INNOVATIVE TECHNOLOGIES FOR WASTEWATER TREATMENT, REUSE AND RESOURCE RECOVERY

- CONSTRUCTED WETLAND+

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PAVITRA GANGA

WORKSHOP

Innovative technologies for wastewater treatment, reuse and resource recovery

TABLE OF CONTENTS

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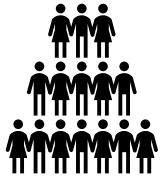
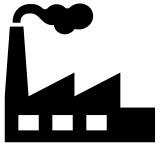
BOUNDARY CONDITIONS IN KANPUR



- Strong demographic developments in the region
- 0.96 million in 1981 to 2.9 million in 2011 and further to 3.1 million in 2020 (Kanpur Metropolitan Area)
- Population density has increased from 3200 persons/km^2 in 1961 to 9700 persons/km^2 in 2011

- Domestic water demand 600 million liters per day (MLD) however, only 385 MLD of domestic water is supplied due to infrastructure limitations
- Estimated sewage generation in Kanpur city is about 339 MLD but only 50% is treated



- City area with insufficient coverage by the sewerage system
- Over 16.000 registered industrial units and 400 tannery sites

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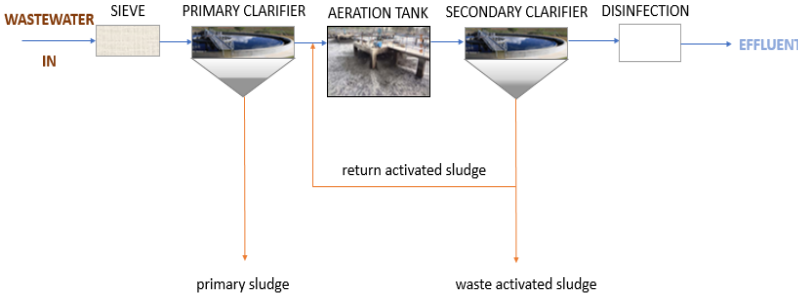
BACKGROUND

- **Municipal sewage impaired by pollution from industrial effluents**
- Mix of tannery wastewater containing leather by-products, hair, chromium and sulfites
- Textile, jute and chemical manufacturers causing the prevalence of HMs Pb, Zn, Cu and Cd
- Poor settleability
- No denitrification leading to increased nitrate concentrations in the effluent
- High salt content results in high TDS levels

→ **Critical for water reuse in irrigation**



STP Jajmau process (top) and clarifier (bottom)

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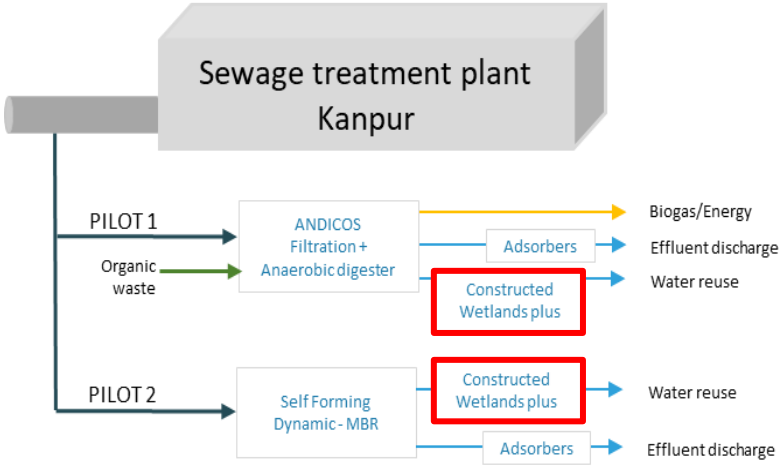
TESTED INNOVATIVE APPROACHES

Novel WWT approaches tested:

- Permeate of the ANDICOS unit achieves high removal of (bulk) organics
- Self Forming Dynamic MBR behaves similarly to conventional MBR except for microbiological contaminants

Posttreatment by Natural Treatment System

- **Vertical CWplus** will reduce nutrients, heavy metals and trace organic compounds
  - Robust and simple operation
  - Low energy demand
  - Resource recovery opportunities



