Treatment of Synthetic Greywater Using 5% and 10% Garbage Enzyme Solution

Fazna Nazim and V. Meera

Abstract--- Garbage Enzyme is a complex solution produced by the fermentation of fresh kitchen waste (fruit and vegetable peel), sugar (brown sugar, jaggery or molasses) and water. Use of Garbage Enzyme is emerging as an effective method for treating greywater. When the treatment of synthetic greywater was done immediately after filtration of the Garbage Enzyme solution, the effluent standards were met after 27 days. The treatment time reduced to 5 days when it was treated 60 days after filtration of the enzyme solution. The enzyme solution is rich in organic content. The lower concentrations of 5% and 10% Garbage Enzymes were effective to treat synthetic greywater. Results showed that ammonia nitrogen and phosphates could be completely removed by using Garbage Enzyme solution. Further tests are required to study the removal mechanisms.

Keywords--- Fermentation, Filtration, Garbage Enzyme, Synthetic Greywater

I. INTRODUCTION

The problem of sewage disposal and industrial waste management has become increasingly critical due to the increase of worldwide population. Catastrophic impacts on human health and on the environment could result if pollution of receiving waters is allowed to continue. Therefore to preserve water quality for future generations, an effective means of solving this problem must be developed. Wastewater treatment technology has been improving, and currently it is possible to treat wastewater to a highly usable level efficiently and cheaply [1].

Greywater is the used water resulting from washing clothes and kitchen utensils, shower or bath and other domestic water not containing excreta. Greywater is also one of the major point pollution sources, which is discharged from residential and commercial areas into the rivers without any treatment [2]. It is the wastewater from kitchen sinks and hand basins in household or cafeteria premises. The quantity of greywater varies with the quantity of water supplied and certain local practices, such as whether personal and clothes washing is done at the home or at the water source [3].

There are many ways to treat greywater so that it can be reused. The treatment and reuse of wastewater is rapidly becoming a subject of great interest to researchers [4]. The various methods must be safe from a health point of view and not harmful to the environment. Decentralized wastewater management offers most opportunities for maximizing recycling opportunities. Although treatment of wastewater and its legislation is well instituted in urban and rural areas in developed countries; proper sanitation, with efficient treatment, has not been practiced in many other places, especially in suburban areas in developed countries [5]. Greywater may be re-used in a sub soil irrigation area, providing it is screened and filtered to remove hair, lint and other suspended particles [6].

Treatment systems for greywater exist in many forms, varying in their complexity, treatment method, and location within or outside the home, and should be designed in accordance with greywater source, quality, site specifications, and reuse patterns. Greywater treatment systems range in sophistication from simple branched-drain garden irrigation networks to full tertiary treatment systems that can filter water to nearly potable levels of quality [7]. The greywater treatment has been practiced for several years in places where water is less abundant or expensive to use. In the southern US, Australia, and many Middle Eastern countries, simple greywater diverting schemes are common as a means of irrigating landscape plants in arid regions [8].

Filtration is the most common physical treatment employed for the treatment of greywater. Coarse filtration (sand filters) followed by sedimentation and/or disinfection is reported for the treatment. Membrane filters achieve excellent removal rates for dissolved and suspended solids but the removal of organic matter is limited [9].

Coagulation with aluminium followed by sand filtration and electrocoagulation are chemical methods employed for the treatment of greywater. Biological treatment is required to remove biodegradable materials from wastewater. In the case of domestic wastewater the biological treatment aims to reduce the organic content and nutrients like nitrogen and phosphorous. Biological methods include attached growth or suspended growth process, aerobic or anaerobic process, etc [8].

Enzymes exhibit a number of features that make their use advantageous as compared to conventional chemical catalysts. The enzymes practically do not present disposal problems since, being mostly proteins and peptides; they are biodegradable and easily removed from contaminated streams. Enzymes used in wastewater belong to the category of biological additives [10]. Enzyme additive like laccase has been widely used and explored in wastewater treatment systems to treat specific pollutants. Enzymes have also been used in pre-treatment of wastewater, in particular in

---

Fazna Nazim, P.G.Student ,Civil-Environmental Engineering, Government Engineering College, Thrissur, Kerala, India, E-mail: faznanazim@gmail.com
Dr. Meera V. Assistant Professor, Civil Engineering Department, Government Engineering College, Thrissur, Kerala, India, E-mail: meerav17@hotmail.com
wastewater rich in lipids and fats [11]. Pancreatic lipase was used for hydrolysis and to reduce the size of fat particles in slaughterhouse wastewater and for hydrolysis of wastewater from dairy industries [12].

