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 Enzme, 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 re-used. 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

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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 feasilbility of using Garbage Enzyme to treat greywater.

Garbage Enzyme is widely used in developing countries like Malaysia. It is being used in Malaysian cafeterias 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.

The mixing process was done in an air-tight plastic container which was able to expand.

During the first month, gases were released during fermentation process. Pressure built up in the container was released daily to avoid rupturing. Fruit/vegetable peels were pushed downward every once in a while. The container was placed in a cool, dry and well ventilated place. It was left to ferment for 3 months to produce enzyme. The fermentation yielded a brownish liquid, which was separated from the solids. The solution was filtered after 3 months to obtain enzyme solution. A white mould formation was observed on the top surface of the solution. These may be B complex Yeast and vitamin C Yeast. The obtained enzyme solution was of light brownish yellow coloured. It was then transferred to a plastic bottle. Enzymes will never expire. The longer you keep, the stronger it becomes. The power of the enzyme will be enhanced when water is added to it. Garbage Enzyme is only for external use. It should not be stored in a refrigerator.

The pure Garbage Enzyme solution was tested in the Central Institute of Fisheries Technology (CIFT) inorder to find out the protein content, a major constituent of enzymes. Synthetic greywater was used in the study. The composition of this waste is given in Table 1**.** The characteristics of synthetic greywater are shown in Table 2. The characteristics of pure Garbage Enzyme solution were analysed immediately after filtration of the enzyme solution (after 3 months of fermentation period). The parameters like pH, TDS, BOD_5, COD, Ammonia Nitrogen, Phosphate, MPN and HPC were analysed as per procedures in standard methods (APHA, 1971).

Batch test was carried out to determine the effect of 5%, 10%, 20% and 50% garbage enzyme solution in treating synthetic greywater. The beakers used were covered with aluminium foil and were left for digestion. The parameters like pH, TDS, BOD_5, COD, Ammonia Nitrogen, Phosphate, and MPN were analysed for the treated samples.

III. Results and Discussion

The characteristics of pure garbage enzyme solution after 3 months of fermentation period **(**immediately after filtration of the enzyme solution), 30 days after filtration and 60 days after filtration are shown in Table 3. The pH of garbage enzyme solution is acidic in nature. The BOD_5 and COD values were high when the enzyme solution was analysed immediately after filtration of the enzyme solution.

Table 1: Composition of Synthetic Greywater [9].

Compound	Concentration
Glucose (mg/l)	300
Sodium acetate trihydrate (mg/l)	400
Ammonium chloride (mg/l)	225
Disodium hydrogen phosphate (mg/l)	150
Potassium dihydrogen phosphate (mg/l)	75
Magnesium sulphate (mg/l)	50
Cow dung (ml/l)	225

Table 2: Characteristics of Synthetic Greywater .

Parameter	Unit	Value
pH	-	6.16
TDS	mg/l	563
BOD	mg/l	192
COD	mg/l	290
Ammonia Nitrogen	mg/l	9.6
Phosphate	mg/l	110
MPN	Total coliforms/100 ml	$11x10^4$

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, BOD5 COD, Ammonia nitrogen, Phosphates and MPN were analysed. The variations of phosphate, Ammonia nitrogen, COD, BOD5, TDS, 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.

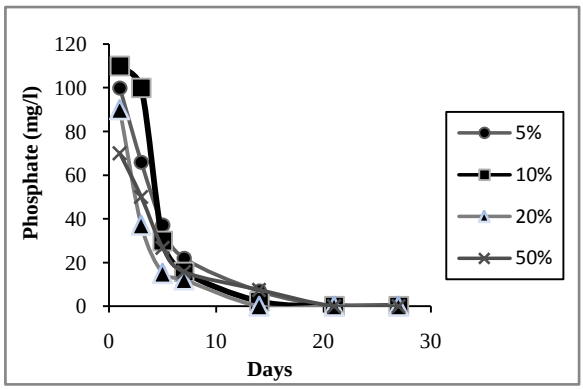

Figure 1: Variation of Phosphate Concentration with Time in Synthetic Greywater for Different Concentrations of Garbage Enzyme Solution

Table 3: Characteristics of Pure Garbage Enzyme Solution

Parameter	After immediate filtration	30 days after filtration	60 days after filtration
pH	2.91	3.01	3.8
TDS(mg/l)	2210	1480(31.9 %)	1120(52.79%)
BOD(mg/l)	1300	560(67.35 %)	92.6(91.09%
COD(mg/l)	48200	2620(94.2 9%)	186(99.52%)
Ammonia Nitrogen (mg/l)	BDL*	BDL*	BDL*
Phosphate(mg/l)	BDL*	BDL*	BDL*
MPN (No:of coliforms/ 100 ml)	<3	<3	<3
HPC(CFU/ml)	18000	8500(53.8 5%)	5000(70.77%)

