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Wastewater Treatment by using Bio-Enzymes Extracted from Fruits and Vegetables Waste

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ABSTRACT

There is urgent need to reclaim the water which gets polluted due to overexploitation and negligence of the human kind to check the water scarcity problem. Many efforts have been made to recycle that water by the help of technologies based on physical, chemical and biological processes. Out of these technologies, Bio-enzyme is the cost effective, eco-friendly and environmentally sustainable option. For the treatment of a sample of domestic wastewater in this investigation, bio-enzyme produced through the fermentation of vegetable and fruit waste was employed. The wastewater samples were mixed with a 5, 10, and 15% bio-enzyme solution and digested for 5, 15, and 25 days. The results demonstrated that bio-enzyme may significantly reduce the TDS, BOD5, and COD characteristics of wastewater, while 100% removal of ammoniacal nitrogen and phosphate was shown at low concentrations of bio-enzyme solution. The pH showed no significant fluctuation and it remains acidic. Low pH of the wastewater sample bio-enzyme makes it suitable for reducing salinity of the soil caused due to excessive use of fertilizers and pesticides. Bio-Enzyme extracted from fruit and vegetable waste gave almost similar results; No large variation was observed. With the help of bio-enzymes, wastewater may be improved and made suitable for a variety of uses. Additionally, using bio-enzymes can aid in reducing greenhouse gas emissions and the disposal of chemicals used in wastewater treatment operations, making it environmentally sustainable. Also reduces the burden on landfill sites by utilizing the waste as resource.

Keywords— Bio-Enzyme; Environmental Sustainability; Fruit Waste; Vegetable Waste; Waste Enzyme; Wastewater Treatment; Water Pollution

I. INTRODUCTION

Water is one of the most vital natural resources for all life on Earth. Most of the evolution theories state that life started with water. The availability and quality of water always have played an important part in determining not only where people can live, but also their quality of life [1]. As we know that about 60% of our body is water and in some organisms, it's as high as 90%. Nearly 97% of the world's water is salty or otherwise undrinkable [2]. Due to the increase in world population, rapid industrialization and ongoing development activities wastewater generation rate become many fold. The problem of management and disposal of the wastewater so generated has become serious threat [3]. Nearly 70-80% of water bodies are carrying polluted water. Large amount of domestic sewage is drained in to river and most of the sewage is untreated. Domestic sewage contains toxicants, solid waste, plastic litters and bacterial contaminants and these toxic materials causes water pollution. About

25% pollution of water is caused by the industries and is more harmful [4]. Hazardous material discharged from the industries is responsible for surface water and ground water contamination. Contaminant depends upon the nature of industries. Toxic metals enter in to water and reduced the quality of water [5]. Different industrial effluent that is drained in to river without treatment is the major cause of water pollution [6]. Municipal waste water generate from different sources, the major source is domestic i.e. waste water originated from residential sources (50-90%) while commercial waste water (5-30%) and industrial waste water (5-20%) are secondary sources. The removal of biological organic pollutants and nutrients is the main priority in domestic waste water treatment [7]. The strength and composition of the domestic wastewater changes on hourly, daily and seasonal basis, with the average strength dependent on per capita water usage, habits, diet, living standard and life style. The main reason is variation in water usage in households. Households in developed countries use more water than those in developing countries [8]. In present study, emphasis is given to domestic wastewater as it contains contain only 0.1% of solid material so there are wide scope to reuse this water for various purpose by giving some degree of treatment [9]. The main purpose for treatment of wastewater is to counterfeit the precious drinking water in applications which do not require the drinking water quality. It is used for various non-portable reuse application include industrial, irrigation, toilet flushing and laundry washing dependent on the degree of treatment of water [10]. By recycling the grey water, it is possible to reduce the amount of fresh water consumption as well as reduction in waste water generation, in addition to reducing the water bill. Use of grey water increases the supply for irrigation, which will lead to increase in agricultural productivity [11]. Various treatment and purification technologies have been developed to reclaim the usefulness of wastewater. Many researchers are working to find new techniques for reclamation of water focusing on biological or physical wastewater treatment methods rather than chemical ones [12]. The use of waste/garbage/bio-enzymes is investigated by researchers as an alternative solution for treatment of waste water. Bio-Enzyme used for treatment of waste water is a very eco-friendly and sustainable way of waste water treatment because organic wastes are used in the making of garbage/waste enzyme which catalyze the rate of chemical reaction in waste water [13].