Enzymes are protein molecules that catalyse chemical reaction. They act as biological catalysts and catalyze only specific molecules (substrates). Enzymes are selective for their substrates and catalyze 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 [13].

Garbage Enzyme (GE) is an organic solution produced by the simple fermentation of fresh vegetable waste, brown sugar and water, in much the same process that wine is made. This fermentation creates a vinegar-like liquid with natural proteins, mineral salts and enzymes that make it magnificently multipurpose in and out of the home [14].

Garbage Enzyme can be utilized as a low-cost alternative to improve wastewater treatment processes. Using and making your own Garbage Enzyme is a growing trend among those who know about it and care about the earth. Kitchen garbage can help to save Mother Earth and through routine daily activities at home, we can reduce global warming and protect the ozone layer. It reduces waste and saves money by turning organic waste into household cleaning solutions and reduces methane and other greenhouse gas emissions, since less waste ends up in landfills. It improves water quality, as enzyme that ends up in groundwater and rivers is reported to remove impurities and harmful sludge and bacteria [15]. The functions of Garbage Enzyme is to resolve (decompose), transform (change), and catalyse the reactions [16].

The Garbage Enzyme functions similarly to enzymes in achieving a higher degree of degradation within a shorter time for domestic wastewater. Many studies have been conducted in Malaysia to explore the feasibility of using Garbage Enzyme to treat greywater. Garbage Enzyme is widely used in developing countries like Malaysia. It is being used in Malaysian cafes as a cheap wastewater treatment method. The Garbage Enzyme has been touted in the Malaysian media recently as a multipurpose solution for a range of uses, including fertilizer and insect repellent in the garden, household cleaning and even as personal shampoo and detergent [10].

The use of Garbage Enzyme is not popular in India. If the Garbage Enzyme is found to be useful in the degradation of wastewater, it may be utilized as a low-cost alternative to improve wastewater characteristics and reuse it for different purposes.

II. MATERIALS AND METHODS

Jaggery, fruit/vegetable peels and water were mixed together in the ratio of 1:3:10 to prepare Garbage Enzyme.
Table 1: Composition of Synthetic Greywater [9].

<table>
<thead>
<tr>
<th>Compound</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (mg/l)</td>
<td>300</td>
</tr>
<tr>
<td>Sodium acetate trihydrate (mg/l)</td>
<td>400</td>
</tr>
<tr>
<td>Ammonium chloride (mg/l)</td>
<td>225</td>
</tr>
<tr>
<td>Disodium hydrogen phosphate (mg/l)</td>
<td>150</td>
</tr>
<tr>
<td>Potassium dihydrogen phosphate (mg/l)</td>
<td>75</td>
</tr>
<tr>
<td>Magnesium sulphate (mg/l)</td>
<td>50</td>
</tr>
<tr>
<td>Cow dung (ml/l)</td>
<td>225</td>
</tr>
</tbody>
</table>

Table 2: Characteristics of Synthetic Greywater.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>-</td>
<td>6.16</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td></td>
<td>563</td>
</tr>
<tr>
<td>BOD (mg/l)</td>
<td></td>
<td>192</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td></td>
<td>290</td>
</tr>
<tr>
<td>Ammonia Nitrogen (mg/l)</td>
<td></td>
<td>9.6</td>
</tr>
<tr>
<td>Phosphate (mg/l)</td>
<td></td>
<td>110</td>
</tr>
<tr>
<td>MPN (No: of Total coliforms/100 ml)</td>
<td>11x10^4</td>
<td></td>
</tr>
</tbody>
</table>

The garbage enzyme solution is rich in organic content. The effluent characteristics are discussed below.

A. Effluent characteristics after treatment with garbage enzyme solution (immediately after filtration of the enzyme solution)

The synthetic greywater was treated using 5%, 10%, 20% and 50% garbage enzyme solution. These were then left for digestion. The parameters like pH, TDS, BOD, COD, Ammonia nitrogen, Phosphates and MPN were analyzed. The variations of phosphate, Ammonia nitrogen, COD, BOD, pH and MPN with time for different concentrations of garbage enzyme solution are shown in Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7 respectively.

pH of pure garbage enzyme is acidic in nature. When it is mixed with greywater, the pH increased to nearly neutral range. Low pH suppresses the activity of the enzymes. The enzyme solution characteristics were found with time. The analysis of garbage enzyme for protein content revealed a concentration of 40 mg/l. Therefore it is clear that the treatment is due to enzyme action. The effluent characteristics after treatment with garbage enzyme after 27 days of digestion are shown in Table 4 and the corresponding percentage reduction is shown in Table 5. The effluent met the irrigation standards as per E (P) rules.
The garbage enzyme solution (10%) when treated with synthetic greywater showed more percentage reduction for parameters TDS (58.795), BOD$_5$ (64.58%), and COD (78.62%) compared to other concentrations. MPN value was higher for 50% garbage enzyme solution.

