELOPED

S. No.	Technology Developed	Patent No.	TR Level
16.	Hydro-Solvo Thermal Graphene oxide synthesis method (PCT Filing) (Nanda Gopal Sahoo, Chetna Tewari, Sandeep Pandey, Manoj Karakoti, Sunil Dhali, Himani Tiwari , Gaurav Tatrari, Anand B. Melkani)	PCT/IB2021/052158 16/03/2021	5
17.	Process of preparation of naturally doped Silicon, Magnesium and Calcium Graphene nanosheets from Paper Waste for Energy Applications (Sandeep Pandey, Manoj Karakoti , Sunil Dhali, Chetna Tewari , Nanda Gopal Sahoo)	27/04/2020 202011017973	3
18.	Software for optimal implementation of wastewater recycling into existining sewerage networks (B. S. Murty)		3
19.	Software for scheduling of WDNs operated with On/Off valves (S.K. Narasimhan & S. Narasimhan)		
20.	Mini atmospheric water generator/23-01 (Design) Ashutosh Das, Kannan TTM, Parthiban P	339122-001	
21.	Solar desalinator/23-01 (Design) Ashutosh Das, Kannan TTM, Parthiban P	339121-001	

PUBLICATIONS

S. No.	Title of the paper	Journal, Issue, etc.	Authors
1	Spatio-temporal analysis of rainfall, meteorological drought and response from a water supply reservoir in the megacity of Chennai, India	Journal of Earth Syst. Science / 2021	**Anandharuban P, Elango L**
2	A box model approach for reservoir operation during extreme rainfall events: A case study	Journal of Earth Syst. Science / 2019	**Anandharuban P, Michele La Rocca, Elango L**
3	Organic micropollutants in groundwater of India – A Review	Water Environment Federation / 2019	**Merin Sackaria, Elango L**
4	Analysis of Challenges and Opportunities for Low-Impact Development Techniques in Urbanizing Catchments of the Coastal City of Chennai, India: Case Study	Journal of Hydrologic Engineering, Volume 25 Issue 10, 2020	**Bakkiyalakshmi Palanisamy, Subham Shaurabh, Balaji Narasimhan**
5	Insights into the Removal of Antibiotics from Water and Wastewater by Electrocatalytic Degradation (2021)	Environmental Science: Nano,2021	**Choudhary, V., Vellingiri, K, Thyalli, M. & Philip, L**
6	Interpretation of the risk associated with emerging contaminants in the aquatic systems of BRICS nations. (2020)	EWRI, American Society of Civil Engineers,2021	**Choudhary, V. & Philip, L**
7	Potential nano-materials based sensors and treatment methods for detecting and removal of aqueous chloroform(2021)	Environmental Nanotechnology, Monitoring & Management	**Choudhary, V. Vellingiri, K, & Philip, L**
8	Fabrication of portable colorimetric sensor based on basic fuchsin for selective sensing of nitrite ions	Journal of Environmental Chemical Engineering,2021	**Vellingiri, K., Choudhary, V., & Philip, L**
9	Characterization of segregated greywater from Indian households: part A—physico-chemical and microbial parameters	Environmental Monitoring and Assessment, Volume 192(7),2020	**Krithika, D and Ligy Philip, (2020)**
10	Characterization of segregated greywater from Indian households—part B: emerging contaminants	Environmental Monitoring and Assessment, Volume 192(7),2020	**Krithika, D and Ligy Philip, (2020)**
11	Sorption of pharmaceutical compounds and nutrients by various porous low-cost adsorbents	Journal of Environmental Chemical Engineering, 9(1), 104916.,2021	**Karthik, R. M., & Philip, L.**
12	Performance evaluation of a novel electrolytic reactor with rotating and non-rotating bipolar disc electrodes for synthetic textile wastewater treatment	Journal of Environmental Chemical Engineering, 8(2), 103462.,2020	**Narasamma.N and Ligy Philip, 2020**

PUBLICATIONS (Contd.)

