A Natural Filter-Based Modular System for Industrial and Runoff Water

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***Abstract*—This study presents a natural filter-based modular system developed for treatment of industrial wastewater and roadside runoff water before groundwater recharge. Rapid urbanization and industrial growth have increased contamination of surface and groundwater resources due to untreated runoff and industrial discharge. The proposed system uses low-cost and eco-friendly filter media such as sand, coarse aggregate, broken roof tiles, activated charcoal, and granular zeolite. The modular acrylic filtration unit was designed to improve water quality through physical filtration, adsorption, and aeration processes. Water quality parameters including pH, turbidity, alkalinity, hardness, dissolved oxygen (DO), chemical oxygen demand (COD), and biological oxygen demand (BOD) were analyzed before and after filtration. The results showed reduction in turbidity, alkalinity, and hardness, along with improvement in dissolved oxygen content. The study concludes that the filtration unit can serve as a cost-effective and sustainable primary treatment system for improving industrial and runoff water quality.**

***Index Terms*—Industrial wastewater, runoff water, groundwater recharge, natural filtration, activated charcoal, modular system.**

I. INTRODUCTION

Water pollution and groundwater depletion are major environmental problems caused by rapid urbanization and industrialization. Untreated industrial wastewater and roadside runoff water contain pollutants such as suspended solids, oils, organic matter, heavy metals, and chemicals. Direct discharge of these pollutants contaminates groundwater and surface water resources. Sustainable treatment systems are required to reduce pollution and support groundwater recharge. The proposed natural filter-based modular system was developed using eco-friendly and locally available materials. The filtration media include sand, coarse aggregate, broken roof tiles, activated charcoal, and granular zeolite. These materials help in removing suspended particles, reducing turbidity, and improving water quality before recharge. The system provides a low-cost and sustainable approach suitable for urban roadside and industrial applications.

II. OBJECTIVES

1. To design a low-cost natural filter unit.
2. To reduce urban water wastage.
3. To compare water quality before and after treatment.
4. To reduce groundwater and environmental pollution.

III. LITERATURE REVIEW

Several studies highlighted the use of natural filtration systems for wastewater treatment and stormwater management. Research on coconut shell activated carbon demonstrated high adsorption capacity for organic pollutants and dyes. Studies on bio-retention systems and stormwater purification showed improvement in runoff water quality and groundwater recharge. Research on neem biomass and zeolite materials also confirmed their effectiveness in adsorption and removal of heavy metals and suspended impurities. These studies support the use of natural and low-cost materials for sustainable water treatment systems.

IV. METHODOLOGY

The filtration system consists of multiple layers of natural filter media arranged in an acrylic modular unit

of size 0.8 m × 0.6 m × 0.5 m. The selected site for runoff collection was JM Road, Pune. The filtration layers include coarse aggregate, sand, broken roof tiles, activated charcoal, and granular zeolite.

Fine aggregate of size 0.3–0.6 mm was used for filtration of suspended solids. Coarse aggregate of size 20–40 mm was provided for permeability and structural stability. Broken roof tiles improved infiltration and primary filtration. Activated charcoal removed organic impurities, odors, and color through adsorption, while granular zeolite improved removal of suspended solids and metal ions.

Water samples were tested before and after filtration for pH, turbidity, alkalinity, hardness, dissolved oxygen, COD, and BOD.

V. RESULTS AND DISCUSSION

The filtration system showed significant improvement in water quality parameters. Turbidity, alkalinity, and hardness were reduced after filtration, while dissolved oxygen increased due to aeration and removal of oxygen-consuming pollutants. However, COD and BOD values increased because of organic matter released from filter media, indicating the need for additional treatment in future work.

VI. CONCLUSION

The natural filter-based modular system proved effective as a primary treatment method for industrial and runoff water. The use of eco-friendly and low-cost filter materials improved water quality by reducing suspended impurities and increasing dissolved oxygen levels. The system is sustainable, economical, and suitable for groundwater recharge applications. Further treatment methods can be incorporated to improve COD and BOD removal efficiency.

TABLE I. COMPARISON OF WATER QUALITY PARAMETERS

Parameter	Raw Water	Filtered Water	Observation
pH	8.5	5.5	Reduction in alkalinity
Turbidity	29 NTU	15 NTU	Improved clarity
Alkalinity	350 mg/L	290 mg/L	Partial reduction
Hardness	300 mg/L	240 mg/L	Reduced hardness
DO	0 mg/L	4 mg/L	Improved oxygen content
COD	900 mg/L	1300 mg/L	Increase due to organics
BOD	0 mg/L	350 mg/L	Increase due to biodegradable matter

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