100% reduction was found for parameters ammonia nitrogen and phosphate after 27 days of digestion period. It can be observed that the concentration of various parameters viz. TDS, BOD$_5$ and COD were highly reduced when compared to the characteristics found out immediately after filtering the enzyme solution.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5%</th>
<th>10%</th>
<th>20%</th>
<th>50%</th>
<th>Irrigation standards E(P) rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.84</td>
<td>6.58</td>
<td>6.37</td>
<td>5.72</td>
<td>5.5 - 9</td>
</tr>
<tr>
<td>TDS(mg/l)</td>
<td>256</td>
<td>232</td>
<td>410</td>
<td>532</td>
<td>2100</td>
</tr>
<tr>
<td>BOD(mg/l)</td>
<td>74</td>
<td>68</td>
<td>91</td>
<td>96</td>
<td>100</td>
</tr>
<tr>
<td>COD(mg/l)</td>
<td>72</td>
<td>62</td>
<td>128</td>
<td>240</td>
<td>-</td>
</tr>
<tr>
<td>Ammonia Nitrogen (mg/l)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>-</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4: Effluent Characteristics after 27 days of Digestion
The effluent characteristics reached the irrigation standards only after 27 days of digestion period when the treatment was done immediately after filtration of the enzyme solution. These may be due to high initial COD and BOD values for the garbage enzyme solution.

The treatment of synthetic greywater using garbage enzyme was done immediately after filtration of the enzyme solution. The enzyme solution had not stabilized after three months of fermentation period. The enzyme solution is rich in organic content. The characteristics of the enzyme solutions were varying with time. Hence the enzyme solution is not suitable for the treatment during this period.

Table 5: Percentage Reduction after 27 Days of Digestion

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5%</th>
<th>10%</th>
<th>20%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mg/l)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDS(mg/l)</td>
<td>54.53</td>
<td>58.79</td>
<td>27.18</td>
<td>5.51</td>
</tr>
<tr>
<td>BOD₅(mg/l)</td>
<td>61.46</td>
<td>64.58</td>
<td>52.60</td>
<td>50.00</td>
</tr>
<tr>
<td>COD(mg/l)</td>
<td>75.17</td>
<td>78.62</td>
<td>55.86</td>
<td>17.24</td>
</tr>
<tr>
<td>Ammonia nitrogen(mg/l)</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Phosphate(mg/l)</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>MPN ( No: of coliforms/100 ml)</td>
<td>99.26</td>
<td>99.38</td>
<td>99.45</td>
<td>99.64</td>
</tr>
</tbody>
</table>

The lower concentrations of 5% and 10% garbage enzyme solutions were used then to treat synthetic greywater 60 days after filtration of the enzyme solution. The effluent characteristics are discussed below.

B. Effluent characteristics after treatment with 5% and 10% garbage enzyme solution (60 days after filtration)

The effluent met the irrigation standards (as per E(P) rules) after 5 days of digestion. The effluent characteristics after treatment with 5% and 10% garbage enzyme solution after 5 days of digestion are shown in Table 6. The percentage reduction of various parameters after treatment with 5% and 10% garbage enzyme solution after 5 days of digestion period is shown in Table 7.

The digestion days were decreased to 5 days when the treatment was done 60 days after filtration of the enzyme solution. The enzyme activity thus has significantly increased. The BOD and COD values of the enzyme solutions were reduced significantly.

The synthetic greywater when treated with garbage enzyme solution 10% showed more percentage reduction for TDS, BOD₅ and COD when compared to garbage enzyme solution (5%). 100% removal of ammonia nitrogen and Phosphates was observed when treated with 10% garbage enzyme solution. The MPN value was >99.9% and 71.43% for 5% and 10% garbage enzyme solutions respectively.

