

Effect of eco-enzymes prepared from selected organic waste on domestic waste water treatment

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World Journal of Advanced Research and Reviews, 2021, 10(01), 323–333

Publication history: Received on 12 March 2021; revised on 14 April 2021; accepted on 16 April 2021

Article DOI: <https://doi.org/10.30574/wjarr.2021.10.1.0159>

Abstract

Water Pollution has become a major problem with increasing urbanisation and rapid industrialisation. Despite the abundance of water, pollution causes the water to be less useful and more harmful to health, environment, and life on our planet. In past few years, many researchers have focussed on use of biological & physical treatment methods that are cost-effective and cause no harm to the environment instead of chemical methods. The aim of the present work is to study the effect of organic solid wastes in the form of orange peels, marigold flowers, and neem leaves on domestic wastewater treatment. Eco-enzyme solutions were prepared using Dr. Rosukon's method from the wastes mentioned which involves mixing jaggery along with the wastes and water in the ratio of 1:3:10. The eco-enzyme solution was then allowed to be prepared through 90 days of fermentation process. The three eco-enzyme solutions – after 10 days of filtration – were then mixed with domestic wastewater samples individually keeping 90% wastewater and 10% eco-enzyme solution. The results after 50 days of digestion period suggests that orange eco-enzyme was the most effective in reducing Total Dissolved Solids (TDS) while Marigold eco-enzyme was most effective in reducing Chemical Oxygen Demand (COD).

Keywords: Eco-enzyme; Garbage enzyme; Bio-enzyme; Domestic Wastewater Treatment; Organic solid Waste Management

1. Introduction

Water is one of the most abundant, valuable, and important resources on the earth for the survival of all living forms as well as for day-to-day human activities [1]. But many people don't have access to safe clean water as a majority of the freshwater resources are polluted. Increasing world population has resulted in large amounts of waste being added to the water and that has resulted in almost 70-80% of rivers and streams all across the world being polluted [2]. Wastewater is defined as water whose physical, chemical or biological properties have been changed as a result of the introduction of certain substances that render it unsafe for some purposes such as drinking. Amongst the types of wastewater, the three main types are Stormwater Runoff, Industrial Wastewater, and Domestic Wastewater. Domestic wastewater is generated from the residences and office buildings and can be classified into Greywater and Blackwater depending on the source [3]. Household practices like bathing, cleaning, cooking etc. lead to Greywater while that from excreting waste by urine, faeces, perspiration fall in Blackwater [4].

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The organic matter and other contaminants make the wastewater a breeding ground for a variety of pathogenic organisms like bacteria, viruses, fungi, and protozoa and cause a lot of water-related diseases [5]. Estimations suggest that around 1.1 billion people globally drink unsafe water. According to the World Bank, 21% of India's communicable diseases are water related [6]. Wastewater treatment has become increasingly important as a result of the huge challenge it poses. The wastewater is a resource for 2 things, one water, and second the nutrients it contains [7]. Thus, it is very important to preserve the water quality for current and future generations and for the ecosystem to survive even when treating the wastewater [8].

In 2012, only around 20 % of the wastewater produced globally was being treated, according to the fourth World Water Development Report. This highlights that currently there is technology available to treat water, but it is not being utilized and implemented at majority of the places due to affordability and feasibility [9]. Treatment of wastewater to remove the various pollutants in it can be accomplished using various methods which can be categorized into: Physical, Chemical, and Biological methods. Physiological and chemical treatment methods require advanced technologies, and trained technicians and thus higher energy and cost to be implemented. Biological treatment methods are very efficient energy & cost wise and require simpler tools and thus in demand currently [10]. Enzymes can be utilized due to their catalytic potential for wastewater treatment as well. However, they have a limitation due to prohibitive cost involved with enzymes and thus not viable at very large scales [11].

