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Comparison of Treatment of Greywater Using Garbage and Citrus Enzymes

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ABSTRACT: Garbage enzyme is the fermentation product of fresh kitchen waste (fruit and vegetable peel), sugar (brown sugar, jaggery or molasses) and water. Citrus enzyme is the fermentation product of citrus fruit peels, sugar and water. Use of these enzymes is emerging as an effective method of treating greywater. A comparative study of both the enzyme solution was done 60 days after filtration of the enzyme solutions. Garbage enzyme solution (10%) was found more effective in treating synthetic greywater. Hence it can be reused for irrigation purposes.

KEYWORDS: Garbage enzyme; Citrus enzyme; Greywater; Fermentation

I. INTRODUCTION

Greywater is one of the major point pollution sources, which is discharged from residential and commercial areas into the rivers without any treatment [1].Greywater is all of the wastewater from plumbing fixtures except the toilet. Usually waste from the kitchen sink is connected to the septic tank as the high levels of fats, organic matter, suspended solids and microorganisms require treatment before discharge into an absorption trench (or other treatment system). This contains high levels of microorganisms that make it unsuitable for spray irrigation. Hair and lint in greywater can clog up the soil and cause absorption trenches to fail. 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 [2].

The characteristics of greywater depend firstly on the quality of the water supply, secondly on the type of distribution network for both drinking water and the greywater and thirdly on the activities in the household. There could be chemical and biological degradation of the chemical compounds, within the transportation network and during storage [3].

In an era of dwindling water resources, the treatment and reuse of wastewater is rapidly becoming a subject of great interest to researchers. Agricultural water represents the lion's share of global water use, and wastewater reuse is an attractive alternative with good potential to supplement freshwater supplies. Irrigation is often the preferred end-use for reclaimed wastewater because it is produced or treated in proximity to agricultural areas and contains valuable nutrients required for plant growth.

However, wastewater can also contain dangerous elements that could negatively impact environmental and public health. Reuse of untreated wastewater in agriculture is a reality in much of the world, especially in areas where poverty restricts farmers' access to freshwater and fertilizer supplies. In order to minimize potential negative impacts, it is strongly recommended that greywater be treated before reuse. 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.

Enzymes are protein molecules that catalyse chemical reaction. They act as biological catalysts and catalyse only specific molecules (substrates). Enzymes are selective for their substrates and catalyse 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 [4].

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 [5].

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. It is dark brown and has a strong sweet sour fermented scent. Citrus enzyme is produced by the fermentation of fresh citrus peels, brown sugar and water. Garbage/citrus enzyme is a multipurpose liquid and its applications covers household, agriculture, animal husbandry, etc. It is a complex organic substance of protein chains and mineral salts and juvenile hormones. The functions of Garbage/citrus Enzyme is to resolve (decompose), transform (change), and catalyse the reactions [6].

Garbage/citrus enzyme is different from fruit enzyme and is not for human consumption. It is a nutritious drink prepared through proper fermentation of fruits. Garbage/citrus enzyme is used as a natural household cleaner; air purifier; deodorizer; insecticide; detergent; body care; car care; organic fertilizer, etc. It removes odour and dissolve toxic air released from smoking, car exhaust, chemical resides from household products, etc. Enzyme that flow underground will eventually purify the river and the sea. It reduces mosquitoes, flies, rats, cockroaches etc. It is natural antiseptic for your home. It prevents drainpipe blockages [7].

The process of garbage enzyme production is a natural fermentation/anaerobic oxidation whose products are alcohol (incomplete/partial fermentation) and acetic acid (complete fermentation). These are enzymatically performed by natural and mixed microbial cultures in the starting preparation (fruit dregs and vegetable trimmings). The acidic condition and the fermentation process may allow enzymes to be extracted from the waste materials into the solution. Likewise extreme environments would destroy most microbes so acetic acid like any other corrosive acid would kill some bugs on contact and if used carefully might be usable as a pesticide/insecticide.

The high acetic acid concentration and low pH could be the main reasons for the many purposes of garbage enzyme, viz. cleaning, odour removal, preventing drain blockages, etc. Garbage/citrus enzyme also contains traces of ethanol and propionic acid. Ethanol is known to have antiseptic properties, while propionic acid is used in food preservation. These substances allow garbage enzyme to act as an anti-microbial agent, insecticide and pesticide. When diluted, it could provide nutrients to plants due to the “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. Fruit and vegetable wastes are generated in huge amounts from both households and commercial/industrial sectors, and large-scale garbage enzyme production would help to put these wastes into better uses. The highlight of garbage/citrus enzyme is that it is organic and can be homemade at low costs, as compared to other products that contain synthetic chemicals (may be toxic to human health or environment) and consume high energy in their production[8].

Garbage/citrus 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. 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.