Treatment trains at the STP Jajmau for enhanced pollutant removal

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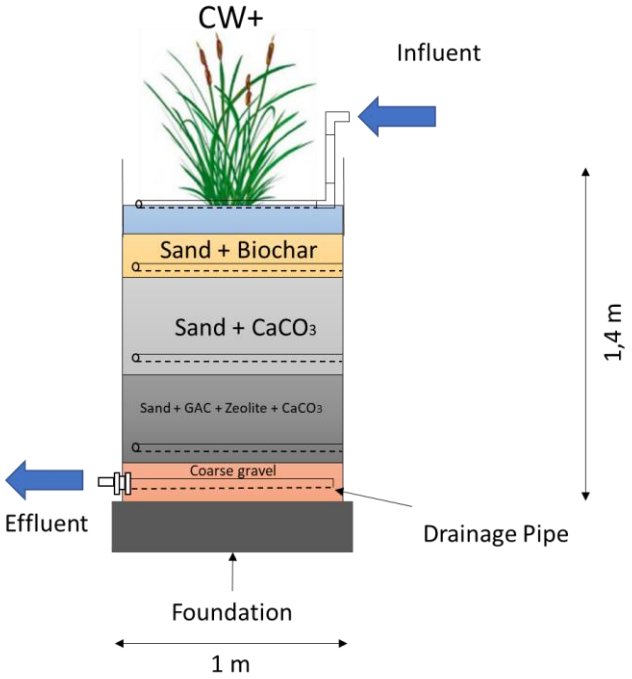
THE NOVELTY OF THIS APPROACH

Pilot wetlands in EU and India

- Conventional substrate
- Modifications in several layers
  - Removal of bulk organics and enhancement of water retention in biochar top layer
  - pH control by limestone addition
  - Zeolite for advanced HM removal
  - Activated carbon (AC) for trace organics removal
- Treatment of primary and secondary effluent



CW+ scheme with modification in different layers

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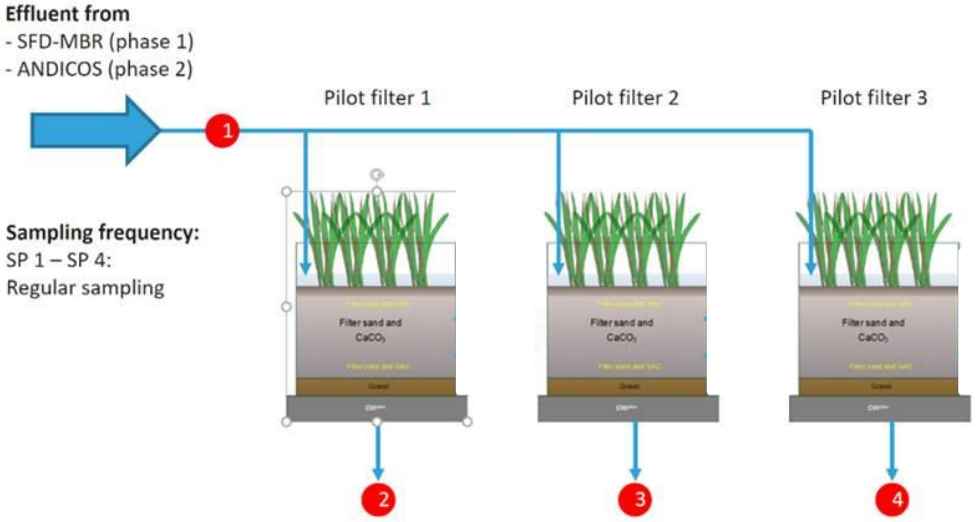
THE NOVELTY OF THIS APPROACH

1. **Conventional CW:** Sand + $CaCO_3$
2. **CW+ 1:** Sand + $CaCO_3$ + Biochar + GAC
3. **CW+ 2:** Sand + $CaCO_3$ + Biochar + Zeolite
4. **CW+ 3:** Sand + $CaCO_3$ + Biochar + GAC + Zeolite



Flow diagram of the Pilot-Scale Constructed Wetland Plus (CWplus)

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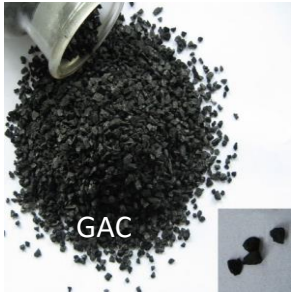
DESIGN AND OPERATIONAL PARAMETERS

- **Wetland type**
- **Plant selection**
  - *Phragmites australis, Canna indica…*
- **Substrate selection**
  - Biochar, GAC, Zeolite…
- **Water/Bed depth**
- **Feeding mode**
  - Continuous, Batch, Intermittent
- **Hydraulic loading rate and retention time**



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FACTORS AFFECTING THE PERFORMANCE

- Design
- Operational
- **Environmental conditions**
  - pH
  - Redox potential
  - Dissolved oxygen
  - Temperature
  - Seasonality
  - Influent concentrations