On another hand, vegetable and fruit wastes are generated through various activities like producing, processing, eating, cooking, peeling, & cutting. And a lot of this waste is dumped inadequately thus causing serious environmental and health concerns. Such dumped garbage is often stale, spoilt, and unfit for consumption. But the solid waste thus generated contains useful fibre content, moisture, and other nutrients [12]. Several examinations have found that up to 80% of such strong waste can be used again and thus reduce the pollution it causes [13]. One such way to utilise the fruit and vegetable waste is in creating eco-enzyme solutions from it. Eco-enzyme is a kind of vinegar prepared at home by fermentation of fresh kitchen waste like fruit and vegetable peels as substrate with sugar and water [14]. Dr. Rosukon Poompanvong invented the process of preparing the bio-enzyme by fermentation of sugar, water, and fruit and vegetable waste [15]. Bio-enzymes are multipurpose natural cleaners that can effectively replace harsh chemicals like bleach, phenyl, and other chemical solutions we typically use in our households. The various roles that eco-enzyme plays are anti-fungal, anti-bacterial, insecticidal and cleaning agent [16]. Bio-enzyme is a new and one of the trending methods used today to treat domestic wastewater, and neither much work has been done on bio-enzyme nor it is practised much in India. Its usage can help to minimise organic waste, reduce greenhouse emissions, and lessen burden on landfills [17].

2. Material and methods

The present study was carried out to determine the effect of 3 different types of eco enzyme solutions in domestic wastewater treatment.

2.1. Materials

The materials that have been used in the preparation of eco-enzyme solution are:

- Citrus peels (Orange) waste,
- Marigold flowers waste,
- Neem Leaves waste,
- Jaggery, &
- Water

The apparatus that has been used for storing materials, testing & measuring parameters are:

- Plastic air-tight bottles (for fermentation process during preparation of eco-enzyme),
- Dr Trust - Electronic Kitchen Scale (as weighing scale),
- Beaker (for taking out samples for parameters testing),
- HANNA pH meter (for measuring pH of wastewater and eco-enzyme solutions),
- HANNA TDS meter (for measuring TDS of wastewater and eco-enzyme solutions),
- Hach DR3900 spectrophotometer (for measuring COD of wastewater solution before and during the treatment with eco-enzyme solutions).

2.2. Collection and Preparation of Samples

We collected citrus peels (orange), marigold flowers, and neem leaves waste from my house, neighbours, and surrounding area.

The water was collected from various sources of water pollution inside the home.

2.2.1. Jaggery

Jaggery is loaded with minerals & antioxidants like selenium & zinc. Among them, zinc helps in killing bacteria and it also has antibacterial properties [18].

2.2.2. Citrus Fruit Peels

Citrus fruit peels contain carbohydrates in the form of sugars, sucrose, glucose, fructose, etc. Organic acid is also present in citrus fruit peels, such as citric acid, malic acid, oxalic acid, succinic acid. The organic acids help to convert carbohydrates to alcohol [18].

2.2.3. Marigold Flowers

Marigold flower has shown anti-oxidant and anti-cancer properties in various studies due to it being a rich source of Xanthophylls called Lutein. Lutein is widely used in food, medicine, health care products and plays an important role in preventing and controlling diseases in the human body [19, 20].

2.2.4. Neem Leaves

Neem is a natural herb available in abundance in India. And it is found to be an effective disinfectant due to its antibacterial activity in killing pathogenic bacteria present in polluted water or wastewater to make the water safe for usage (especially in rural and tribal areas) [21]. *Azadirachta indica* (Neem) has shown strong potential in removing several harmful toxic metals and pathogenic microbes from wastewater along with improving quality parameters of water with minimal or no side effects [22].

2.3. Experimental Design

2.3.1. Preparation of Eco-enzyme

Ingredients for preparing

- Citrus eco-enzyme solution: Citrus peels waste + Jaggery + Distilled Water
- Marigold eco-enzyme solution: Marigold flowers waste + Jaggery + Distilled Water
- Neem leaves eco-enzyme solution: Neem leaves waste + Jaggery + Distilled Water

Composition: The composition ratio of ingredients for preparing Eco-enzyme is described below (table 1).

Table 1 Composition of ingredients for preparing Eco-enzyme.