Figure 8. shows percentage reduction of various parameters after treatment with four different concentrations of garbage enzyme solution after 27 days. Figure 9. shows percentage reduction of various parameters after treatment of synthetic greywater with 5% garbage & 10% garbage enzyme solution after 5 days. Low pH suppresses the activity of the enzymes. It also contains traces of propionic acid & ethanol. The antiseptic and anti microbial activity is due to the action of these. The treatment of garbage enzyme may also be due to the presence of citric acids and amino acids in fruit peels. Their chemical conversions turn carbohydrates, fats & proteins into CO₂ & water to generate a form of usable energy.

Table 6: Effluent Characteristics after Using 5% and 10% Garbage Enzyme Solution after 5 Days of Digestion

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5% Garbage enzyme</th>
<th>10% Garbage enzyme</th>
<th>Irrigation standards E(P) rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.92</td>
<td>6.84</td>
<td>5.5 - 9</td>
</tr>
<tr>
<td>TDS(mg/l)</td>
<td>460</td>
<td>430</td>
<td>2100</td>
</tr>
<tr>
<td>BOD(mg/l)</td>
<td>82</td>
<td>70.5</td>
<td>100</td>
</tr>
<tr>
<td>COD(mg/l)</td>
<td>228</td>
<td>216</td>
<td>-</td>
</tr>
<tr>
<td>Ammonia Nitrogen (mg/l)</td>
<td>2.8</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Phosphate(mg/l)</td>
<td>1.6</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>MPN ( No: of coliforms/100 ml)</td>
<td>&lt;3</td>
<td>&lt;3</td>
<td>-</td>
</tr>
</tbody>
</table>

It was found out that 10% concentration was the optimum concentration (10 times dilution). The optimum days of digestion were 5 days. The ammonia nitrogen and phosphate removal efficiency is high for both the enzyme solutions.

The presence of more nitrifying bacteria will enhance the nitrification process. If nitrification is more, BOD removal efficiency will be low. Nitrification process is more significant at pH greater than 6. The acetate ion present in the enzyme solution is taken up by the phosphorous storing bacteria and is then converted to carbon storage products that provide energy. These bacteria are capable of storing excess amounts of phosphorous as polyphosphates in their cells. There will be
more cell growth if the acetate concentration is more. Hence the removal of phosphorous will be high. The concentrations of the enzyme solutions for parameters viz, BOD, COD, TDS and HPC were found reducing with time. This showed that the enzyme solutions had not stabilized. The Heterotrophic bacteria require organic compounds of carbon and nitrogen for their nourishment.

Table 7: Percentage Reduction of Various Parameters after Treatment with 5% and 10% Garbage Enzyme Solution after 5 Days

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5% Garbage enzyme</th>
<th>10% Garbage enzyme</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDS (mg/l)</td>
<td>18.29</td>
<td>39.22</td>
</tr>
<tr>
<td>BOD (mg/l)</td>
<td>57.29</td>
<td>69.38</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>21.38</td>
<td>50.47</td>
</tr>
<tr>
<td>Ammonia nitrogen  (mg/l)</td>
<td>70.83</td>
<td>100</td>
</tr>
<tr>
<td>Phosphate (mg/l)</td>
<td>98.55</td>
<td>100</td>
</tr>
<tr>
<td>MPN (No: of coliforms/100 ml)</td>
<td>&gt;99.9</td>
<td>71.43</td>
</tr>
</tbody>
</table>

The nutrient deficiency will hinder the growth of bacteria with time. High concentrations of bacterial population may hinder the recovery of coliforms. MPN value was less for the enzyme solution.

IV.  CONCLUSIONS

From the study, it was found out that garbage enzyme solution was not suitable for treating greywater immediately after filtration of the enzyme solution. The enzyme characteristics were varying with time. The enzyme solution was effective when the treatment was done 60 days after filtration of the enzyme solution. 100% removal of ammonia nitrogen and phosphates was possible using enzyme solution. Garbage enzyme solution (10%) was found more effective than other concentrations. The treatment time also reduced to 5 days.

The variation of enzyme characteristics with time should be monitored. Treatment of greywater using garbage enzyme solution is found to be effective only after reduction of BOD and COD values of the enzyme solution. Further studies are required to investigate suitable additives or activators on enzyme action. Studies on pre-treatment methods prior to enzyme action need to be explored for reduction of high initial BOD and COD. More importantly, characterization of the garbage enzyme to reveal its constituents is a critical step for any future studies.

REFERENCES

[5] A. H. Tan, ”A study into a viable wastewater treatment system for commercial site in Sarawak. BEng, Curtin University Sarawak Campus