Enzymes are basically protein molecules that catalyses the chemical reaction. They act as biological catalysts and catalyses only specific molecules (substrates). Enzymes are selective for their substrates and catalyses only one or a small number of chemical reactions among many possibilities. However they are physiologically important because they speed up, by at least 1000-fold, the rates of reactions by decreasing the amount of energy required to form a complex of reactant, known as the transition state complex, that is competent to produce reaction product [14]. Enzymes produced under anaerobic conditions from fermentation of organic waste material such as fruit/ vegetable waste along with brown sugar and water in a fixed proportion are called as Bio-Enzymes or Waste Enzyme or Garbage Enzymes [15]. These are the biocatalysts produced by living cell to lead specific biochemical reaction by forming the various metabolic processes of the cell and essential to maintain the activity of life. Enzymes are effective in their action on substrates and usually many different enzymes are required to create chain of metabolic reaction performed by a living cell. Each strain of a microorganism produces a large number of enzymes which can be hydrolyzing, oxidizing or reducing and metabolic in nature. Microbial enzymes are noted to play essential role as metabolic catalysts, resulting in their

use in various industrial applications [16]. In order to improve the properties of enzyme i.e. stability, substrate specificity and specific activity, it can be selected on the basis of genetic, and chemically-modified [17]. Garbage/Waste enzyme is different from fruit enzyme and is not for human consumption. It is a nutritious drink prepared through proper fermentation of fruits/vegetable wastes [18]. It is dark brown and has a strong sweet sour fermented scent. It is a complex organic substance of protein chains and mineral salts and juvenile hormones. The functions of bio-enzyme is to resolve (decompose), transform (change), and catalyze the reactions [7].

It is claimed as a multi-use solution for domestic and agricultural applications [19]. Due to low PH and high acetic acid concentration bio enzymes are used for many purposes. It contains traces of ethanol and propionic acid, ethanol has antiseptic properties and propionic acid is used for food preservation. Bio enzyme is used as a natural household cleaner, car care, air purifier, deodorizer, insecticide, detergent, body care, organic fertilizer, etc. It removes odour and dissolve toxic air released from smoking, car exhaust, chemical resides from household products, etc. It is natural antiseptic for your home and it also prevents drainpipe blockages [18].

Bio-Enzyme can be used as an anti-microbial agent, insecticide and pesticide. When diluted, it could provide nutrients to plants in the form of growth hormones, minerals, enzymes and/or other organic compounds extracted directly or converted from the waste materials. Rather than to be disposed and incinerated, these waste materials can further serve additional purposes through garbage enzyme, and subsequently be composted into organic fertilizer. This will surely help in preventing or reducing all forms of pollutions from the improper solid waste management and incineration, as well as to "close the waste loop" and promote recycling of waste back into the earth [18]. For the treatment of domestic wastewater with advanced level of degradation in a shorter span of time, bio-enzyme performs the same task as done by enzymes. In Malaysia, many researchers have performed investigation to check the bio-enzyme as viable solution for wastewater treatment [7]. In India, bio-enzyme is not much known and practiced at very low level [17]. Usage of bio-enzyme not only provides an alternative solution to biological recovery from organic waste it will also help in minimization and reduction of waste; since municipal solid waste mainly consists of organic waste. It also puts a check on greenhouse emissions; lessen the burden on landfills [20].

