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Assessment of Innovative Wastewater Technologies in India

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Master thesis, Life Sciences ET

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INTRODUCTION

The Pavitra Ganga project aimed to test and develop innovative solutions for the optimization of the existing wastewater treatment infrastructure in Kanpur, India. As part of the project, this thesis aims to holistically assess the sustainability of two of the innovative pilot technologies proposed and tested at the test site: Self-forming Dynamic Membrane Bioreactor (SFD-MBR) and Constructed Wetlands Plus (CW+). The assessment uses a multicriteria analysis (MCA) framework supported by a screening life cycle assessment (LCA) to examine nine indicators covering environmental, economic, social, and technological impacts specific to the Indian context and priorities.

MATERIALS AND METHODS

The following methods were used to achieve the thesis objectives (Figure 1).

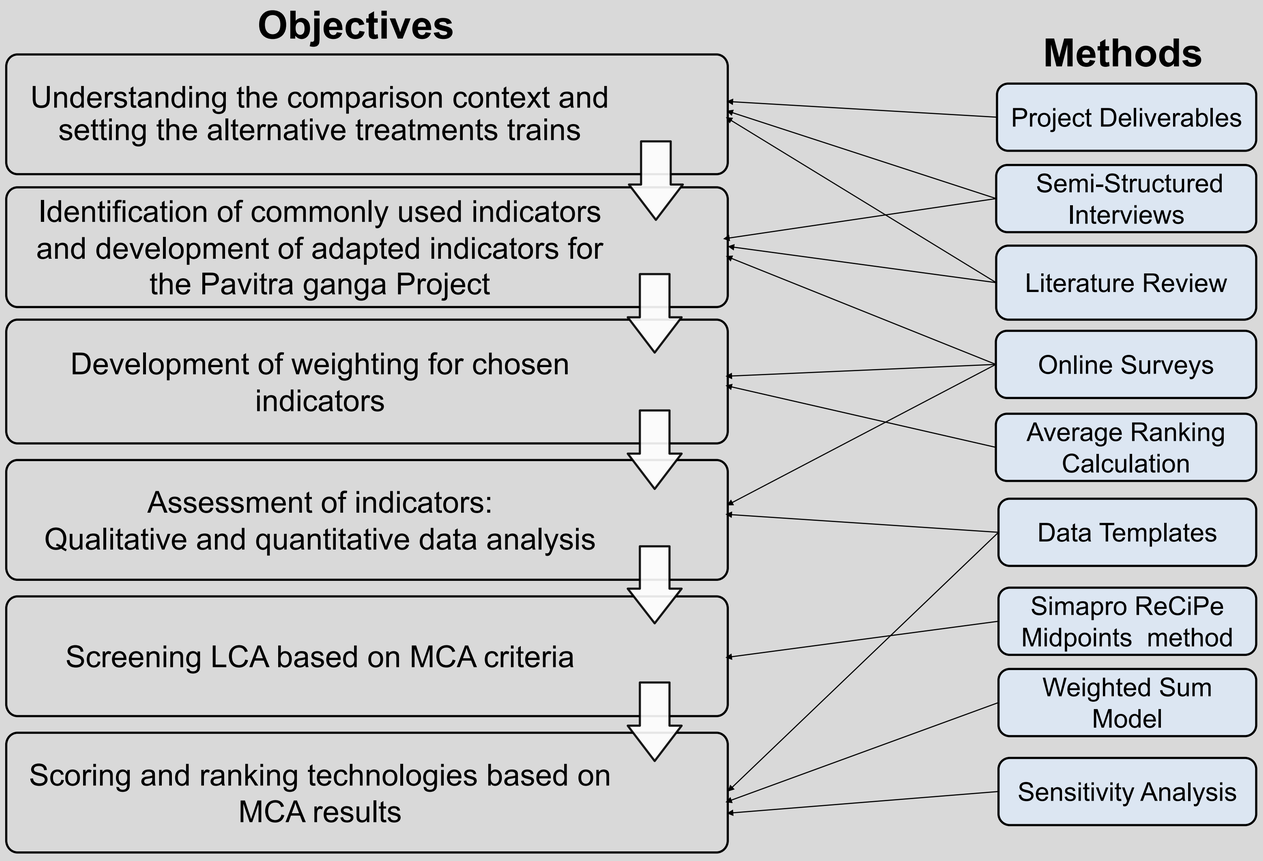

Fig. 1: Objectives and Methods used in this Thesis

The innovative technologies (SFD-MBR and CW+) were compared to the existing activated sludge process (current ASP), an upgraded ASP, and a membrane bioreactor (MBR) as benchmark technologies. Treatment trains were designed (Figure 2) based on the predicted pollutant eliminations and the National Green Tribunal discharge standards for sewage treatment plants (STPs)[1].