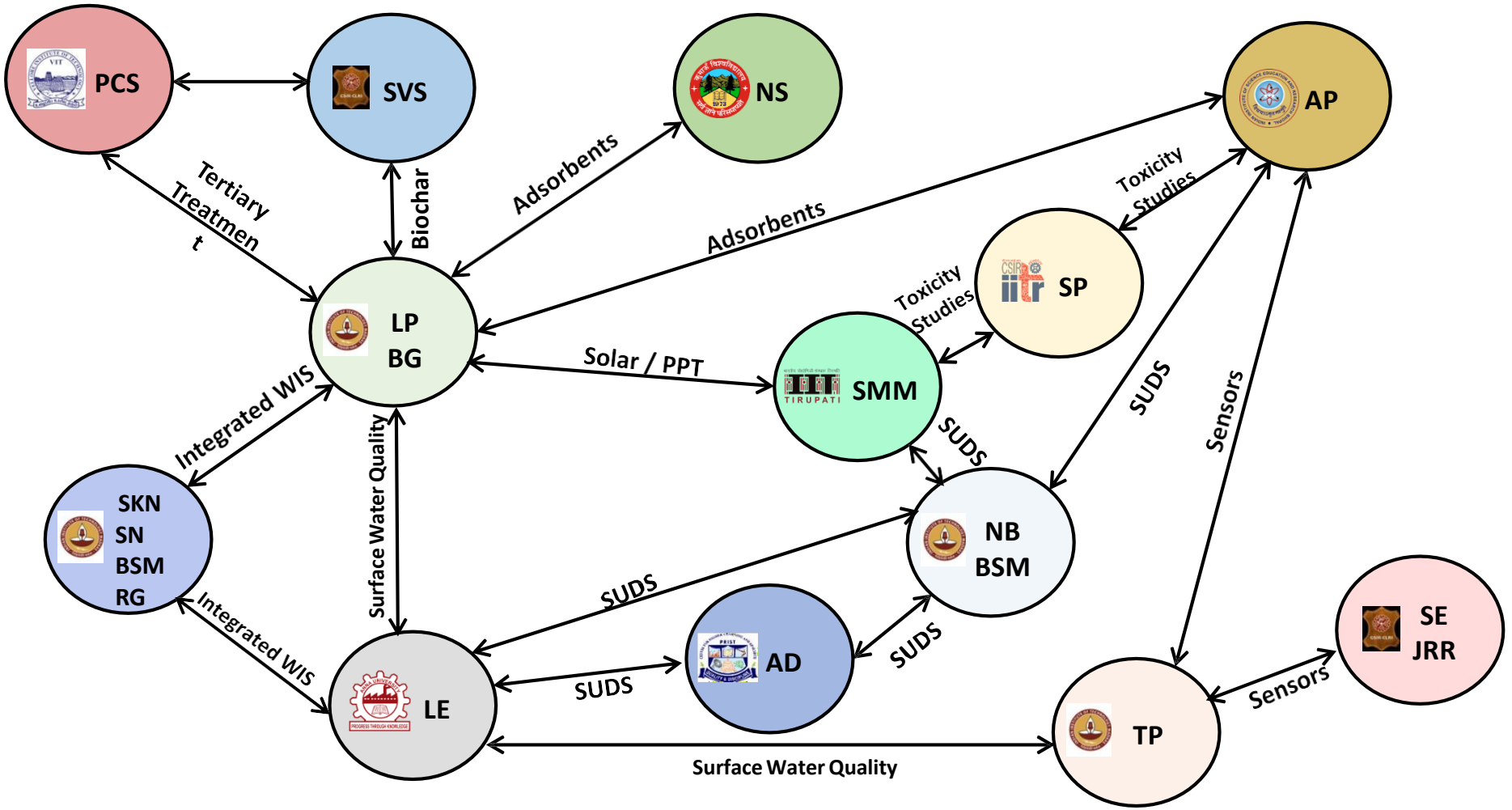
S. No.	Title of the paper	Journal, Issue, etc.	Authors
13	Simultaneous decolorization and mineralization of high concentrations of methyl orange in an anoxic up-flow packed bed reactor in denitrifying conditions,	Journal of Water Process Engineering, 2021, 40, 101813, *Elsevier publication*	**Desireddy Swathi, Sabumon P.C., Aditi Trivedi**
14	Assessment of novel rotating bipolar multiple disc electrode Electrocoagulation–flotation and Pulsed Power Plasma Technology	Water Science and Technology (IWA Journal), 81(3), 564-570	**Nippatla N. and Philip L, 2020**
15	Electrochemical process employing scrap metal waste as electrodes for dye removal	Journal of Environmental Management, 273, 111039	**Nippatla, N. and Philip L, 2020**
16	Effect of various electrolytes and other wastewater constituents on the degradation of volatile organic compounds in aqueous solution by pulsed power plasma technology	Environmental Science: Water Research & Technology, 6 (2020) 2209-2222	**Jerin Jose, Ligy Philip**
17	Comparative study of degradation of toluene and methyl isobutyl ketone (MIBK) in aqueous solution by pulsed corona discharge plasma	Journal of Environmental Sciences, 101 (2021) 382-396	**Jerin Jose, Ligy Philip**
18	Analysis of a Direct Microcontroller Interface for Capacitively-Coupled Resistive Sensors	IEEE Transactions on Instrumentation and Measurement, vol. 70, Art. no. 1501010 (2021)	**Areekath L., George B. and Reverter F**