Sr. No.	Ingredients	Parts/Ratio	Weight/Volume
1.	Jaggery	1	100 gm
2.	Citrus Peels Waste	3	300 gm
	Marigold Flowers Waste		
	Neem Leaves Waste		
3.	Water	10	1000 ml (1L)

Procedure: The materials that have to be used for the preparation of eco-enzyme solutions are jaggery & water along with fruit, flower, or leaves waste for respective solutions.

After the collection of waste, separation is done to ensure that no chemical substance enters into the system, which can affect the process. All the 3 types of wastes were then shredded into small pieces to increase the surface area for reaction. It is done so as to increase the rate of decomposition.

We used Dr Trust - Electronic Kitchen Scale for measuring the weights of the ingredients.

The ratio used to prepare the eco-enzyme solution is 1:3:10. Thus one part of jaggery, three parts of respective wastes and ten-parts of water have to be mixed in an airtight plastic container for each of the three wastes separately (figure 1). The container must be in such a way that it can accommodate the eco-enzyme and still have 10-20% space left empty [23].

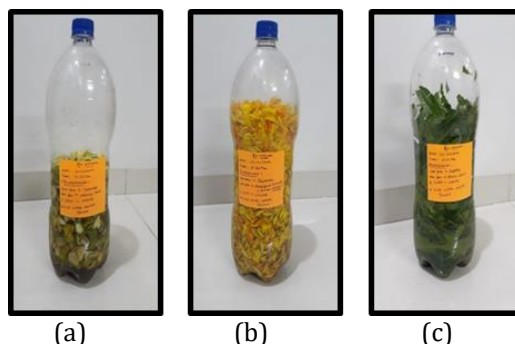


Figure 1 Eco-enzyme Production: (a) Orange eco-enzyme production, (b) Marigold eco-enzyme production, (c) Neem eco-enzyme production

The principle behind the enzyme preparation is the simple fermentation process. An airtight container is used to promote fermentation by minimizing oxygen. Usually, it takes three months for the eco-enzyme to be ready.

When the process of fermentation starts there will be some release of gases that will be built up in the space of the container. The bubble formation during the fermentation process is due to the release of gases. So, we must release the gases by opening the lid once in a day and the container must be closed again tightly. This must be repeated for one week and from the second week it can be opened in alternative days as the formation of gases will be reduced.

The enzyme prepared must be stored in a cool place at room temperature and should not be stored under direct sunlight. Settling of the citrus fruit peels in the bottom of the container and less bubble formation indicates the completion of the fermentation process.

After 90 days of fermentation, coloured liquids along with many small particles and some undigested residue was prepared in the container. The colour of orange, marigold, and neem eco-enzyme was light yellowish brown, brown, and dark greenish brown respectively. These coloured liquids were raw enzymes and it was needed to separate it out from other solid matter left after digestion. Filtration was done to obtain the prepared eco-enzyme to improve the structural and functional properties (figure 2).

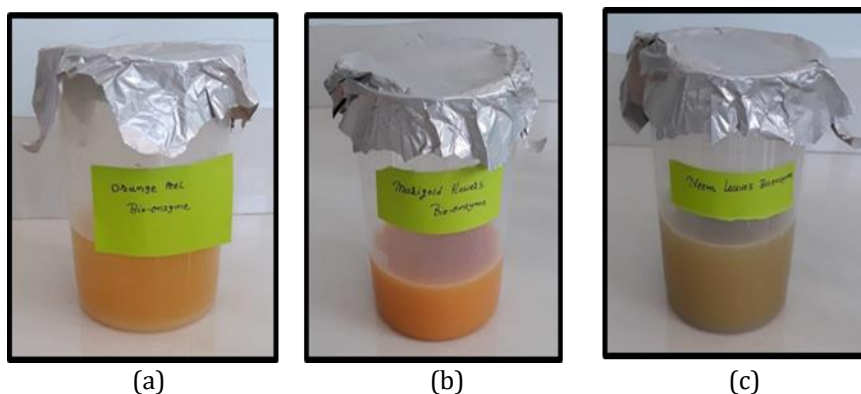


Figure 2 Eco-enzyme Solutions after Filtration: (a) Orange eco-enzyme solution, (b) Marigold eco-enzyme solution, (c) Neem eco-enzyme solution

Filtered bio-enzyme solution was kept separately in a closed container. The characterization of the bio-enzyme was done after 10 days of filtration [17].