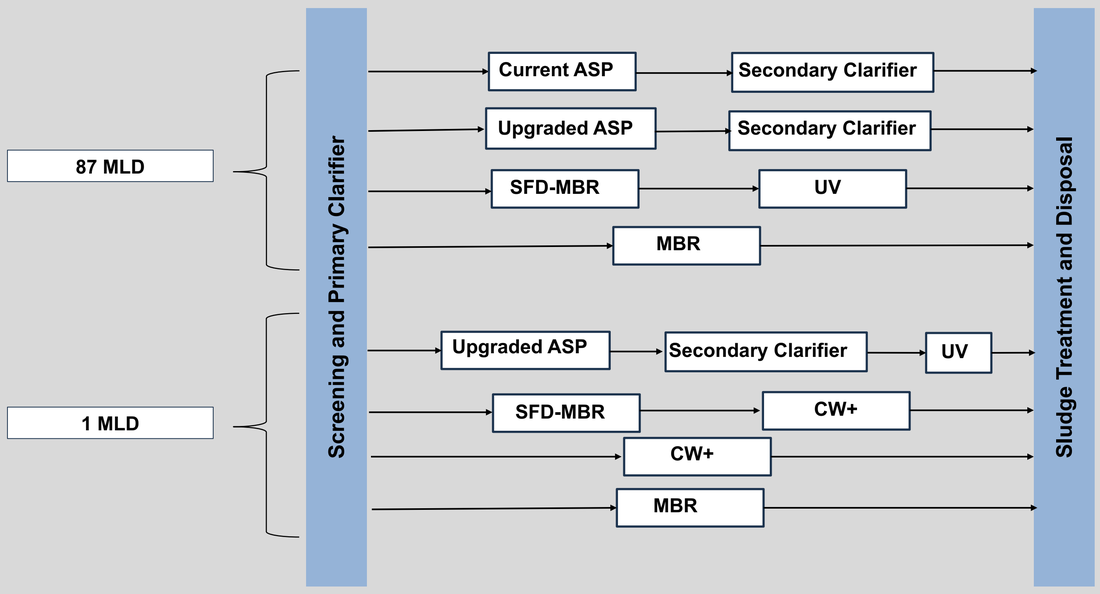

Fig.2: Alternative Treatment Trains

Sustainability indicators were identified based on literature and weighted through an online survey filled out by twenty experts. The resulting nine indicators are OPEX (EUR/m^3; normalized weight nm=0.16), pollutants removal (per substance %; nm=0.151), CAPEX (EUR/m^3;nm=0.139), reliability (nm=0.126) energy consumption (kWh/m^3; nm=0.109), level of expertise required (nm=0.088), global warming potential (kg CO_2 eq/m^3; nm=0.084) land area requirements (m^2/m^3; nm=0.071), occupational health and safety (risk scores; nm=0.071).

RESULTS AND DISCUSSION

At the large scale, operational expenses (OPEX) were lowest for the upgraded ASP (0.103 EUR/m^3), and capital expenses (CAPEX) lowest for the MBR (0.061 EUR/m^3). While at the small scale SFD-MBR with CW+ had the lowest OPEX (0.232 EUR/m^3) and CW+ had the lowest CAPEX (0.059 EUR/m^3).

The energy requirements were highest for membrane technologies (MBR and SFD-MBR) and correlated with global warming potential, while land requirements were around 12 times higher for CW+ (12 m^2/m^3) than other technologies.

The SFD-MBR was the most reliable technology and occupational health and safety favored enclosed membrane technologies (SFD-MBR and MBR) and treatment trains with fewer unit processes. The level of expertise required was also highest for membrane technologies due to the high level of automation.

The gathered data showed an insufficient pollutant removal in all treatment trains when it comes to discharge standards. The MBR and the SFD-MBR with CW+ were the only treatment trains with sufficient eliminations for both discharge and reuse [1] [2]. The discharge standards were unmet for total suspended solids (0.03-0.05 kg/m3) (current ASP, upgraded ASP, SFD-MBR with UV, and upgraded ASP with UV), for fecal coliforms (<1000 CFU/100 ml)(current ASP, upgraded ASP, and CW+), and for total phosphorous (<0.001 kg/m^3) (current ASP, upgraded ASP, SFD-MBR with UV, upgraded ASP with UV)

LCA results showed that energy consumption contributes more than chemical use to global warming potential (around 95%), while the biggest influencer of overall environmental impact is pollutant removal, notably in this case phosphorous removal. Revealing the importance of considering pollutant removal capacity and energy requirements as environmental MCA indicators, especially in contexts with low accessibility to LCIA.

MCA results (Fig. 3) indicate that at a small scale the upgraded ASP with UV and the CW+ have the highest performance index (PI=0.7) then the SFD-MBR with CW+ (PI=0.6) and the MBR (PI=0.5) last.

At the large scale, the upgraded ASP, the SFD-MBR with UV and the MBR all three have the PI= 0.8. The current ASP has the lowest score (PI=0.7).

