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Enhanced Waste Water Treatment Through Bio-Enzymes

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Abstract: Wastewater treatment is an important process to keep our environment clean and safe. Traditional methods use physical, chemical, and biological processes to remove pollutants, but they often require high energy, chemicals, and produce a large amount of sludge. The use of bio-enzymes offers a more natural and eco-friendly solution. Bio-enzymes are biological catalysts produced by microorganisms that help break down complex organic waste like fats, oils, and proteins into simpler, harmless substances. This enzymatic process is often integrated into biological treatment stages to improve efficiency, reduce chemical use, and produce cleaner water. The breakdown of pollutants by enzymes makes the water cleaner and can make it easier for other treatment steps to remove contaminants, leading to a higher quality effluent.

This study focuses on developing the conventional treatment of wastewater using bio-enzymes represents an emerging sustainable approach for efficient pollutant removal and resource recovery. The study demonstrates how the waste water treatment is processed by using bio enzymes in the process for the purification of water for further purposes in our college campus.

I. INTRODUCTION

Water is one of the most essential resources for sustaining life, yet its quality is continuously threatened by increasing wastewater generation. In institutional environments such as college campuses, wastewater is produced from hostels, kitchens, laboratories, and other daily activities. If not properly treated, this wastewater can lead to environmental pollution, health risks, and degradation of natural water bodies.

Traditional wastewater treatment methods involve a combination of physical, chemical, and biological processes. While these methods are widely used, they often require significant infrastructure, energy, and chemical inputs. Moreover, they may produce secondary pollutants like sludge, which require further treatment and disposal.

In recent years, there has been a growing interest in eco-friendly and sustainable alternatives. One such promising solution is the use of bio-enzymes. These are naturally produced through the fermentation of organic waste materials and have the ability to break down complex organic substances efficiently. Bio-enzymes not only reduce pollution levels but also promote the recycling of organic waste, contributing to a circular economy.

This study focuses on evaluating the effectiveness of bio-enzymes in treating domestic wastewater within a college campus. By using locally available organic waste materials, this approach aims to provide a cost-effective and environmentally friendly solution for wastewater management and reuse.

II. METHODOLOGY

The methodology adopted in this study is designed to simulate a simple and practical wastewater treatment process using bio-enzymes. The entire procedure consists of preparation of bio-enzymes, collection of wastewater samples, treatment with different dosages, and analysis of water quality parameters

A. Bio-Enzyme Preparation

Bio-enzyme is prepared by following a simple ratio of 1:3:10. This involves mixing one part of jaggery (or brown sugar), three parts of citrus peel (e.g., lemon and orange), and ten parts of water into a plastic bottle that is sealed tightly with a lid. The mixture should be stirred well to ensure that the jaggery has been completely dissolved, but about 20 percent of space in the bottle must

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remain free to allow gas formation. The bottle should be kept in a cool and dark place for three months while opening it every day within the first few weeks to let out accumulated gases.

Figure 1. Preparation of Bio Enzyme

B. Collection of Wastewater Sample

Wastewater samples collected from the college campus of Dr. Lankapalli Bullayya College can be considered systematic since the aim of the collection is to take into account the varied waste generated in academic buildings, labs, and canteens. Therefore, composite samples are taken when technicians collect water at the primary points such as manholes to representatively examine their contents.

The collection process requires the use of sterilized containers where all the parameters should be measured at the site. The importance of preventing contamination cannot be underestimated and includes rinsing the collecting equipment with the source water to ensure no mixing occurs in the process. After obtaining the samples, they are transferred to the lab in cold conditions, which provides an opportunity for analyzing whether or not the BOD and COD levels are within the permissible limits.

C. Treatment with Different Dosage

Bio-enzymes have been successfully applied in the purification of wastewaters in place of chemicals through catalytic reactions for breaking down of organic contaminants. It is important to test different dosages, such as 5%, 10%, and 15% for purposes of determining which dosage level gives the most desirable results. With a low dosage level of 5%, the breakdown of organic contaminants in the form of simple chains occurs. However, because of low enzyme-substrate ratios, the rate of reaction might not be optimal. With an increase in dosage to 10%, significant reduction in COD and TDS takes place as a result of reduced activation energies necessary for breaking lipids and proteins.

With a high dose of 15%, the activity of enzymes reaches its maximum; therefore, there will be no increase in the rate of contaminant degradation. Through comparative analysis of all three levels of dosages, it will be easy to establish the "optimal dosage" to achieve maximum organic contamination breakdown at the minimum cost.