2.3.2. Preparation of Domestic Wastewater

The domestic wastewater used in this study was prepared at home. The colour of the domestic wastewater was found to be grey.

Procedure

Collect the wastewater separately as prepared from various household activities that pollute water such as:

- Cleaning Utensils
- Laundry
- Washing fruits and vegetables
- Cooking
- Cleaning House
- Kitchen waste
- Body washing
- NaCl

Mix the separately collected wastewater into a single large container to obtain the domestic wastewater (figure 3).



Figure 3 Domestic Wastewater Sample

Duration

The eco-enzyme was prepared at home and was kept to allow for fermentation for duration of 3 months. It was filtered at the end of the 90th day.

After 10 days of the filtration, the measurement of parameters was undertaken over a period of next 50 days.

2.3.3. Domestic wastewater treatment using 3 different Eco-enzyme Solutions

Procedure

- After 10 days of filtration of the three eco-enzyme solutions, their pH and TDS parameters were measured separately.
- Immediately after the domestic wastewater was prepared, its COD, pH, and TDS reading were measured by taking out different samples.
- Three more domestic wastewater samples of 450 ml each were taken out from the prepared domestic wastewater and were separately mixed with 50 ml of each of the three eco-enzyme solutions giving us 10% eco-enzyme diluted wastewater samples (figure 4).
- pH, and TDS of the three samples hence prepared were measured at days 3, 5, 10, 15, 20, 25, 30, 40, and 50 after mixing.
- COD of three samples was measured on day 30 after mixing.



Figure 4 Samples with Domestic Wastewater & Eco-enzyme: Left-most bottle has Orange eco-enzyme, Middle bottle has Marigold eco-enzyme and Rightmost bottle has Neem eco-enzyme added to Domestic wastewater

Parameter Tests Conducted

The tests that have been conducted are:

- pH: The pH of the samples/solutions was measured using HANNA pH meter which immediately displays the pH reading (in the range of 1-14) of the solution on its digital display upon dipping the sensor part into the solution.
- TDS: The TDS of the samples/solutions was measured using HANNA TDS meter which immediately displays the TDS reading (display reading has to be multiplied by a factor of 100 to obtain actual TDS reading in mg/L) of the solution on its digital display upon dipping the sensor part into the solution.
- COD: The COD of the samples was measured for reading in mg/L using HACH DR3900 instrument in SICART Lab of Anand. It is a benchtop visible spectrum (320 – 1100 nm), split beam spectrophotometer with over 220 pre-programmed methods optimized for laboratory water analysis. It provides optimised and accurate results for the parameters it is programmed for.

3. Results

3.1. Characteristics of Eco-enzyme

The characteristic of eco-enzyme solutions of orange peels, marigold flowers and neem leaves waste have been tabulated below (table 2).

Table 2 Characteristics of three different eco-enzyme (after 10 days of filtration).

Parameters	Orange peel waste Eco-enzyme Value	Marigold flowers waste Eco-enzyme Value	Neem leaves waste Eco-enzyme Value
pH	3.1	2.9	3.2
TDS (mg/L)	1300	1400	2500

The low pH value of eco-enzyme solutions prepared from orange peels, marigold flowers and neem leaves show its acidic nature. The TDS readings were quite high upon analysis.

3.2. Characteristics of Domestic Wastewater

Below table demonstrates the domestic wastewater characteristics used in the present study (table 3).

Table 3 Domestic wastewater characteristics.

Parameters	Domestic Wastewater Value
pH	7.1
TDS (mg/L)	3800
COD (mg/L)	1920

The pH of domestic wastewater suggests it's slightly alkaline in nature. The TDS value is quite high.