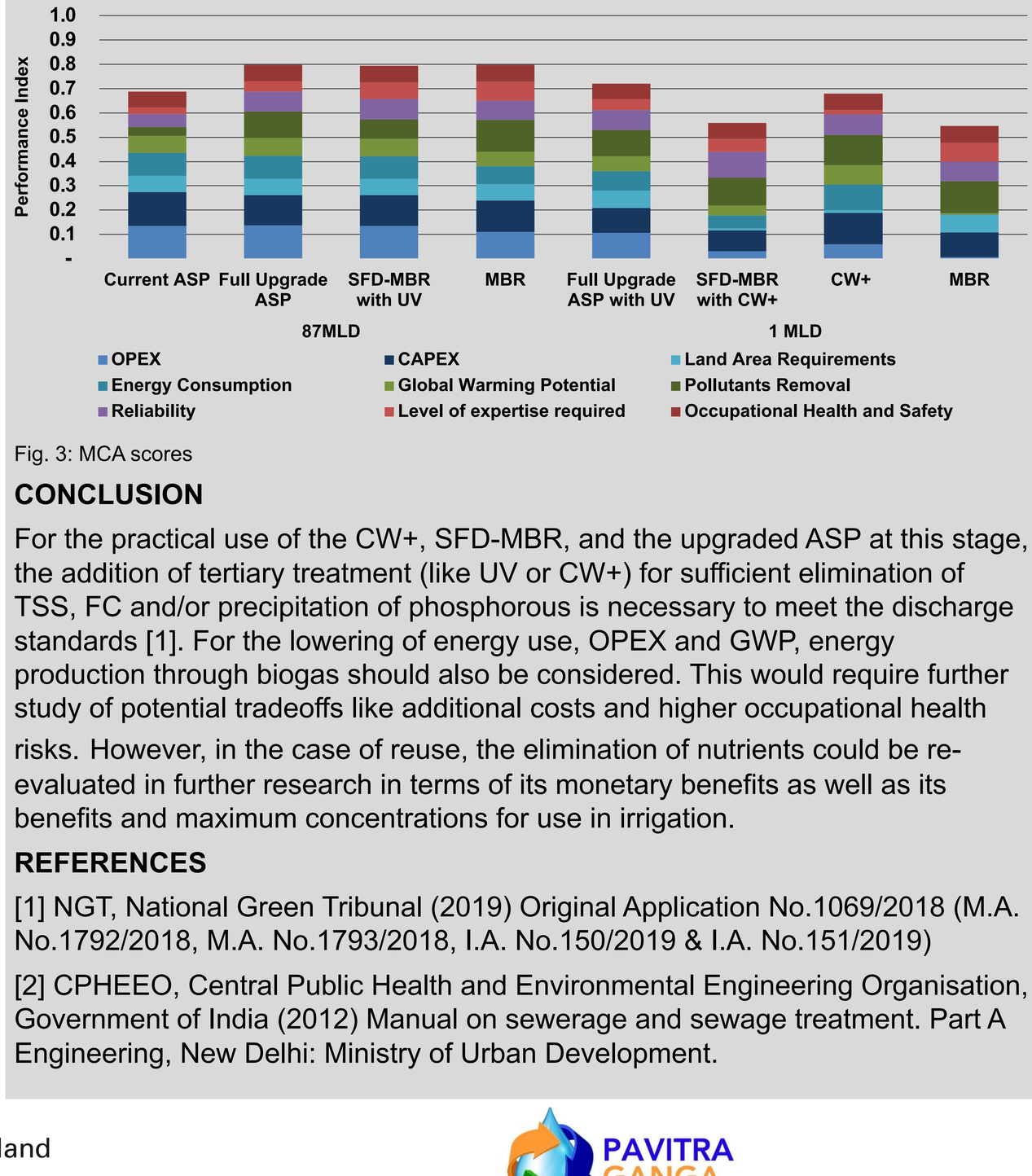

Fig. 3: MCA scores

CONCLUSION

For the practical use of the CW+, SFD-MBR, and the upgraded ASP at this stage, the addition of tertiary treatment (like UV or CW+) for sufficient elimination of TSS, FC and/or precipitation of phosphorous is necessary to meet the discharge standards [1]. For the lowering of energy use, OPEX and GWP, energy production through biogas should also be considered. This would require further study of potential tradeoffs like additional costs and higher occupational health risks. However, in the case of reuse, the elimination of nutrients could be re-evaluated in further research in terms of its monetary benefits as well as its benefits and maximum concentrations for use in irrigation.

REFERENCES

[1] NGT, National Green Tribunal (2019) Original Application No.1069/2018 (M.A. No.1792/2018, M.A. No.1793/2018, I.A. No.150/2019 & I.A. No.151/2019)

[2] CPHEEO, Central Public Health and Environmental Engineering Organisation, Government of India (2012) Manual on sewerage and sewage treatment. Part A Engineering, New Delhi: Ministry of Urban Development.