D. Analysis of Water Quality Parameters

The assessment of all four water quality parameters helps understand the environmental impact and performance of the purification process of the wastewater. For instance, pH values determine the ability of nutrients to dissolve in the water and also determine if the micro-organisms would live there, and any abnormal values make the use of treatment agent ineffective. TDS provides information on how many inorganic salts and organic materials have been dissolved into the water. Usually, a higher value means the presence of some industrial and domestic mineral mining.

However, the most important aspect is measuring the organic material present in the water as well as how much it needs to be cleaned. Therefore, BOD and COD should be analyzed. While the first one is measuring how much oxygen is needed by aerobic micro-organisms to consume the organic materials, the latter indicates how much oxygen needed to completely oxidize the organic compounds, whether biodegradable or not. In other words, COD shows how many complex synthetic compounds are in the water that cannot easily be degraded by micro-organisms. Hence, one should take into consideration all four parameters and decide which dosage will solve the problem.

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III. OBSERVATIONS & RESULTS

A. Tests on Bio-Enzyme

Table 1: Characteristics of Fruits Waste Enzyme

Parameters	0 Days	15 Days	30 Days
pH	4.92	3.85	3.33
TDS (mg/l)	1188	825	564
BOD(mg/l)	1567	1355	1194
COD (mg/l)	3157	2461	2144

B. Tests on Raw Wastewater Sample

Table 2: Characteristics of Raw Wastewater Sample

Parameters	Value
pH	8.3
TDS (mg/l)	774
BOD (mg/l)	386
COD (mg/l)	593

C. Tests on Treated Wastewater Sample Using 5% Bio-Enzyme

Table 3: Characteristics of Treated Wastewater sample using 5% Bio-Enzyme

Parameters	Just after Treatment	15 Days of Treatment	30 Days of Treatment
pH	8.1	7.56	7.2
TDS (mg/l)	805	658	524
BOD (mg/l)	451	314	175
COD (mg/l)	754	508	311

D. Tests on Treated Wastewater Sample Using 10% Bio-Enzyme

Table 4: Characteristics of Treated Wastewater sample using 10% Bio-Enzyme

Parameters	Just after Treatment	15 Days of Treatment	30 Days of Treatment
pH	7.78	7.41	6.9
TDS (mg/l)	926	614	452
BOD(mg/l)	558	271	133
COD (mg/l)	935	467	241

E. Tests on Treated Wastewater Sample Using 15% Bio-Enzyme

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Table 5: Characteristics of Treated Wastewater sample using 15% Bio-Enzyme

Parameters	Just after Treatment	15 Days of Treatment	30 Days of Treatment
pH	7.15	6.7	6.4
TDS (mg/l)	1234	710	527
BOD(mg/l)	766	243	105
COD (mg/l)	1291	477	198

F. Comparative Study

Table 6: Comparative Study Just After Treatment

Parameters	5% using Bio-Enzyme	10% using Bio-Enzyme	15% using Bio-Enzyme
pH	8.1	7.78	7.15
TDS (mg/l)	805	614	1234
BOD5(mg/l)	451	271	766
COD (mg/l)	754	467	1291

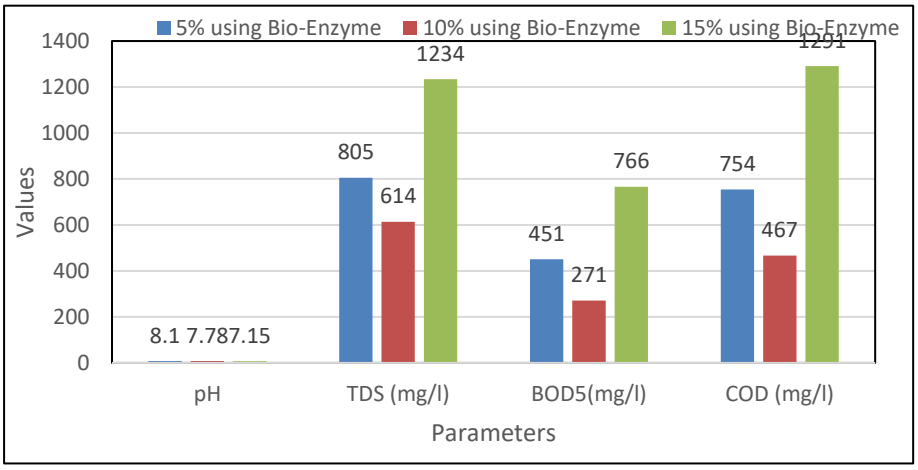

Figure 2. Observed Concentrations of Different Parameters for Different Dosage just After Treatment

Table 7: Comparative Study After 15 Days of Treatment

Parameters	5% using Bio-Enzyme	10% using Bio-Enzyme	15% using Bio-Enzyme
pH	7.56	7.41	6.9
TDS (mg/l)	658	614	710
BOD5(mg/l)	314	271	243
COD (mg/l)	508	467	477