*Below detectable limit

Values in paranthesis shows percentage reduction

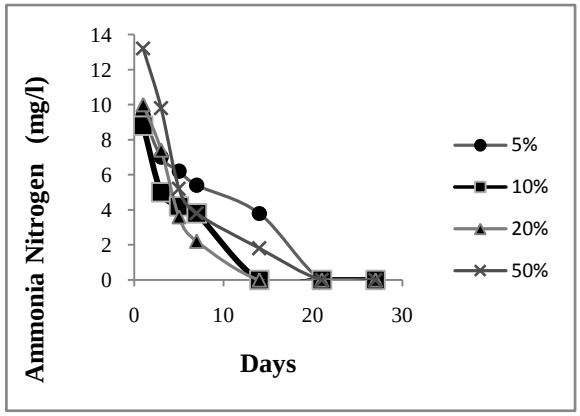

Figure 2: Variation of Ammonia Nitrogen Concentration with Time in Synthetic Greywater for Different Concentrations of Garbage Enzyme Solution

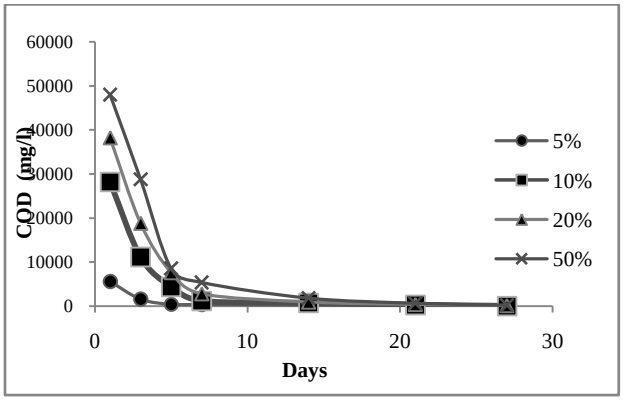

Figure 3: Variation of COD Concentration with Time in Synthetic Greywater for Different Concentrations of Garbage Enzyme Solution

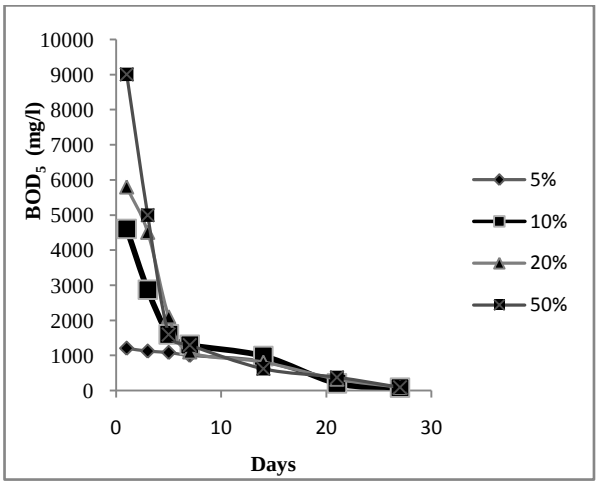

Figure 4: Variation of BOD5 Concentration with Time in Synthetic Greywater for Different Concentrations of Garbage Enzyme Solution

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.

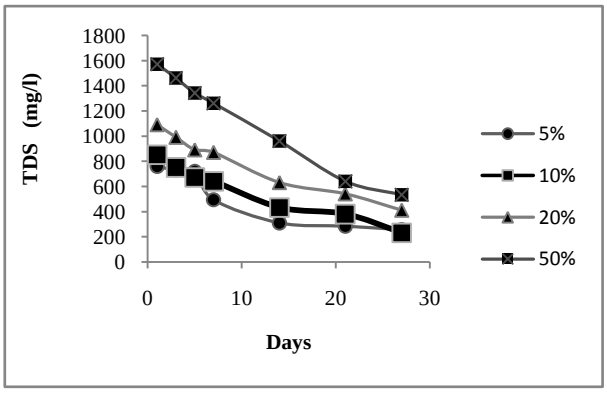

Figure 5: Variation Of TDS Concentration with Time in Synthetic Greywater for Different Concentrations of Garbage Enzyme Solution