This paper presents the results from digestion of domestic wastewater using bio-enzymes produced from flower waste at three different concentrations i.e. 5%, 10% and 15% after 5, 10 and 25 days of digestion period. An attempt has been made to understand the effectiveness of bio-enzymes produced from organic waste material in treating domestic wastewater.

II. METHODOLOGY

Based on the objectives of this study the methodology adopted for the present investigation is presented below:

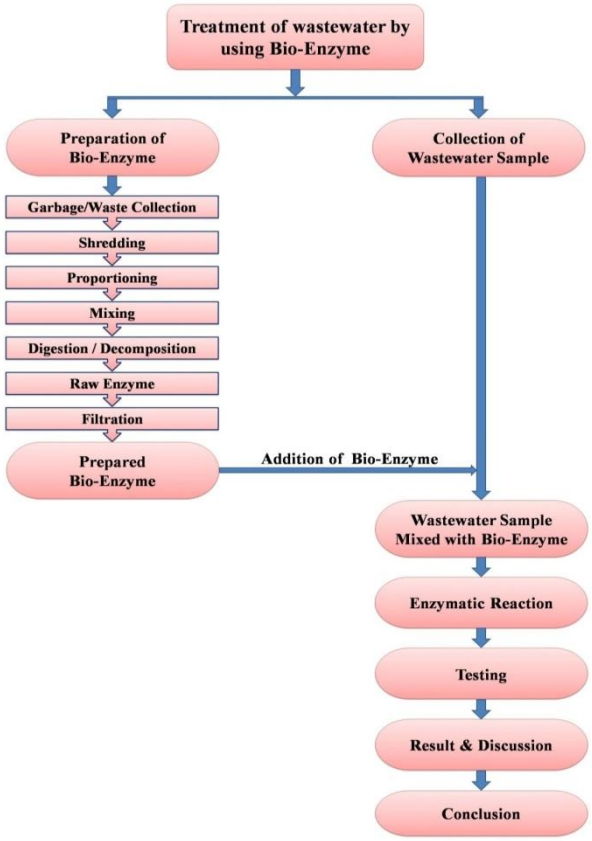

Fig. 1: Flow diagram of the work plan

A. Bio-Enzyme Preparation

Fruits and vegetables waste are collected from kitchens, vegetables shops, fruit & vegetable markets and fresh juice corners. After the collection of raw garbage separation is done on the basis of their chemical properties (citrus/garbage) and then shredding is done to reduce the size of garbage or fruits and vegetables waste into small size so that it can be decomposed easily After shredding the waste in to small pieces all the materials i.e. Jaggery, fruit/vegetable/flower waste and water were taken in proportion of 1: 3: 10 to mix them together for preparing bio-enzymes. All ingredients were mixed in a plastic container that has screw bottle caps to release the gases produced during the process. So, plastic container is the best option; with bottles having screw caps it is easier to manage the release of gases; don't screw the bottle too tight it could explode because of the gases formed inside and kept it at a dark place for digestion.

Then the lid of container was open to release the gases once in a day repeat this procedure to release the gases for first one month. In the second month the lid was opened once in a week and again kept in the dark. After the fermentation of three months the solutions which we get in raw form with undigested material and pulp. It was needed to separate out undigested or solid matter from liquid portion using filtration to enhance the properties of bio-enzyme and was stored in air tight container. To know the maturity of enzymatic solution, the different parameters were checked after filtration at 0, 30 and 60 days. [21].