19	Nanocellulose reinforced organo- inorganic nanocomposite for synergistic and affordable defluoridation of water and an evaluation of its sustainability metrics	ACS Sustainable Chem. Eng. 2020, 8, 1, 139-147 (doi: 10.1021/acssuschemeng.9b04822)	**Sritama Mukherjee, ……., Ligy Philip, and Thalappil Pradeep**
20	Scalable drop-to-film condensation on a nanostructured hierarchical surface for enhanced humidity harvesting	ACS Appl. Nano Mater., 2021 (DOI: 10.1021/acsanm.0c03032)	**Ankit Nagar, ……., Thalappil Pradeep**
21	A covalently integrated reduced graphene oxide-ion exchange resin electrode for efficient capacitive deionization	Adv. Mater. Interfaces, 2020 (DOI: 10.1002/admi.202001998)	**Md Rabiul Islam, ……and Thalappil Pradeep**
22	A smartphone-based fluoride-specific sensor for rapid and affordable colorimetric detection and precise quantification at sub-ppm levels for field applications	ACS Omega, 5 (2020) 25253–25263 (DOI: 10.1021/acsomega.0c03465)	**Sritama Mukherjee, ……., Ligy Philip and Thalappil Pradeep**
23	Development of an eco-friendly and reusable point-of-use disinfection system	Process Safety and Environmental protection, Volume 148, April 2021, Pages 104-113; https://doi.org/ 10.1016/ j.pse, p.2020.09.055	**U. Kannan, P.C. Sabumon, S. M. Maliyekkal**
24	Dissolved arsenic in groundwater bodies: A short review of remediation technologies in “Pollution Control Technologies: Current Status and Future Prospects”	Accepted	**M. S. V. Naga Jyothi, Gayathri S., T. Pushparaj Gandhi, S. M. Maliyekkal**