3.3. Characteristics of Domestic wastewater sample after treatment with Eco-enzyme

The domestic wastewater sample was treated with 10% eco-enzyme solutions obtained from orange peels, marigold flowers, and neem leaves waste. The bottles were kept for digestion periods of 50 days, and the pH & TDS were measured on 3, 5, 10, 15, 20, 25, 30, 40, and 50 days. While the parameter of COD was measured on the 30th day. The results have been discussed below.

3.3.1. pH

After treatment with eco-enzyme the variation was observed in pH value of effluent and the corresponding variation in the characteristic of treated domestic wastewater samples is shown below (figure 5).

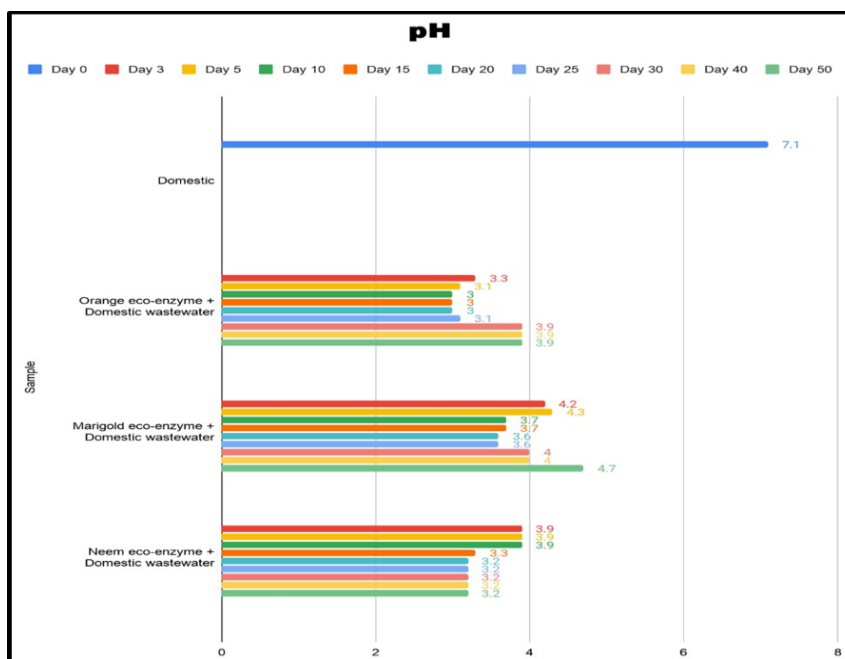


Figure 5 pH Graph

It was observed during the dilution period that the pH of domestic wastewater sample decreased from 7.1 before mixing with eco-enzymes to 3.3, 4.2, and 3.9 after 3 days of addition of orange, marigold, and neem eco-enzymes respectively. The pH kept going down till 20 days for all samples and it stabilized at 3.2 from there on till the 50th day for the sample with neem eco-enzyme while it increased slightly to 3.9 and 4.7 for the samples with orange and marigold eco-enzymes respectively. The acidic nature of eco-enzyme solution influenced the domestic wastewater samples and made them acidic.

3.3.2. TDS

After treatment with eco-enzyme the variation was observed in TDS value of effluent and the corresponding variation in the characteristic of treated domestic wastewater samples is shown below (figure 6).

