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Name of the Scholar: Mahmood Ahmad

Name of the Supervisor: Dr. Abid Ali Khan

Name of the Co-supervisor: Dr. S. Shakil Afsar

Department: Department of Civil Engineering, Faculty of Engineering & Technology, JMI

Topic of Research: Efficacy of micro-aerobic UASB process: a modified UASB system for municipal wastewater treatment

Findings

The UASB process is a technology implemented at full-scale sewage treatment plants (STPs), particularly in warm climate regions such as India, due to several operational advantages. However, it also presents limitations, including suboptimal treated effluent quality and nutrient removal. Various post-treatment systems have been combined with the UASB reactor to enhance effluent quality. Most of these systems have not been widely adopted, often due to higher capital costs, land requirements, and inconsistent treatment performance. This study aimed to modify and upgrade the existing UASB system.

The objective of this thesis is to assess the effectiveness of the Micro-Aerobic UASB process by introducing small amounts of air to maintain lower dissolved oxygen (DO) levels, thereby supporting improved removal of organics, suspended solids, total sulfides, and nitrogenous and phosphorous compounds from municipal wastewater.

The conventional UASB process was modified by creating micro-aerobic conditions in the upper zone of the reactor. This modified process is referred to as the Micro-Aerobic UASB (MUASB) process. The research involved two reactors: one conventional UASB and one MUASB in operation for over 1,000 days in the lab facility at the Department of Civil Engineering, Jamia Millia Islamia, New Delhi. Additionally, the treatment performance of full-scale STPs was monitored concurrently to evaluate biological process efficiencies in field settings. The conventional UASB reactor was specifically investigated in a laboratory setting to assess treatment performance under controlled conditions for municipal wastewater.

Key findings are summarized as follows:

- Monitoring thirty-six full-scale STPs enabled assessment of various biological processes under field conditions. The highest removal rates of BOD, COD, and TSS were observed in SBR-based STPs, followed by UASB with EA. MBBRs, UASB with alternative post-treatment options and WSP showed satisfactory to poor results.
- The conventional UASB reactor operated under laboratory conditions for more than 1,000 days, achieving removal rates of 71 ± 11% for COD, 70 ± 10% for BOD, and 74 ± 13% for

TSS. Laboratory results indicated that the conventional UASB reactor achieved 10 - 15% greater removal efficiency compared to field reactors, potentially attributed to controlled operation and maintenance.

- A separate conventional UASB reactor was modified to create micro-aerobic conditions, referred to as the MUASB reactor. The introduction of micro-aerobic conditions facilitated the formation of simultaneous anaerobic, anoxic, and aerobic zones, supporting concurrent organic and nutrient removal, as well as enhanced biomass retention relative to the conventional UASB. The MUASB achieved up to 90% removal of BOD, COD, and TSS at DO levels between 0.5 and 2.5 mg/L with a total HRT of 6 hours and 30 minutes of aeration on an intermittent basis. Simultaneous nitrification and denitrification were also observed, with NH_4-N removal exceeding 80% and final NO_3-N concentrations below 0.5 mg/L. Micro-aerobic conditions promoted the dominance of microaerophilic bacteria with high oxygen affinities, which contributed to effective removal of COD and NH_4-N.
- Under the MUASB process, the addition of a bioplastic carrier at DO levels of 1.5-2.0 mg/L during intermittent aeration resulted in increased removal efficiencies of 40–50%.
- The MUASB reactor achieved maximum removal rates of 79% for sulfides and 55% for methane. Biofilm growth on plastic media within the reactor demonstrated the impact of additional biomass carriers.
- Zeolite was used as a biomass carrier in the MUASB to evaluate microbial community development for the removal of sulfides, nitrogen, and phosphorus. Removal rates of BOD, COD, and TSS with zeolite ranged from 80-90%. SEM analysis of cultivated sludge identified a microbial population including sulfide-oxidizing bacteria (SOB) with spherical-cocci and cauliflower-like structures, along with groups of nitrifiers and denitrifiers.

Keywords: Rapid Urbanization, Anaerobic Process, Micro-Aerobic UASB, Anoxic Process, Nutrient removal, Post Treatment, Wastewater.