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The Effect of Seasonal Variation on the Treatment Efficiency of DEWATS: A Case Study of Wazir Bagh Peshawar

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Abstract: ***Seasonal variation significantly influences the performance of anaerobic wastewater treatment processes. Higher temperatures, typically observed during the summer months, enhance bacterial activity, thereby improving the breakdown of organic matter in wastewater. This case study, conducted at the DEWATS facility in Wazir Bagh, Peshawar, demonstrates a clear relationship between seasonal temperature changes and treatment efficiency. The findings indicate that treatment efficiency was notably higher during the summer, while a decrease in performance was observed during the winter months due to lower temperatures. Specifically, the average BOD removal efficiency was recorded at 77% in winter and 74% in summer. While temperature is a key factor, other variables such as organic loading rate and hydraulic loading rate also contribute to seasonal performance variations. This study highlights the need to consider multiple operational and environmental factors when assessing and optimizing DEWATS efficiency under varying climatic conditions.***
Keywords: Seasonal Variation, Temperature.

I. INTRODUCTION

Decentralized Wastewater Treatment Systems (DEWATS) have emerged as a practical and sustainable approach to managing domestic and small-scale industrial wastewater, particularly in developing regions. These systems are designed to function efficiently with minimal maintenance and energy input, relying heavily on natural biological processes, often under anaerobic conditions. However, the performance of DEWATS is significantly influenced by external environmental factors, with seasonal variation playing a crucial role in determining treatment efficiency [1].

Temperature fluctuations throughout the year impact microbial activity, which is central to the anaerobic digestion process. Warmer temperatures typically enhance the metabolic rate of anaerobic bacteria, improving the degradation of organic matter and thereby increasing treatment efficiency. Conversely, lower temperatures during colder months can inhibit microbial activity, leading to reduced system performance. This variability underscores the importance of understanding how seasonal changes affect the treatment outcomes of DEWATS in real-world applications [2]. The present study focuses on the DEWATS facility located in Wazir Bagh, Peshawar—a region that experiences distinct seasonal temperature variations. By analyzing treatment efficiency across summer and winter seasons, the study aims to evaluate how key parameters such as Biological Oxygen Demand (BOD) respond to changing environmental conditions. While temperature is a primary factor, other variables such as organic loading rate and hydraulic loading rate also play a role in influencing treatment outcomes [3]. This research not only provides insight into the seasonal dynamics of DEWATS performance but also contributes to the optimization of such systems for year-round efficiency. The findings can guide engineers, policymakers, and water management authorities in designing and managing decentralized systems in similar climatic and socio-economic contexts [4].

II. METHODOLOGY

This study was conducted to assess the impact of seasonal variation on the treatment efficiency of the DEWATS facility located in Wazir Bagh, Peshawar. To capture the influence of different weather conditions, data was collected consistently over a one-year period, encompassing both summer and winter seasons.

A. Sample Collection

Wastewater samples were collected from both influent and effluent points of the DEWATS system at regular intervals throughout the year. The sampling schedule was designed to cover a wide range of climatic conditions to ensure representative seasonal data. All samples were collected following standard protocols for wastewater analysis to maintain consistency and accuracy.

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B. Parameters Analyzed

BOD was measured for each collected sample to evaluate the organic load reduction capability of the system over different seasons. Measurements were performed using standard methods outlined in the APHA (American Public Health Association) guidelines for the examination of water and wastewater.

C. Data Analysis

The collected data was subjected to statistical analysis to identify seasonal trends in treatment efficiency. Mean removal efficiencies for BOD was calculated separately for the summer and winter seasons. Additionally, other influencing factors such as temperature variations, organic loading rates, and hydraulic loading rates were reviewed to understand their combined effect on the system's performance.

This methodological framework enabled a comparative evaluation of the DEWATS system's performance under varying seasonal conditions and provided insight into the factors influencing its efficiency.

III. RESULTS AND DISCUSSION

The performance of the DEWATS facility in Wazir Bagh, Peshawar, was evaluated by analyzing BOD removal efficiency over a one-year period, capturing seasonal variations. The results reveal a distinct relationship between ambient temperature and treatment efficiency, underscoring the sensitivity of anaerobic processes to environmental conditions.

A. BOD Removal Efficiency

The Biological Oxygen Demand (BOD) removal efficiency varied across seasons. During the winter months, the average BOD removal efficiency was recorded at 77%, while in the summer, it slightly decreased to 74%. Although this difference appears marginal, it highlights the system's stable performance even under fluctuating temperatures. The higher efficiency in winter may be attributed to consistent organic loading and the acclimatization of microbial communities to lower temperatures. However, in summer, increased microbial activity can sometimes lead to system imbalances if not carefully monitored.

B. Influence of Seasonal Factors

Temperature was identified as a primary driver of seasonal efficiency, with microbial activity generally increasing in warmer conditions. However, this does not always correlate with higher treatment performance, especially if hydraulic or organic loading rates vary. For instance, increased organic loading during warmer months can overwhelm the system's capacity, reducing overall efficiency. Conversely, colder temperatures may slow bacterial activity but maintain steady performance if the system is well-buffered and the load remains manageable.

Other contributing factors such as Hydraulic Loading Rate (HLR) and Organic Loading Rate (OLR) were also found to influence treatment performance. Seasonal fluctuations in wastewater flow and composition—affected by household water use patterns and rainfall—may contribute to these variations.