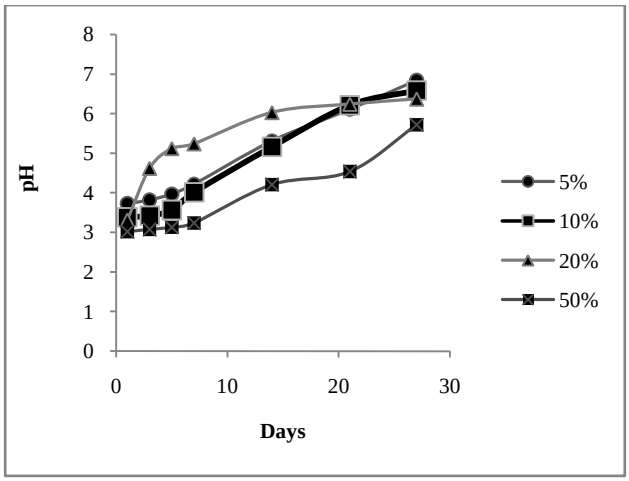

Figure 6: Variation of ph with Time in Synthetic Greywater for Different Concentrations of Garbage Enzyme Solution

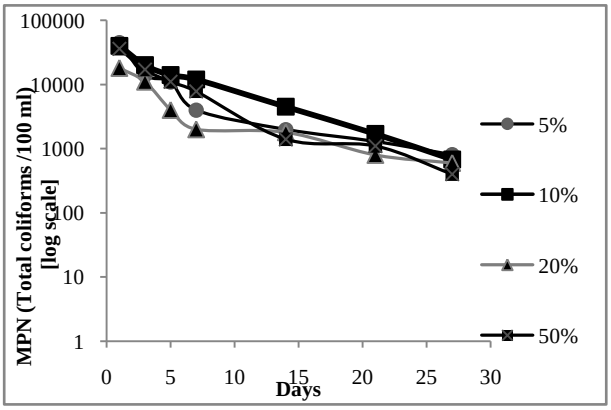

Figure 7: Variation of MPN with Time in Synthetic Greywater for Different Concentrations of Garbage Enzyme Solution

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 4: Effluent Characteristics after 27 days of Digestion

Parameter	**5%**	**10%**	**20%**	**50%**	**Irrigation standards E(P) rules**
pH	6.84	6.58	6.37	5.72	5.5 - 9
TDS(mg/l)	256	232	410	532	2100
BOD(mg/l)	74	68	91	96	100
COD(mg/l)	72	62	128	240	-
Ammonia Nitrogen (mg/l)	0	0	0	0	-
Phosphate	0	0	0	0	-

Parameter	5%	10%	20%	50%	Irrigation standards E(P) rules
(mg/l)					
MPN (No: of coliforms/ 100 ml)	8.1×10^2	6.8×10^2	6×10^2	4×10^2	-

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

Parameter	5%	10%	20%	50%
TDS(mg/l)	54.53	58.79	27.18	5.51
BOD_5(mg/l)	61.46	64.58	52.60	50.00
COD(mg/l)	75.17	78.62	55.86	17.24
Ammonia nitrogen(mg/l)	100.00	100.00	100.00	100.00
Phosphate(mg/l)	100.00	100.00	100.00	100.00
MPN (No: of coliforms/ 100 ml)	99.26	99.38	99.45	99.64

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, BOD_5 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 CO_2 & 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

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

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_5, 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

Parameter	5% Garbage enzyme	10% garbage enzyme
TDS(mg/l)	18.29	39.22
BOD_5(mg/l)	57.29	69.38
COD(mg/l)	21.38	50.47
Ammonia nitrogen(mg/l)	70.83	100
Phosphate(mg/l)	98.55	100
MPN (No: of coliforms/ 100 ml)	>99.9	71.43

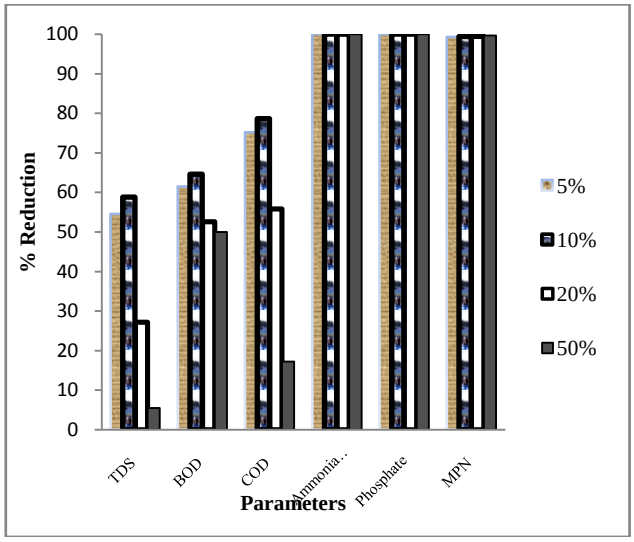

Figure 8: Shows The Percentage Reduction of Various Parameters after Treatment with Four Different Concentrations of Garbage Enzyme Solution after 27 Days.