PUBLICATIONS (Contd.)

S. No.	Title of the paper	Journal, Issue, etc.	Authors
25	Advanced Oxidation Processes: A Promising Route for Abatement of Emerging Contaminants in Water in "Pollution Control Technologies: Current Status and Future Prospects"	Accepted	**Divya Kusuma T., M. S. V. Naga Jyothi, Chebrollu Pulla Rao, S. M. Maliyekkal**
26	Multifunctional ionic porous frameworks for CO_2 conversion and combating microbes	Chem. Sci. 2020, 11, 7910-7920	**MD. Waseem Hussain, Vipin Bhardwaj, Arkaprabha Giri, Ajit Chande* and Abhijit Patra***
27	Cavitand and Molecular Cage-Based Porous Organic Polymers	ACS Omega 2020, 44, 28413–28424	**Arkaprabha Giri*, Aniket Sahoo, Tapas Kumar Dutta, and Abhijit Patra***
28	Mass Production of Metal Doped Graphene Sheets from Biomass Waste of Quercus ilex Leaves for Supercapacitor Application: Inclusive structural confirmation by DFT Study	RSC Advances (Revised)	**Gaurav Tatrari ,Chetna Tewari, Manoj Karakoti, Ritu Jagra, Boddepalli Santhibhushan, SwaroopGanguly, Anurag Srivastava, Nanda Gopal Sahoo***
29	QUANTUM DOTS BASED MATERIALS FOR WATER TREATMENT	Quantum Dots: Properties and Applications; Materials Research Forum LLC. 96 (2021) 280-304 https://doi.org/10.21741/9781644901250-11	**Chetna Tewari, Sumit Kumar, Neema Pandey, Sandeep Pandey, Nanda Gopal Sahoo**
30	Introduction, past and present scenario of plastic degradation	Quantum Dots: Properties and Applications; Materials Research Forum LLC. In press, 2021.	**Neema Pandey, Chetna Tewari, Bhashkar Singh Bohra, Nanda Gopal Sahoo**
31	Development of an up -flow anoxic nano -biotechnological reactor for simultaneous removal of ammonia and COD from low C/N secondary treated wastewater	Journal of Water Process Engineering, 36, August 2020, 101344	**Swathi Desireddy, Sabumon P. C., Manasa R.L., Alka Mehta**
32	(2021). Development of an anoxic nitrification-denitrification process in a granulated nanoscale oxyhydroxides of Fe packed bed reactor for the simultaneous removal of NH_4^+-N and COD,	Environmental Nanotechnology, Monitoring& Management,Vol.15, 100412. *Elsevier publication*	**Swathi Desireddy, Manasa Raghupatruni Lakshmi, Sabumon, P. C., Alka Mehta.**

Collaborative Research & Group activities

Identified areas where inter institutional cooperation is possible. Many initiatives are already taken



Collaborations: Proposed

Prof. Ligy Philip & Prof. Boby George (IIT Madras)

- **Assessment of competitive adsorption of pharmaceuticals and personal care product on carbonized absorbent derived from waste: Single and Multicomponent study: We will be collaborating with Dr. Abhijit Patra ISER Bhopal. The new material developed by their team will be used for the removal of multitude of PharmaceuticalsLow cost carbonaceous material could be a replacement for metal based catalyst**

- **Adsorptive and catalytic application of PWC in textile dye degradation study: This work is in collaboration with Prof. Sahoo of Kumaun University. The plastic waste carbon developed by their laboratory is used as a base for adsorptive and catalytic removal of textile dye.**

- **Electro catalytic removal of trace pollutants from water: We are developing new catalysts. For bulk preparation of the base material (Graphene oxide) for the catalytic processes, our team will be collaborating with IIT Tirupati**

- **Treatment of textile wastewater: IIT madras has looked into the treatment of textile wastewater. VIT is also looking into this aspect. We will be collaborating to improve the secondary treated wastewater quality using AOPs**

Prof. S. M. Maliyekkal (IIT Tirupati)

- **Modification of antimicrobial film for imparting contact killing properties – Dr. Abijit Patra, IISER, Prof. Sabumon, VIT**

- **Graphene based materials for removal of heavy metals and organic pollutants (Prof. Ligy Philip, IITM; Prof. Nanda Gopal Sahoo)**