Garbage/citrus enzyme may be used effectively in the treatment of greywater. Many studies have been conducted in Malaysian universities regarding garbage enzyme. It is widely used in Malaysian houses also. The use of garbage enzyme in India has not been popularized and its use in Indian homes has yet to be practiced. The study focuses on the comparative study of garbage and citrus enzymes in treating synthetic greywater.

II. MATERIALS AND METHODS

Jaggery, fruit/vegetable peels and water were mixed together in the ratio of 1:3:10 to prepare garbage enzyme. To prepare citrus enzyme, jaggery, citrus fruit peels and water were mixed in the ratio of 1:3:10. The mixing process was done in two air-tight plastic containers which were able to expand [6].

During the first month, gases were released during fermentation process. Pressure built up in the containers was released daily to avoid rupturing. Fruit/vegetable peels were pushed downward every once in a while. The two containers were placed in a cool, dry and well ventilated place. They were left to ferment for 3 months to produce enzyme. The fermentation yielded a brownish liquid, which was separated from the solids. The two solutions were filtered after 3 months to obtain enzyme solution. A white mould formation was observed on the top surface of the solutions. These may be B complex Yeast and vitamin C Yeast. The obtained enzyme solutions were of light brownish yellow coloured. These were transferred to plastic bottles. 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. Garbage/citrus enzyme is at its best after 6 months of fermentation [9]. It should not be stored in a refrigerator.

The filtered garbage and citrus enzyme solutions were tested for parameters like pH, TDS, BOD, COD, Ammonia Nitrogen, Phosphate, MPN and HPC. The characteristics of pure garbage and citrus enzyme solutions were analysed after filtration. A comparative study of the enzymes was done 60 days after filtration.

The pure garbage and citrus enzyme solutions were tested in the Central Institute of fisheries technology (CIFT) in order to find out the protein content, a major constituent of enzymes. Synthetic greywater was used in the study. The characteristics of synthetic greywater used in the study are shown in table 1.

Table 1. 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	CFU/100 ml	$11x10^4$

The characteristics of pure garbage and citrus enzyme solutions were analysed after 60 days of filtration. 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 tests were carried out to determine the effective dosage of both garbage and citrus enzyme for treatment. In the study, 5% (20 times dilution) and 10% (10 times dilution) of garbage and citrus enzyme with wastewater were selected. Four beakers were filled by the respective dilutions of garbage and citrus enzyme solution. These beakers 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 all the samples as per procedures in standard methods (APHA, 1971).

III. RESULTS AND DISCUSSION

The characteristics of pure garbage and citrus enzyme (after 3 months fermentation + 60 days after filtration) are shown in table 2.

Table 2. Characteristics of garbage and citrus enzyme solutions

Parameter	Garbage enzyme	Citrus enzyme
pH	3.8	3.91
TDS(mg/l)	1120	930
BOD(mg/l)	92.6	87.3
COD(mg/l)	186	158
Ammonia Nitrogen (mg/l)	BDL*	BDL*
Phosphate (mg/l)	BDL*	BDL*
MPN (Total coliforms/ 100 ml)	<3	<3
HPC(CFU/ml)	5000	3800

BDL –below detectable limit*

III.A Effluent characteristics after treatment of synthetic greywater using 5% garbage and 5% citrus enzyme solutions

The synthetic greywater is treated using 5% garbage and 5% citrus enzyme solutions, 60 days after filtration of the enzyme solution. The parameters like pH, TDS, BOD_5, COD, Ammonia nitrogen, Phosphates and MPN were analysed. The effluent characteristics after treatment of synthetic greywater using 5% garbage enzyme solution and 5% citrus enzyme solution are shown in table 3and 4 respectively.

Table 3. Effluent Characteristics after treatment of synthetic greywater using 5% Garbage Enzyme solution

Parameter	1 Day	3 Days	5 Days	Irrigation standards E(P) rules
pH	4.26	6.45	6.92	5.5 - 9
TDS(mg/l)	632	550	460	2100
BOD(mg/l)	163.2	120	82	100
COD(mg/l)	386	310	228	-
Ammonia Nitrogen (mg/l)	4.6	3.2	2.8	-
Phosphate(mg/l)	3.4	2.7	1.6	-
MPN (Total coliforms/ 100 ml)	$4.5x10^4$	$3.6 x10^4$	<3	-

The pH values were increased from 4.26 to 6.92 after 5 days of digestion period. The TDS values were gradually reduced to 460 mg/l. The BOD values were decreased to 120 mg/l after 3 rd day and 82 mg/l after 5th day. The COD values were reduced to 228 mg/l after 5th day. Ammonia nitrogen and Phosphate values were 2.8 mg/l and 1.6 mg/l respectively after 5 days of digestion period.