C. Implications for System Design and Operation

The results suggest that while DEWATS systems are generally robust, seasonal variations can impact their treatment efficiency. This highlights the importance of designing systems with flexibility to accommodate environmental changes. Operators should consider implementing adaptive management strategies such as seasonal monitoring, load regulation, or thermal insulation to enhance performance during temperature extremes.

In summary, the DEWATS facility at Wazir Bagh demonstrated satisfactory performance across seasons, with only slight fluctuations in BOD removal efficiency. These findings validate the potential of decentralized systems in regions with variable climates, provided that proper monitoring and operational controls are in place.

IV. CONCLUSION

This study evaluated the effect of seasonal variation on the treatment efficiency of a DEWATS facility located in Wazir Bagh, Peshawar. By monitoring key parameters such as BOD throughout the year, it was observed that the system maintained relatively stable performance across both summer and winter seasons, with average BOD removal efficiencies of 74% and 77%, respectively. Although microbial activity is typically enhanced at higher temperatures, the results indicate that treatment efficiency can slightly decline during summer months due to possible fluctuations in hydraulic and organic loading rates.

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Temperature, while a critical factor, is not the sole determinant of treatment efficiency. Operational factors such as flow rate, organic load, and retention time also contribute to seasonal performance variations. These findings highlight the resilience of DEWATS in coping with environmental changes, as well as the importance of continuous monitoring and adaptive operational practices.

Overall, the study confirms that DEWATS can function effectively in regions with distinct seasonal climates, provided that appropriate design considerations and management strategies are in place. The insights gained from this research can inform the development and optimization of decentralized wastewater treatment systems in similar urban and peri-urban settings.

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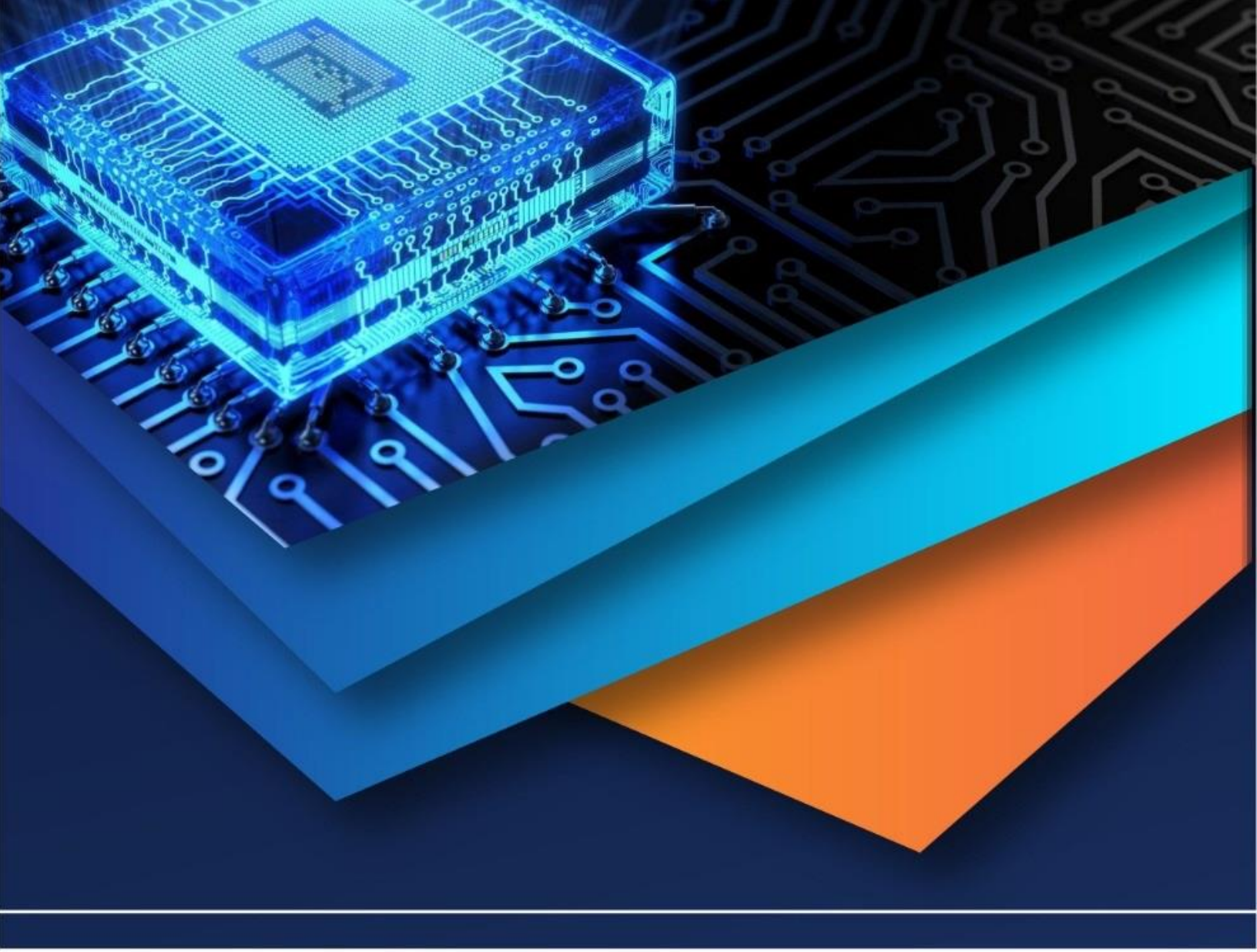
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