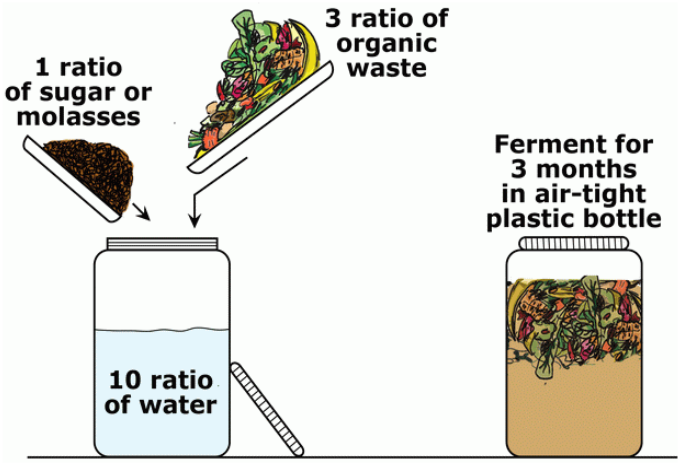

Fig. 2: Bio-Enzyme Production

B. Wastewater Treatment

Sample for testing should be collected from sewage treatment plant or drains which carry waste water from kitchens, washrooms, food producing and other industries. Bio-enzymes were added to the wastewater in different proportion i.e. 5%, 10%, and 15% [17]. Each three beakers having wastewater sample mixed same concentration of bio-enzyme was prepared for 5, 10, 15 days digestion.

III. Results & Discussion

To determine the effective dosage of bio-enzymes extracted from fruits and vegetables waste, to treat domestic wastewater sample various test were performed. In this study, parameters like pH, TDS, BOD_5, COD, Ammonia Nitrogen and Phosphate were analyzed as per procedures discussed in standard methods [22]. To understand the effect of bio-enzymes for treatment of waste water, characteristics of enzymes produced from vegetable waste and fruit waste are also determined. For treatment of the wastewater, 5%, 10% and 15%, of each enzyme solution was mixed. The variations in characteristics of the wastewater sample after 5, 15 and 25 days of digestion were observed and analyzed.

A. Characteristics of Bio-Enzymes

The characteristics of vegetable waste enzyme and fruit waste enzyme solutions were analyzed immediately after filtration, 30 days after filtration and 60 days after filtration. The parameters like pH, TDS, BOD_5, COD, Ammonia Nitrogen and Phosphate were observed. The characteristics of vegetable waste enzyme, fruit waste enzyme and flower waste enzyme solutions immediately after filtration of the enzyme solution, 30 days after filtration and 60 days after filtration are shown in Table 1 and 2. The pH of both enzyme solutions shows acidic character. The BOD_5 and COD values were high when the enzyme solution was analyzed immediately after filtration of the enzyme solution. But after 60 days of filtration BOD5 reduced to half and COD was reduced to 99% of its initial value. The enzyme solutions obtained from vegetable, fruit and flower were rich in organic content.

TABLE 1: Characteristics of Vegetable Waste Enzyme

Parameter	Just after filtration	30 Days of filtration	60 days of filtration
pH	3.01	3.5	4.18
TDS (mg/L)	2230	1505	1130
BOD_5(mg/L)	1311	570	94
COD (mg/L)	47900	2230	161
Ammonical Nitrogen (mg/L)	0	0	0
Phosphate (mg/L)	0	0	0

TABLE 2: Characteristics of Fruit Waste Enzyme

Parameter	Just after filtration	30 Days of filtration	60 days of filtration
pH	3.14	3.53	4.1
TDS (mg/L)	1963	1250	941
BOD_5(mg/L)	1270	553	90.1
COD (mg/L)	42310	2328	149
Ammonical Nitrogen (mg/L)	0	0	0
Phosphate (mg/L)	0	0	0

B. Characteristics of Domestic Wastewater (Raw) Sample

Before treating the wastewater sample with bio-enzyme, it is important to know the characteristics of the raw wastewater sample before treatment. The wastewater characteristics like pH, TDS, BOD5, COD, Ammonia nitrogen and Phosphates were determined and tabulated in Table 3.