- **Understanding the assessing the impact of storing drinking water in abandoned quarries (Anna University, IITM, IITT)**

- **Development of Photoreactor for Disinfection of water (with IIT Madras)**

Prof. L. Elango (Anna University)

- Water quality assessment for major, minor and trace elements is being carried out for the collected surface and groundwater samples from quarries, lakes, check dams and wells. Collaboration with Dr. Ligy Philip, IIT Madras, for analyzing micro pollutants will help to assess the water quality issues holistically.
- Assessment of possible presence of specific minerals and metals in quarry water and surrounding groundwater due to prolonged water storage. (Dr. T. Pradeep, IIT Madras)
- Incorporating interventions like micro scale drainage for the city with sustainable urban drainage (SUD's) for efficient water discharge and storage (Dr. Balaji Narrasimhan & Dr. B. S. Murty, IIT Madras)
- The oxidation reduction potential variation and solubility of different minerals in the collected quarry water samples (Dr. Sankar Narasimhan, IIT Madras)
- Groundwater modelling (Dr. Ashutosh Das, Prist university)

Prof. AbhijitbPatra (IISER, Bhopal)

Collaborators	Work plan	Remarks
Prof. Ligy Philip	• Large scale synthesis of highly porous organic polymers • Loading on suitable substrates/beads/resins which can be used in adsorption columns • Studies for commercial value for micropollutants removal (e.g., endocrine disruptor)	RN4-F, SKTP for testing were dispatched
Prof. T. Pradeep	• Metal scavenging using composite of highly porous organic polymers and metal oxides • Uranium uptake by CDI electrodes using highly charged polymers	RN4-F for testing was dispatched
Prof. Boby	• Highly porous polymer loaded on graphene/conducting suitable substrate –electrical read out –sensor for metals	
Prof. Shihab	• Cationic antimicrobial polymers for contact killing properties of Guanidinium based porous organic polymers with/without ZnO loading. • Possibility of making such polymers conducting	POF-1 for testing was dispatched

Prof. Nanad Gopa; Sahoo (Kumaun University

1. **Kumaun University (Prof. N. G. Sahoo) and IIT-Madras (Prof. Ligy Philip)**
2. **Kumaun University (Prof. N. G. Sahoo) and PRIST (Prof. Ashutosh Das)**
3. **Kumaun University (Prof. N. G. Sahoo) and IISER Bhopal (Dr. Abhijit Patra)**
4. **Kumaun University (Prof. N. G. Sahoo) and IITR-Lucknow (Dr. Satyakam Patnair)**

Dr. Srinivasan CLRI

1. IITM in the area of development of suitable materials (adsorbents/catalyst) for treatment of wastewater using biochar obtained from different agro and municipal solid wastes.

2.VIT, Chennai campus in the area for biological treatment of tannery and textile wastewater /dye degradation studies.

J. Raghava Rao,S. Easwaramoorthi,CSIR-CLRI

3.The collaboration of Dr. Sridharkumar Narasimhan, and Dr. Shankar Narasimhan, Department of Chemical Engineering, IIT Madras would address to discriminate the overlapping signals and interference from other species. Further, the collaboration will also look for the image processing of paper strip sensors and possible quantification of the concentration of the metal ions.

4. We also look for the teams which could collaborate with us in the fabrication of portable devices. (IITM&IITR Luknow)

Way Forward

Bringing technologies to TRL-9 and Launching and operation

Many Technologies are in TRL Level 5 and above- We want to take it for extensive field testing

- **Major Technologies**
  - **Sensors**
    - **Sensors for Fluoride detection**
    - **Electrical conductivity, ORP and turbidity**
    - **Sensors for detection of nitrate, nitrite and phosphate**
    - **Heavy metals**
    - **Emerging contaminants**
  - **CDI**
  - **Pulse Power Technology for Tertiary treatment**
  - **Greywater Treatment system**
  - **Metal Oxyhydroxide mediated anoxic ammonia removal from aqueous solutions**
  - **A reusable Dip & Sip type point-of-use disinfection system**

Additional funding and manpower required

Way Forward-contd..