Table 4. Effluent Characteristics after treatment of synthetic greywater using 5% citrus enzyme solution

Parameter	1 Day	3 Days	5 Days	Irrigation standards E(P) rules
pH	4.22	5.84	6.34	5.5 - 9
TDS(mg/l)	640	564	480	2100
BOD_5(mg/l)	190.7	130.2	96	100
COD(mg/l)	420	362	240	-
Ammonia Nitrogen (mg/l)	4.2	3.6	2.2	-
Phosphate(mg/l)	2.8	1.6	1.4	-
MPN (Total coliforms/ 100 ml)	$4x10^4$	$2 x10^4$	<3	-

The pH values were increased from 4.22 to 6.34 after 5 days of digestion period. The TDS values were gradually reduced to 480 mg/l. The BOD values were decreased to 130.2 mg/l after 3 rd day and 96 mg/l after 5th day. The COD values were reduced to 240 mg/l after 5th day. Ammonia nitrogen and Phosphate values were reduced to 2.2 and 1.4 `mg/l after 5 days of digestion period. The Figure 1 shows the percentage reduction of various parameters after treatment with 5% garbage and 5% citrus enzyme solution after 5 days of digestion period.

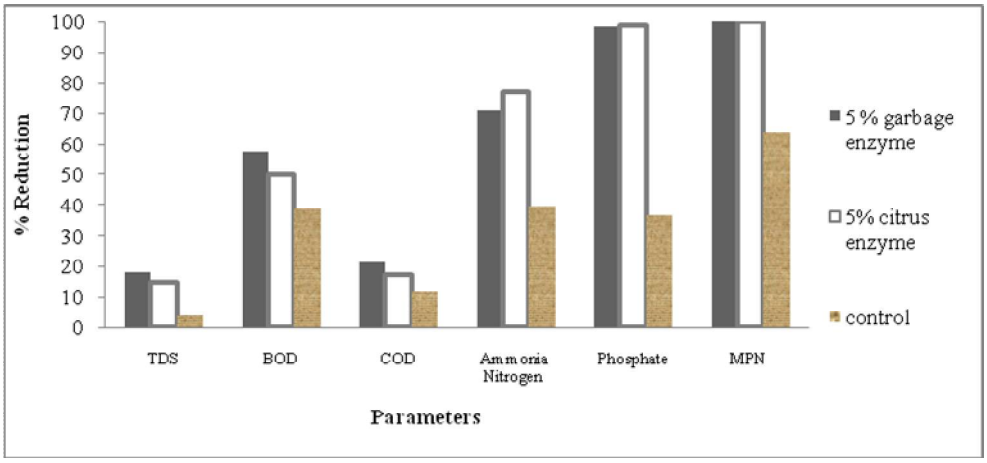

Fig. 1.Percentage Reduction of various parameters after treatment of synthetic greywater with 5% garbage & 5% citrus enzyme solution after 5 days.

The synthetic greywater when treated with garbage enzyme solution (5%) showed more % reduction for parameters TDS (18.29%), BOD_5 (57.29%) and COD (21.38%) when compared to the treatment with citrus enzyme solution (5%). Percentage removal using citrus enzyme solution (5%) was higher for ammonia nitrogen (77.08%) and Phosphates (98.73%). Both showed >99.9% removal for MPN.

III.B **Effluent characteristics after treatment of synthetic greywater using 10% garbage and 10% citrus enzyme solutions**

Similarly the synthetic greywater is treated using 10% garbage and 10% citrus enzyme solutions. The parameters like pH, TDS, BOD COD, Ammonia nitrogen, Phosphates and MPN were also analysed. The effluent characteristics after treatment with 10% garbage and 10% citrus enzyme solution after 5 days of digestion are shown in table 5 and 6 respectively.

Table 5. Effluent characteristics after treatment of synthetic greywater using 10% garbage enzyme solution

Parameter	1 Day	3 Days	5 Days	Irrigation standards E(P) rules
pH	4.12	6.28	6.84	5.5 - 9
TDS(mg/l)	650	540	430	2100
BOD(mg/l)	182.6	110	70.5	100
COD(mg/l)	410	380	216	-
Ammonia Nitrogen (mg/l)	3.6	1.2	0	-
Phosphate(mg/l)	2.2	1.4	0	-
MPN (No:of coliforms/ 100 ml)	$4x10^4$	$3.6 x10^4$	<3	-

Table 6. Effluent characteristics after treatment of synthetic greywater using 10% citrus enzyme solution

Parameter	1 Day	3 Days	5 Days	Irrigation standards E(P) rules
pH	4.01	5.97	6.19	5.5 - 9
TDS(mg/l)	680	570	460	2100
BOD(mg/l)	202.0	114.3	82.7	100
COD(mg/l)	486	390	236	-
Ammonia Nitrogen (mg/l)	3.8	2.1	0	-
Phosphate(mg/l)	2.7	1.2	0	-
MPN (Total coliforms/ 100 ml)	$3.6 x10^4$	$1.8 x10^4$	<3	-

The pH values were increased from 4.12 to 6.84 after 5 days of digestion period. The TDS values were gradually reduced to 430 mg/l. The BOD values were decreased to 110 mg/l after 3 rd day and 70.5 mg/l after 5th day. The COD values were reduced to 216 mg/l after 5th day. Ammonia nitrogen and Phosphate values were reduced to zero after 5 days of digestion period (While using10% garbage enzyme solution).