TABLE 3: Raw Wastewater Characteristics

Parameter	Units	Value
PH	--	6.16

TDS (mg/L)	mg/L	563
BOD5(mg/L)	mg/L	192
COD(mg/L)	mg/L	290
Ammonical Nitrogen (mg/L)	mg/L	9.6
Phosphate (mg/L)	mg/L	110

C. Characteristics of Treated Wastewater Sample

5%, 10% and 15% solution of bio-enzymes extracted from fruits and vegetables waste, was used for the treatment of domestic wastewater. The treated wastewater sample characteristics like pH, TDS, BOD5 COD, Ammonia nitrogen and Phosphates were analyzed after 5, 15 and 25 days of digestion.

➢ *pH*

The corresponding variations observed in pH value of the effluent after 5, 15 & 25 days of digestion are shown in the figure 3.

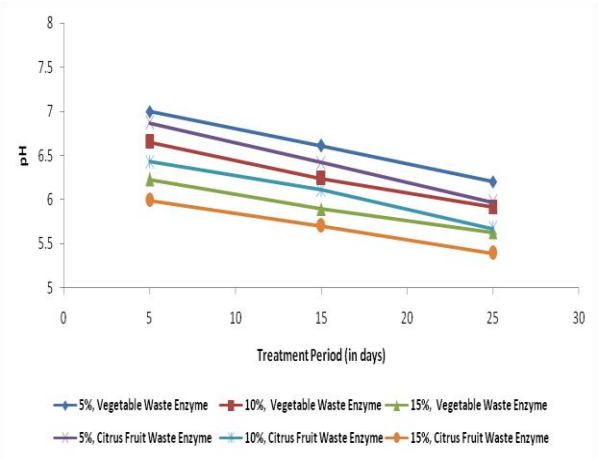

Fig. 3: Variation in pH characteristic of the treated wastewater sample

The filtered bio-enzyme obtained from garbage enzyme and citrus enzyme was found acidic in nature as indicated by low its pH value (Table 4.1 and 4.2). When it get mixed with domestic wastewater, the pH of wastewater sample having 5% bio-enzyme for digestion of 5 days, increased to nearly neutral range due to enzymatic reactions but slowly get reduced at constant rate with increase in digestion period as indicated in figure 4.1. Similar variation is also noted for wastewater samples having 10% and 15% bio-enzyme mixed..

➢ *TDS*

After treatment with bio-enzyme the variations was observed in TDS content of the effluent and the corresponding variation in the characteristic of treated wastewater sample after 5, 15 & 25 days of digestion are shown in figure 4.2. TDS characteristic of wastewater sample mixed with 5% bio-enzyme for digestion of 5 days, 15 days and 25 days was noted with decrement at constant rate; When compared with initial TDS of raw

wastewater sample (see Table 4.2), more than 50% TDS got removed after 25 days of digestion due to enzymatic reactions. Similar, variation is also noted for wastewater samples having 10% and 15% bio-enzyme mixed.

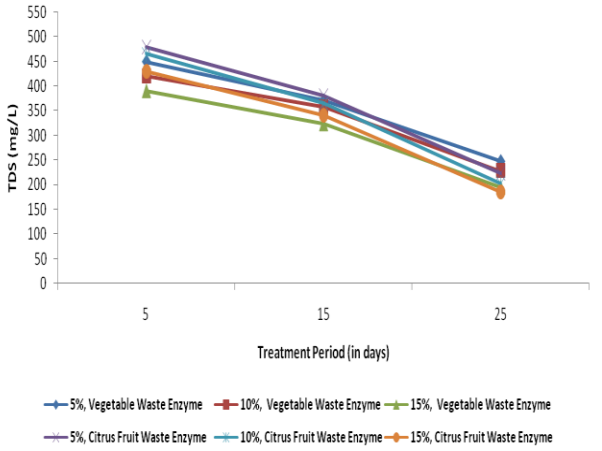

Fig.4: Variation in TDS characteristic of the treated wastewater sample

➢ *BOD_5*

The BOD_5 characteristic of treated wastewater sample after 5, 15 & 25 days of digestion with all three concentrations (i.e. 5%, 10% and 15%) of bio-enzyme solution, a constant rate of reduction in BOD_5 was observed for digestion of 5 days, 15 days and 25 days (see figure 5). For first 5 days of digestion period reduction was more than 50% but for next 10 and 20 days this rate got reduced to less than 10%.