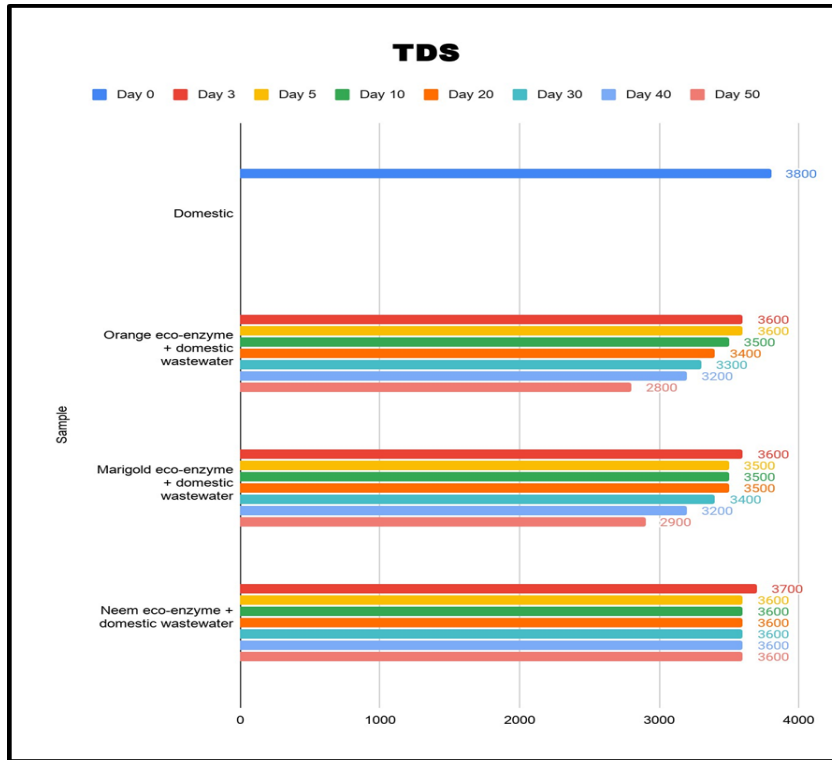


Figure 6 TDS Graph

TDS of the domestic wastewater sample was 3800 mg/L before being mixed with the eco-enzyme solutions. The TDS showed reduction in general for all the samples after being mixed with the eco-enzyme solutions gradually over the 50-day dilution period. The sample with orange eco-enzyme showed the highest improvement as the value reduced to 2800 mg/L from 3800 mg/L which is about 26.3% reduction. The sample with marigold eco-enzyme managed to reduce it to 2900 mg/L at the end of the 50-day dilution period. Whereas the sample with neem eco-enzyme managed to reduce it to 3600 mg/L.

3.3.3. COD

After treatment with eco-enzyme the variation was observed in COD value of effluent and the corresponding variation in the characteristic of treated domestic wastewater samples is shown below (figure 7).

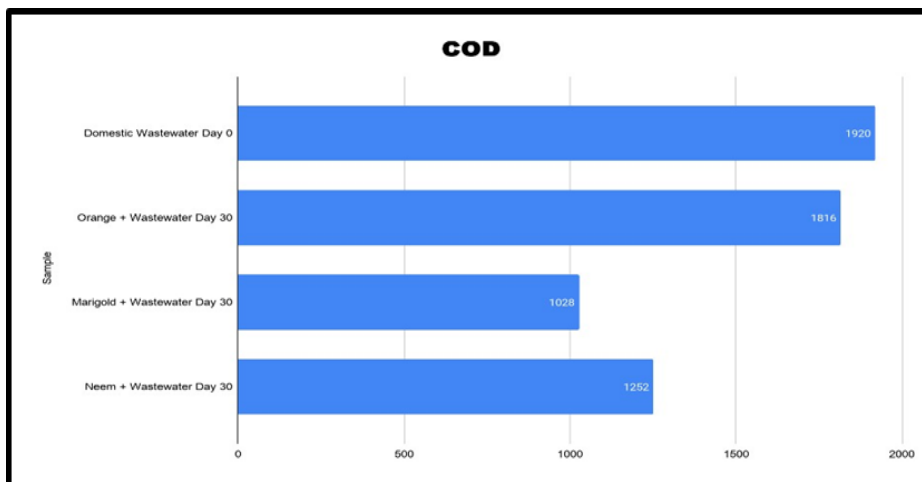


Figure 7 COD Graph

4. Discussion

Water pollution is a major concern given the importance of water in survival and dependence on it for a variety of day-to-day activities. Increasing population and urbanisation is causing the quantity and rate of pollution to increase rapidly, thus putting a lot of strain on the demand of usable water, which is proving to be increasingly insufficient for all the uses. Not only that, water pollution causes a lot of harmful effects on the health of humans and environment. A lot of ecosystems are being destroyed and a lot of diseases are caused and spread because of it.

It has been pointed out that there is an urgent need to start identifying and applying many new methods to treat the wastewater before it mixes with the freshwater bodies. Moreover, the focus has to be on the viability of the method as it should be quick, cost effective, and efficient in treating the wastewater to meet various standards for different uses. Several studies have highlighted eco-enzyme as a probable solution to treat wastewater in an effective manner without causing harm to the environment.