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

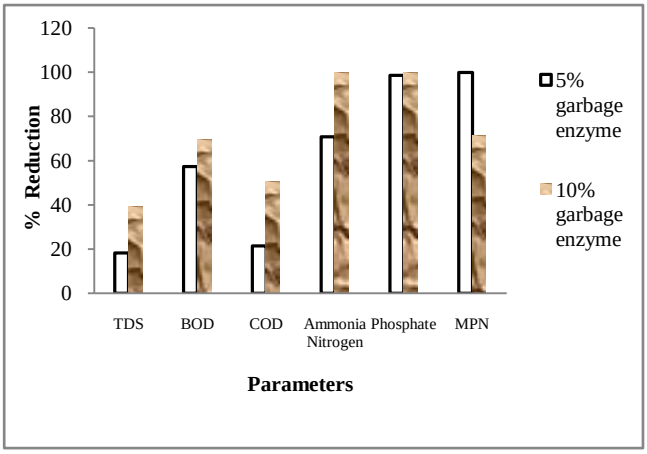

Figure 9: Shows the Percentage Reduction of Various Parameters after Treatment of Synthetic Greywater with 5% Garbage & 10% Garbage Enzyme Solution after 5 Days.

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

[1] M. Husain and Q. Husain , "Applications of redox mediators in the treatment of organic pollutants by using oxidoreductive enzymes, a Rreview", Critical reviews in Environmental Science and Technology,vol 38, No: 1.,pp 1-42, 2008.

[2] A. Idris and W.N.W Azmin,"The importance of sullage (greywater) Treatment in the Restoration and Conservation of Urban Streams', Ist International Conference on managing rivers in the 21 st century", Issues and challenges.,Rivers, pp. 363-369, 2004.

[3] World Health Organization, "Disposal of sullage and drainage' Fact Sheet on environmental Sanitation, No:3.10,2011

[4] E. Eriksson, K. Auffarth, M. Henze, and A. Ledin , "Characteristics of grey wastewater", Urban Water, vol 4, pp 85- 104, 2002

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

[6] K.B.B. Bakar,"Garbage enzyme as an alternative method in treatment of sullage", Master thesis, University Technology Malaysia, Malaysia, 2010.

[7] EPA, U. S. "The National Water Quality Inventory: Report to Congress for the 2002 Reporting Cycle– A Profile". Washington, DC.: United States Environmental Protection Agency (EPA)., 2002

[8] P.S. Anjaly, 'Enhancement of efficiency of treatment of greywater by downflow hanging sponge (DHS) biotower," M.Tech thesis, Government Engineering College, Thrissur, 2011.

[9] G.Ramon, M.Green, R. Semiat and, D. Dosoretz, "'Low strength greywater characterization abd treatment by direct membrane filtration", Desalination, vol 170, pp. 241-250,2004.

[10] E. Fu Tang, and W.Tong, "A study of the Garbage Enzyme's effects in domestic wastewater", World Academy of Science, Engineering and Technology,vol 60, pp 1143-1148, 2011.

[11] Cammarota M.C., and Freire D.M.G,"'A review on hydrolytic enzymes in the treatment of wastewater with high oil and grease content". Bioresource Technology, vol. 97, pp. 2195 – 2210, 2006.

[12] L. Masse., K.J.Kennedy and S.P. Chou, "The effect of an enzymatic pretreatment on the hydrolysis and size reduction of fat particles in slaughterhouse wastewater", Journal of Chemical Technology and Biotechnology, vol. 76, pp. 629 – 635, 2001.

[13] C.G. Whiteley and D.J. Lee, "Enzyme Technology and Biological Remediation' Enzyme and Microbial Technology, vol 38, pp. 291-316, 2006.

[14] EcoWalktheTalk, "How effective are Garbage Enzymes'', [Online], Available from HTTP:http:// www.ecowalkthetalk. com [6 Dec 2012].

[15] Ground up Initiative, A workshop on garbage enzyme, "Doing our bit for Planet earth" [Online], Available HTTP:http://www.groundupinitiative.org/GEflyer-web.pdf [11 Nov 2012].

[16] V.Voet, "Ways to Save Energ"', [Online], Available from HTTP: http:// www.waystosaveenergy.net [8 Nov 2012].