- Many Technologies are in TRL level 3-4. Developing them to TRL level -6 and above

Thank you

Accomplishment in Terms of Milestone: WP-1

Milestones	Target month	Progress
Collection of existing data (Lithologs, Rainfall, Soil, Water level)	March, 2019	Completed
Preparation of topographic map	July, 2019	Completed
Identification of pits/ quarries/ tanks	August, 2019	Completed
Assessment of quarry water, surface water and groundwater quality	Periodical collection once in three months up to June, 2023	Completed for the samples collected until February 2021
Identification and assessment of various recharge measures	May, 2022	Initiated
Modelling to assess the impact of identified measures	June, 2023	Initiated
Evaluation of the impact of sustainable urban drainage systems on hydrological response for a mixed land use setting. (M. Tech thesis completed)	June 2020	Completed
Optimal planning of sustainable urban drainage systems.	June 2021	In progress
Data collection for the monsoon event (Cyclone Nirvar) of Dec 2020 and analysis of data	January 2020	Completed
Zone-specific Hydrographs and Depth-Duration-Frequency curves For the specific zones identified based on previous studies, hydrographs were generated using limited secondary data available because the primary data could not be collected due to the pandemic situation. Besides the depth-duration-frequency (DDF) data were procured from the AWS installed in the study area which were used in conjunction with the hydrographs to generate DDF curves. These will be calibrated and validated with the field data as the normalcy get restored	19-24 months	In Progress

Accomplishment in Terms of Milestone: WP-2

Milestones	Target month	Progress
Bio-based carbon material finalized for removal studies of plasticizers	April 2021	On going
Fabrication of Capacitive deionization cell and development of material for deionization	April 2021	On going
Synthesis of Carbonaceous materials from waste plastic (PWC)	April, 2020	Completed
Characterization of PWC	August,2020	Completed
Adsorptive and catalytic application of PWC in textile dye degradation study	January, 2021	Completed
Optimization of process parameters	November 2020	Complete
Synthesis of working materials	July 2020	Complete
Completion of performance evaluation towards water capture	July 2020	Complete
Fabrication of cells	November 2020	Complete
Study on performance evaluation of antibacterial activity of silver nanocomposite in the presence of background ions in water: Evaluation of the antibacterial activity of the silver composite in in groundwater samples	6-36 Months	The individual ions effect in antibacterial activity of the composite is tested
Project initiation, identifying the structural motif's	6th Month	Structural motifs are identified and are synthesized.
Synthesis of intermediate compounds	12th Month	Signaling units and receptor units were identified. Three derivatives were synthesized and characterized and their preliminary studies are in progress.

Accomplishment in Terms of Milestone: WP-2 (Contd…)

Milestones	Target month	Progress
Bio-based carbon material finalized for removal studies of plasticizers	April 2021	On going
Fabrication of Capacitive deionization cell and development of material for deionization	April 2021	On going
Synthesis of Carbonaceous materials from waste plastic (PWC)	April, 2020	Completed
Characterization of PWC	August,2020	Completed
Adsorptive and catalytic application of PWC in textile dye degradation study	January, 2021	Completed
Optimization of process parameters	November 2020	Complete
Synthesis of working materials	July 2020	Complete
Completion of performance evaluation towards water capture	July 2020	Complete
Fabrication of cells	November 2020	Complete
Study on performance evaluation of antibacterial activity of silver nanocomposite in the presence of background ions in water: Evaluation of the antibacterial activity of the silver composite in in groundwater samples	6-36 Months	The individual ions effect in antibacterial activity of the composite is tested
Project initiation, identifying the structural motif's	6th Month	Structural motifs are identified and are synthesized.
Synthesis of intermediate compounds	12th Month	Signaling units and receptor units were identified. Three derivatives were synthesized and characterized and their preliminary studies are in progress.