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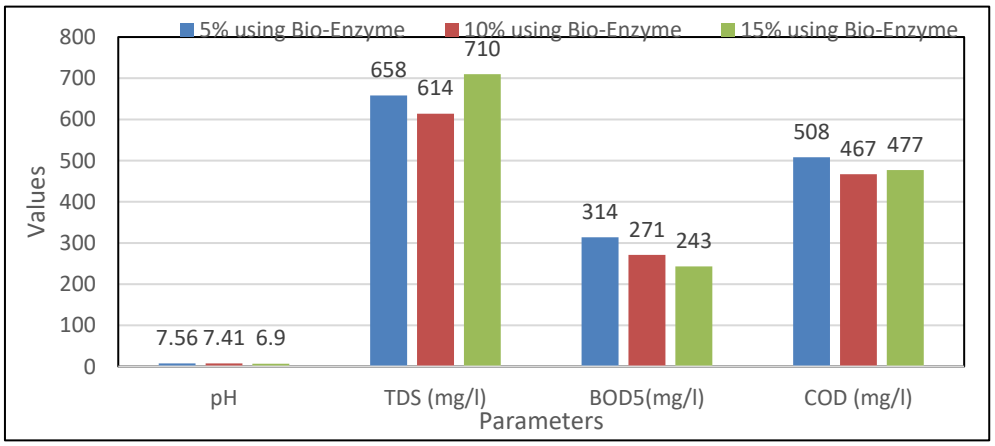

Figure 3. Observed Concentrations of Different Parameters for Different Dosage After 15 Days of Treatment

Table 8: Comparative Study After 30 Days of Treatment

Parameters	5% using Bio-Enzyme	10% using Bio-Enzyme	15% using Bio-Enzyme
pH	7.2	6.9	6.4
TDS (mg/l)	524	452	527
BOD5(mg/l)	175	133	105
COD (mg/l)	311	241	198

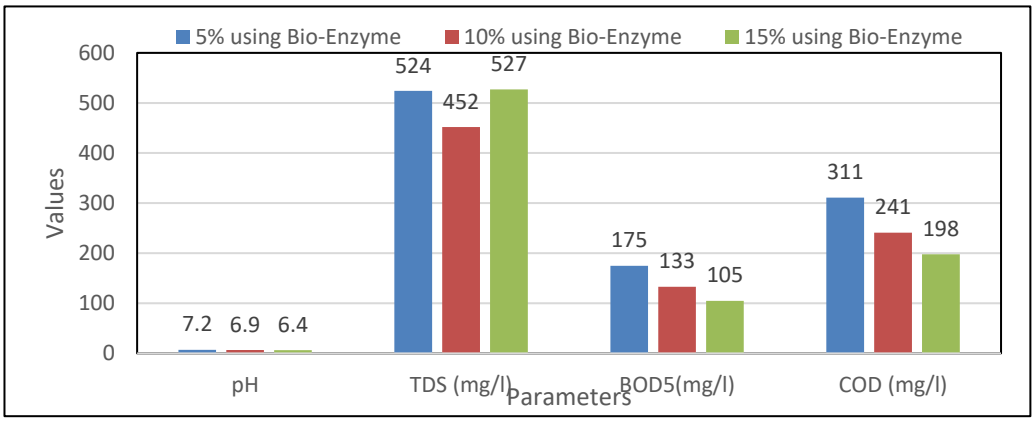

Figure 4. Observed Concentrations of Different Parameters for Different Dosage After 30 Days of Treatment

IV. CONCLUSION

From this study, it can be concluded that bio-enzymes offer a highly effective and environmentally friendly approach to wastewater treatment. They utilize organic waste materials, making the process sustainable and cost-efficient. The results clearly show that increasing the dosage and retention time improves treatment efficiency. However, the 10 % dosage was identified as the most optimal, as it provided high pollutant removal while remaining economically feasible. The treatment process achieved its maximum efficiency within 15 to 30 days, after which further improvement was minimal. This makes bio-enzyme treatment a practical solution for real-world applications.

In conclusion, bio-enzymes can be successfully implemented for domestic wastewater treatment and can support water reuse for non-potable purposes such as irrigation and cleaning. This approach not only helps in reducing environmental pollution but also promotes sustainable waste management practices. In summary, the use of 1:3:10 citrus bio-enzyme is a scientific way to treat institutional wastewater at minimal cost and sustainably. The dosage rate of 10% is advised as the preferred rate for use in college campuses because it offers the most optimal conditions for pH balancing and pollution control. This study shows that wastewater can be treated without necessarily using costly chemicals and heavy machinery; fermentation alone suffices.

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