Fat, Oil and Grease (FOG) Removal by Using Enhanced Lipase Enzymatic Culture (ELEC)

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Summary
Timcare Biotech Sdn Bhd has appointed Dr. Ng Chee Guan to assess the Fat, Oil and Grease (FOG) removal by using Enhanced Lipase Enzymatic Culture (ELEC) . The objective of the present study is to assess the FOG removal for a restaurant's grease trap (GT) waste water by using different dosage of ELEC. From the present study, application of ELEC in waste water treatment in GT resulted in up to 92.8% FOG removal within 4 days.The average FOG removal efficiency can be estimated based on the average values as 2.02g FOG removed/g ELEC. FOG removal by using ELEC produced faster result as compared to other methods such as composting, anaerobic digestion and chemical treatment. The samples treated with ELEC also showed rapid reduction in unpleasant odour. Result from the present study is in agreement with previous research done by Dong, Y (2015) from Michigan State University showing that pretreatment of restaurant wastewater using an in-situ enzyme would prevent the clogging and premature drain field aging. In a nutshell, application of ELEC in GT's FOG removal is preferable due to its high efficiency, lower carbon footprint, lower environmental impact as well as its user-friendliness.

Introduction

Fats, oils, and grease (FOG) are the by-products of cooking. Typically, FOG includes matter such as food scraps, meat fats, lard, tallow, cooking oil, butter, margarine, sauces, gravy, dressings, deep-fried food, baked goods, cheeses, and butter. FOG can be solid or a viscous liquid depending on the saturation of the carbon chain. Oils and fats are a subsection of lipids that are composed of fatty acids, triacylglycerols, and lipid-soluble hydrocarbons that are minor but important components of FOG.

FOG blockage is a worldwide concern. For example, the American Environmental Agency (EPA) estimated that at least 10,350–36,000 sanitary sewer overflows (SSOs) occur per year in the USA, approximately 47% of which is related to FOG. Similarly, in the UK over 25,000 flooding incidents per year are due to sewer blockages, of which, 50% is due to FOG. Moreover, up to 70% of the SSOs that occur in Malaysia are due to FOG. In 2010 only, the waste water company in Malaysia, Indah Water Konsortium (IWK), received a total of 22,184 blockage enquiries.Continuous build-up of FOG decreases the capacity of the sewer system as the FOG solidifies and deposits on the interior walls of the sewer, causing blockage of pipes and hence restricting the waste water flow. Over time, sewers blocked by FOG will fail, leading to the overflow of sewage from manholes; this sewage may eventually make its way to state water sources as a contaminant. The blockages and sewer flooding may result in other environmental problems, both locally and beyond the premises.

Problem Statement

FOG is usually produced at food service establishments, residences, and slaughterhouses. FOG components are introduced into the sewer system either by direct dumping into the sewer or by escape from grease traps (GTs) that are usually installed in restaurants. The GTs (interceptors) are designed to trap most of the FOG in the restaurant effluent and separate it from the sewage before reaching the sewer pipe. However, the efficiency of the GT depends strongly on the frequency of its maintenance. Moreover, if a dish washer or high-temperature water is used for dish washing, FOG may melt and emulsify within the waste water phase and thus escape the GT. Upon subsequent flow into the sewer pipe, FOG may solidify and form particles that deposit on the surface of the pipe, thus obstructing the waste water flow. Stoll and Gupta found that the concentration of FOG in waste water from Asian restaurants in Thailand ranged from 730 to 1100 mg/L. This high quantity of FOG arises from fast-food restaurant effluent. The menu of these restaurants consists mainly of fried chicken, seafood, French fries, and salad

dressing that contain a large amount of FOG.

Currently, there is only one method to control FOG at the source of generation. This method involves installing a grease interceptor (GI) that separates the FOG from the restaurants' sullage reducing, its concentration in the effluent. Recent efforts have been made to enforce good management practices at restaurants and food service establishments to ensure the right disposal of residual FOG. Moreover, certain companies have agreements with restaurants to collect used cooking oil and use it to produce biodiesel. As a solution to blockage of sewer pipes, wastewater municipalities utilize high-pressure water jets to clear FOG deposits from sewer pipes, whereas FOG in manholes is collected manually using a shovel and armed net. The collected FOG deposits are disposed as solid waste at landfill. This raises additional environmental concerns because the hydroconductivity of soil is highly reduced by FOG. Moreover, biological oxidation of high concentrations of FOG undesirably releases carbon dioxide and methane into the atmosphere.