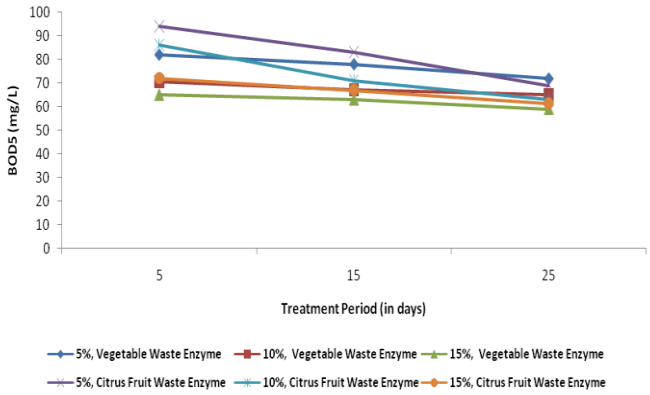

Fig. 5: Variation in BOD_5 characteristic of the treated wastewater sample

➢ *COD*

A decrease of about 20% can be observed in COD characteristic of wastewater sample (see Figure 5) mixed with 5% of bio-enzyme for 5, 15 and 25 days of digestion. When 10% and 15% bio-enzyme solution was mixed with wastewater a very good removal rate was noted.

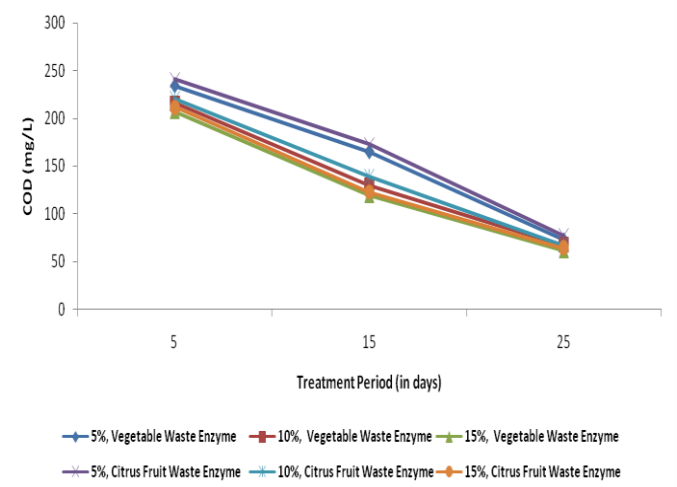

Fig. 6: Variation in COD characteristic of the treated wastewater sample

➢ *Ammonical Nitrogen*

A sharp reduction in the ammonical nitrogen characteristic of the treated wastewater sample after 5, 15 & 25 days of digestion with bio-enzyme was observed (see figure 7). More than 70% of the ammonical nitrogen was removed with 5% bio-enzyme for digestion of first 5 days. While 100% removal rate was observed for wastewater sample mixed with 10% and 15% bio-enzyme solution for first 5 days of digestion.