In the present study, we explored the potential of eco-enzyme solutions made of orange (citrus) peels, marigold flowers, and neem leaves waste in treating a domestic wastewater sample. The domestic wastewater sample prepared had initial readings of 7.1 pH, 3800 mg/L TDS, and 1920 mg/L COD indicative of a neutral-alkaline nature with high TDS and COD which make it unfit for drinking and agriculture amongst many other uses. The solutions prepared had initial readings of 3.1, 2.9, 3.2 pH and 1300, 1400, 2500 mg/L TDS for orange, marigold, and neem eco-enzymes after 10 days of filtration indicating the acidic nature of the solutions.

The readings taken over the course of the dilution period of 50 days indicate reduction in the values of pH, TDS, COD. The highest reduction in TDS was found in case of Orange eco-enzyme which had the lowest reading of 2800 mg/L after 50 days of dilution. The highest reduction in COD was found to be in the case of marigold eco-enzyme which had the reading of 1028 mg/L after 30 days of dilution. As far as pH is concerned, the closer it is to neutral the better and hence the pH readings of all 3 eco-enzyme solutions actually showed acidification of the sample for initial 20 days after which the pH started increasing towards 7. The marigold eco-enzyme had the best reading in this matter of 4.7 after 50 days of dilution period.

One of the studies had identified that 10% dilution of garbage and citrus enzymes is more efficient than 5% dilution when mixed with wastewater sample for treatment. Moreover, they noted that the longer time the eco-enzyme solution is kept for after filtration and before being mixed for treatment, the quicker it becomes in treating [24].

Present study shows that eco-enzyme has good potential to help reduce the TDS and COD values which indicate its effectiveness in purifying the domestic wastewater sample of its impurities to an extent. But the reduction in TDS and COD still wasn't enough to fall within permissible limits of 250 mg/L for COD and 2000 mg/L for TDS. We can also say that the domestic wastewater sample can still be improved in terms of its pH value with the help of some additional additives that do not affect its quality and help to neutralise the pH value. More research about the effect of the eco-enzymes when kept for a longer time before being added with the domestic wastewater sample can potentially help understand the benefit in terms of shorter time taken to treat the wastewater.

5. Conclusion

The study highlights that solutions for domestic wastewater treatment which can be implemented at the household level on an interim basis need to be identified to help mitigate domestic water pollution till the time a solution can be found to treat huge quantities of water at once and effectively.

The eco-enzyme solution prepared using marigold flowers waste emerged ahead of the eco-enzyme solutions prepared using orange peels and neem leaves waste. It managed to reduce the COD of domestic wastewater sample from 1920 mg/L to 1028 mg/L against 1252 mg/L for neem eco-enzyme and 1816 mg/L for orange eco-enzyme. It also managed to reduce TDS from 3800 mg/L to 2900 mg/L just behind orange eco-enzyme which reduced it to 2800 mg/L, whereas neem eco-enzyme managed to reduce TDS to just 3600 mg/L. And it also emerged ahead of the other two eco-enzymes in terms of managing to keep the pH closer to neutral as it ended up with a pH of 4.7 against that of 3.9 for orange eco-enzyme and 3.2 for neem eco-enzyme.

We can conclude that given the preparation of eco-enzyme solutions is in-expensive as they are prepared from the waste of fruits or flowers or leaves, which is abundant in quantity, they have great potential in not only treating domestic

wastewater, but also reducing the load on organic solid waste management. Moreover, eco-enzyme solutions thus prepared also have proven utility in cleaning, other domestic, and agricultural purposes.

Compliance with ethical standards

Acknowledgments

The author acknowledges Mr. Hardik Parekh and the authorities of Sophisticated Instrumentation Centre for Applied Research and Testing (SICART), Vallabh Vidyanagar, Anand (India) for providing their facilities and services for analysis and testing of useful parameters corresponding to the study.

Disclosure of conflict of interest

The authors declare no competing interests.

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