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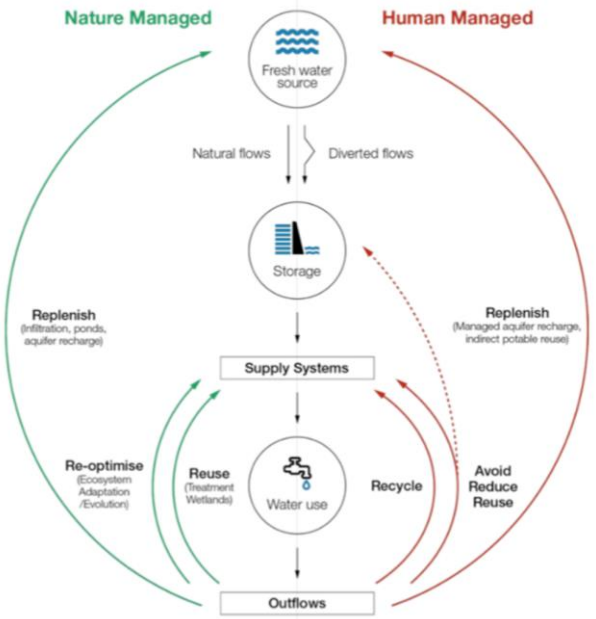
SPECIFIC OBJECTIVES OF THIS STUDY

- **Water Reuse for agriculture**
  - Enhanced heavy metal removal
  - Enhanced removal of trace organics
- **Resource recovery**
  - Ammonium and heavy metals
    - Desorption processes
    - Plant harvesting

→ The application of vertical CWs combined with GAC/sorbents will be taken from TRL3 to TRL6.



Water in the circular economy, Tahir et al. (2022)

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PICTURES OF THE PILOT SETUP

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CW PLUS

Fig. 1: Network of pipes used to distribute the influent evenly on the wetland's surface.

Fig. 2: Two wetlands provided for the ANDICOS system.

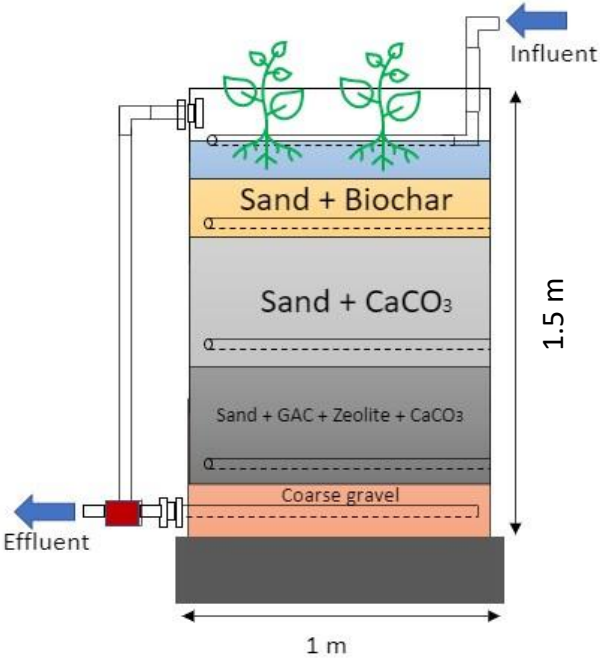

Fig. 3: Schematic showing all the layers of CW+3.

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CONCLUSIONS

- Removal efficiency for organics is more than 75%.
- Removal for ammoniacal Nitrogen initially was almost 70%, but now it has come down to 40-50%. The same is the case with ortho-phosphates.
- Presence of adsorbents in the substrate means greater removal of heavy metals, which was also proved by lab data.
- Condition inside the wetlands remains mostly aerobic as dissolved oxygen (DO) is not a concern for these wetlands. This is due to the low hydraulic loading rate, because of which the system is never fully saturated.

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FUTURE RESEARCH PERSPECTIVES

- Analysis of trace organic compounds
- Substrate sampling of the different filter layers to investigate vertical pollutant behaviour
- Analysis of the plants for enriched heavy metals
- Resource Recovery
  - Desorption processes
  - Plant harvesting
    - Phytoextraction

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PUBLICATIONS FROM THIS RESEARCH

- C. Kazner, L. Ofiera (2021) Constructed Wetlands plus – upgrading Nature Based Solutions for advanced pollutant removal. G-STIC Conference 2021: Water - Nature-based solutions, October 2021, Dubai, UAE

- Ofiera et al. (2023) Removal of heavy metals in modified constructed wetlands using activated carbon and zeolite. 13th IWA International Conference on Water Reclamation and Reuse, 15-19 January 2023, Chennai, India

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THANK YOU FOR YOUR KIND ATTENTION

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