The pH values were increased from 4.01 to 6.19 after 5 days of digestion period. The TDS values were reduced to 460 mg/l. The BOD values were decreased to 1114.3 mg/l after 3 rd day and 82.7 mg/l after 5th day. The COD values were reduced to 236 mg/l after 5th day. Ammonia nitrogen and Phosphate values were reduced to zero after 5 days of digestion period. The Figure 2 shows the percentage reduction of various parameters after treatment with 10% garbage and 10% citrus enzyme solution after 5 days of digestion period (While using 10% citrus enzyme solution).

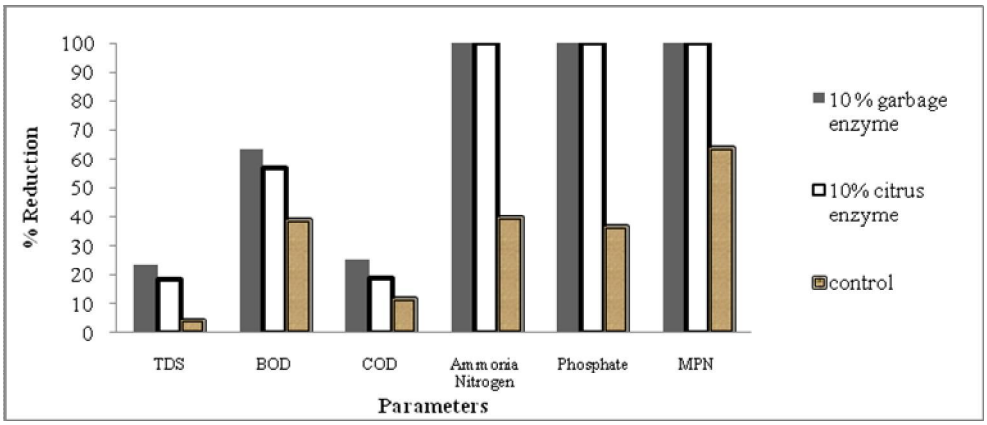

Fig. 2.Percentage reduction of various parameters after treatment of synthetic greywater with 10% garbage & 10% citrus enzyme solution after 5 days.

The synthetic greywater when treated with garbage enzyme solution 10% showed more percentage reduction for TDS (23.63%), BOD_5 (63.28%) and COD (25.52%) when compared to citrus enzyme solution (10%). 100% removal of ammonia nitrogen and Phosphates was observed when treated with both 10% garbage and 10% citrus enzymes solution. The MPN value was >99.9% for both garbage and citrus enzyme solutions.

pH of pure garbage and citrus enzymes is acidic in nature. When both enzymes are mixed with synthetic greywater, the pH increased to nearly neutral range. Low pH suppresses the activity of the enzymes. Therefore low concentrations of 5% and 10% were selected for the treating synthetic greywater. The effective concentration was 10%. It was found that 10% garbage enzyme has more potential results compared to 10% citrus enzyme solution. 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 analysis of garbage and citrus enzyme solution for protein content revealed a concentration of 40 mg/l and 60 mg/l respectively. Therefore it is clear that the treatment is due to enzyme action.

The percentage reduction of various parameters of enzyme solution was higher after 60 days of filtration. The enzyme activity of both garbage and citrus enzymes was enhanced with time. When the treatment was done immediately after filtration of the enzyme solutions, the treatment days for meeting irrigation standards were found more (27 days). The digestion days can be reduced by increasing the time of fermentation period. Both the enzymes were effective when the treatment was done 60 days after filtration of the enzyme solutions. The effluent characteristics met the irrigation standards after 5 days. The treatment of greywater using enzymes is economical only when the time of digestion is less. Further studies are required to reduce the digestion days so that enzymes can be used effectively.

IV. CONCLUSION

From the study, the garbage/citrus enzyme produced was found to be acidic, and contained a large amount of organic material which resulted in high initial BOD. The results indicate that the 10% garbage and 10% citrus enzyme solution may effectively remove ammonia nitrogen and phosphate in greywater. Garbage/citrus enzyme is cheap and cost effective. Hence they can be utilized as a low-cost alternative for the treatment of greywater in Indian conditions. 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. The effect of enzymes in treating other wastewaters can also be studied. More importantly, characterization of the garbage enzyme to reveal its constituents is a critical step for any future studies.

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