Accomplishment in Terms of Milestone: WP-2 (Contd…)

Milestones	Target month	Progress
Preliminary investigation of sensing the metal ions	24th Month	Few receptors were developed to sense the Hg^{2+} at picomolar level using optical methods
Standardizing gram scale protocol for HCP and testing with a wide range of micropollutants. Optimization of fabrication conditions for macrocycle and cage-based network polymers	18th to 29th month	Benzene-based HCP was synthesized in gram scale
		Mechanistic investigation of the generation of distinct morphology of tripticyne based HCPs completed
		Micropollutants including plastic components, drugs and pesticides / herbicides were checked using triptycene based HCPs
		Optimization of the fabrication condition for macrocycle/cage-based porous networks for nanofiltration applications
Writing of the manuscript	18th – 29th month	Publication of triaminoguanidinium-based ionic porous frameworks for combating microbes and decontamination of water from bacteria by filtration.
		Publication of a comprehensive mini-review on cavitand based porous organic polymers and covalent organic framework for task-specific applications, including water treatment
Synthesis of porous carbon nanomaterials/activated carbon black by using traditional precursors and waste plastic	18-24 Month	Completed
Carbon nanomaterials/activated carbon black/ nano-zeolite based polymer nano composites as filter as filter membranes for water filtration unit	24-36 Month	In progress

Accomplishment in Terms of Milestone: WP-3

Milestones	Target month	Progress
Experiments with 4 µm ceramic filter membranes for the secondary treated wastewater at lab scale along with optimization of air plus water backwash	Jan-Feb 2020	Completed
Continuous experiments with 250nm filter at the condition of feed flow rate (0.5 -3 m^3/h) for different turbidity (low-10 NTU to high-100 NTU) with water and wastewater along with air plus water backwash at lab scale	Feb-Mar 2020	Completed
Flipping of 250nm filter assembly Continuous experiments with 250 nm filter at 3 m^3/h for 10,25.50 and 100 NTU using water in flipping mode Shifting of membrane set up to STP and fixing near to SBR outlet tank	Sep-Oct 2020	Completed
Continuous filtration cycle followed by air+water backwash (1-62 cycles) with secondary treated wastewater	Oct-Nov 2020	Completed
Optimization of chemical enhanced backwash (3-CEB) and continuation of filtration cycle (63-145 cycles)	Nov-Dec 2020	Completed
Auto SBR operation for the removal of C, N and P	20^{th} Month	Completed
Filing of patent	20^{th} Month	Completed
Preparing manuscripts for SBR operation and other studies	25^{th} Month	Completed
Results obtained in SBR studies with synthetic wastewater on CNS	(End of September 2020)	Performance of SBR with Synthetic wastewater has been completed. Subsequent anaerobic treatment initiated could not be continued due to COVID-19. SBR has been restarted and stabilized. Currently the anaerobic treatment with the effluent from SBR has been initiated.
Quantitative real time (RT-PCR) data analysis of nitrifiers, denitrifiers and sulphur reducers	(End of March 2021)	Consortia from SBR and UASB have to be evaluated

Accomplishment in Terms of Milestone: WP-4

Milestones	Target month	Progress
Coding for retro-fitting of sewer networks for recycling of greywater and wastewater.	36 Months	Coding for single-objective model is over and it is tested. Formulation for multi-objective model is over.
Testing of retro-fit models for sewer networks	42 Months	Single-objective model is tested for realistic systems.
Software for network mapping and scheduling	36 Months	Scheduling software being converted to python for hosting and access Network mapping methodology under development

Accomplishment in Terms of Milestone: WP-5

Milestones	Target month	Progress
Continuation and completion of process set up	December 2020	In progress