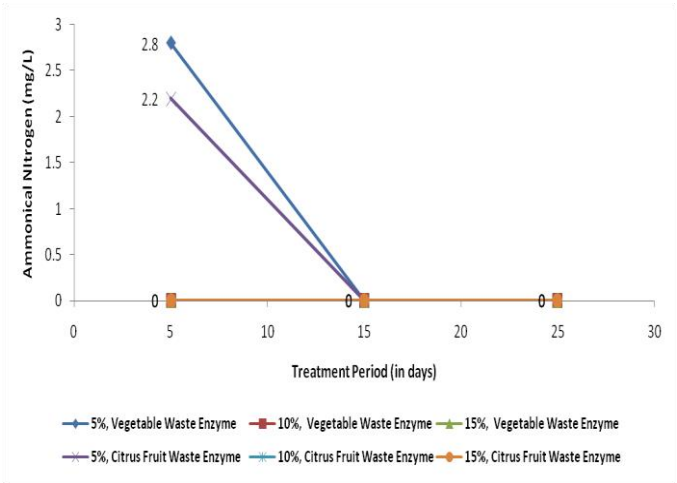

Fig. 7: Variation in ammonical nitrogen characteristic of the treated wastewater sample

➢ *Phosphate*

When compared with ammonical nitrogen a similar trend was observed in the phosphate characteristic of the treated wastewater sample after 5, 15 & 25 days of digestion with bio-enzyme. The variations in phosphate characteristic of the treated wastewater sample after 5, 15 & 25 days of digestion with bio-enzyme are shown in figure 8.

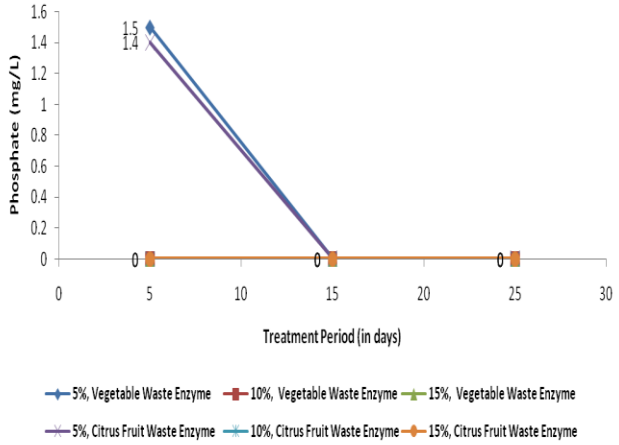

Fig. 8: Variation in phosphate characteristic of the treated wastewater sample

In case of phosphate characteristic, more than 95% removal was observed for wastewater sample mixed with 5% bio-enzyme solution for digestion of first 5 days. While 100% removal was observed for wastewater sample mixed with 10% and 15% bio-enzyme solution for the first 5 days of digestion.

IV. CONCLUSION

Bio-Enzymes are organic compounds extracted from fresh vegetable/fruit waste in presence of water and brown sugar/jaggery. Bio-Enzymes are powerful waste digesting enzymes, essential nutrients and breaks down the complex organic material into water-soluble nutrients. Bio-enzymes can be used for improving the efficacy and odor control in all facilities which generate organic contaminated wastewater treatment facilities. In this investigation, the treatment of wastewater using bio-enzymes has been examined along with the characteristics of bio-enzymes exteracted from different raw materials.

Due to the presensce of high organic content the bio-enzyme extracted from fruit/ vegetable waste exhibited high initial BOD. Acidic charcter exhibited by bio-enzymes helps in lowering the pH of the wastewater sample; makes the treated wastewater suitable for utilized as soil salinity reduction option. The results it can also be inferred that ammonical nitrogen, phosphate, TDS, BOD5 and COD characteristics of domestic wastewater can be removed effectively by using 10% bio-enzyme solution. The results obtained for the effluent showed similar trend when wastewater sample was treated with both type of enzyme solution i.e. fruit waste enzyme and vegetable waste enzyme. Because it is made from waste, bio-enzyme is inexpensive and cost-effective.Additionally, by making use of waste as resources, it helps to lessen the impact on the planet.As a result, Bio-Enzyme can be utilized as a cost-effective option to improve the characteristics of wastewater to make it suitable for further use.

ABBREVIATIONS

Acronyms	Full form
TDS	Total Dissolve Solid
BOD	Bio-chemical Oxygen Demand
COD	Chemical Oxygen Demand

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