Objective

The in-situ biological treatment of waste water from restaurants is needed to reduce the FOG content in GTs. As such, Timcare Biotech Sdn Bhd has worked with University of Malaya to assess the FOG removal by using Enhanced Lipase Enzymatic Culture (ELEC) . The objective of the study is to study the FOG removal for restaurants' GT waste water by using alternative dosage of ELEC.

Method

The FOG content was analyzed by using EPA method 1664. EPA method 1664 uses n-hexane as the extraction solvent for Oil and Grease and other extractable material that is not adsorbed by silica gel in surface and saline waters, and industrial and domestic aqueous waste. N-hexane extracts non-volatile hydrocarbons, vegetable oils, animal fats, waxes, soaps, greases, and related materials. The Oil and Grease in the collected sample is extracted using n-hexane. The sample is transferred to a separatory funnel, receives 30 mL of n-hexane, mixed vigorously, and allowed to settle to let the organic and aqueous phases separate. The lower layer (aqueous layer) is drained into the original sample container, and the hexane layer remains in the separatory funnel. The hexane extract is drained through a funnel containing anhydrous sodium sulfate to remove any excess water from the extract and is collected in a pre-weighed container (flask or pan) to evaporate the hexane. The original sample goes through the process two more times to remove all Oil and Grease compounds for the analysis. Once the three extract portions are collected, the solvent is evaporated and the pre-weighed container is weighed to constant weight. The difference in mass is the amount of Oil and Grease in the collected sample.

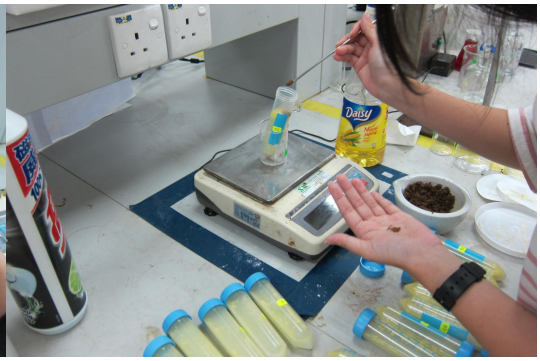
In order to check the FOG removal efficiency of ELEC, samples with alternative dosage of ELEC were prepared and FOG contents were tested on Day 1 and Day 4 after mixing ELEC with water sample taken from a GT from a restaurant in Petaling Jaya.

Samples were prepared as below:

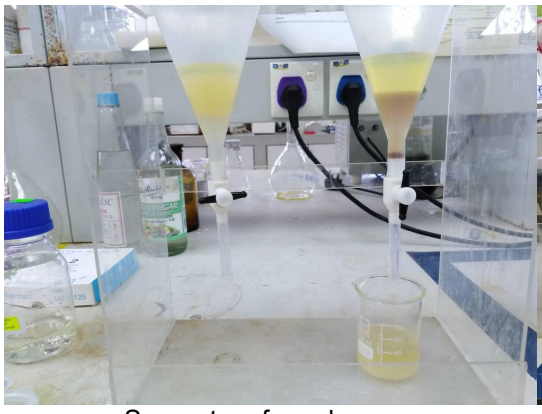
Table: Sample Preparation and Labeling

Lable	Sample
O	Blank sample with 35ml of wastewater sample
A	35ml wastewater sample + 0.003g of ELEC
B	35ml wastewater sample + 0.006g of ELEC
C	35ml wastewater sample + 0.03g of ELEC
D	35ml wastewater sample + 0.06g of ELEC
E	35ml wastewater sample + 0.12g of ELEC

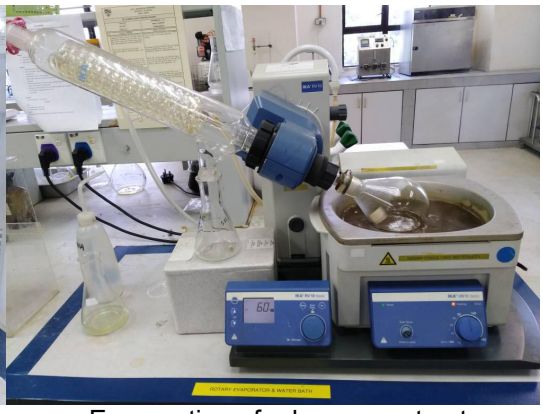
Samples preparation



mixing ELEC with sample



Separatory funnel



Evaporation of n-hexane extracts

Results

FOG analysis was carried out upon all samples in Day 0, Day 1 and Day 4. The FOG analysis was tabulated as below:

Table: FOG Removal by using ELEC

Sample	*FOG (%) Day 0*	*FOG (%) Day 1*	*FOG (%) Day 4*	*Total FOG removal (%) in 4 days*	*FOG Removal efficiency (g FOG removed /g ELEC)*
Blank	75	-	-	-	-
A	75	46.8	28.1	62.5	5.71
B	75	41.4	23.3	68.9	3.15
C	75	26.7	18.7	75.1	0.68
D	75	-	11.8	84.3	0.38
E	75	-	0.54	92.8	0.21

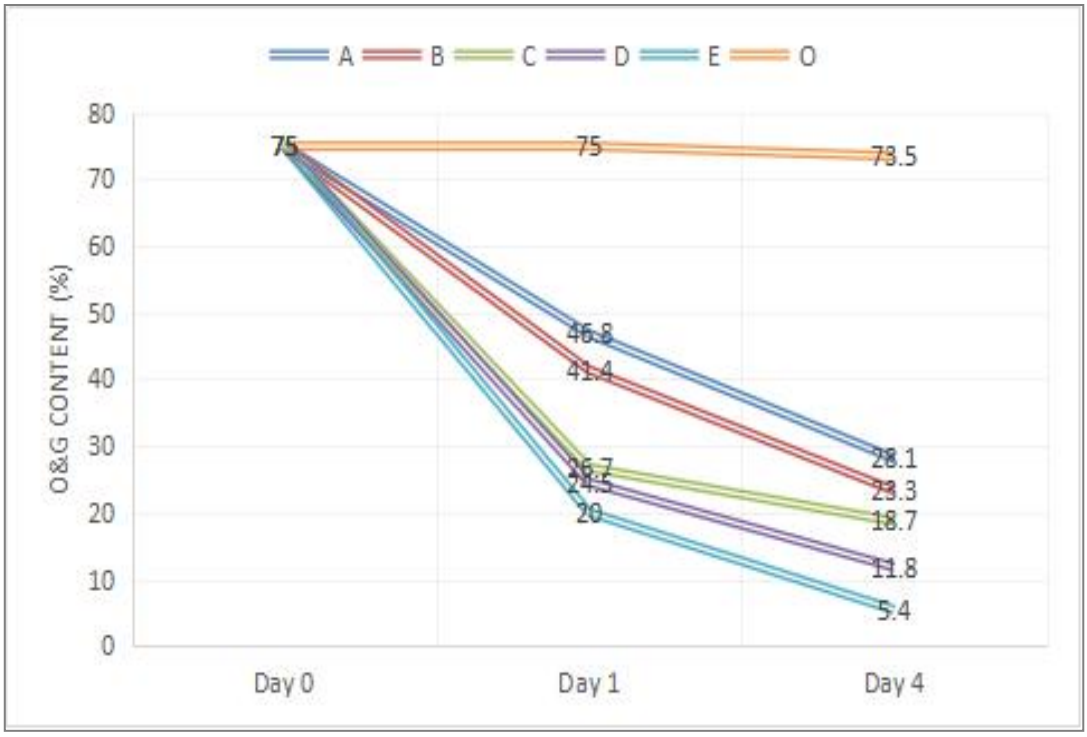


Figure: FOG Removal over Time

Discussions

Application of ELEC in waste water in GT resulted in up to 92.8% FOG removal within 4 days. This result is in agreement with previous studies by other researchers where the biological treatment of FOG-rich waste water using a mixed bacterial activated sludge resulted in ＞90% removal efficiency. In another study, lipase-producing microorganisms were isolated from the bakery and palm-oil-industry waste water.The bio-degradation of FOG in the isolates was tested, and up to 87.7% FOG removal was achieved.

FOG removal by using ELEC is more preferable as compared to composting in terms of shorter of time required to achieve higher FOG removal. Lemus and Lau reported a series of preliminary experiments for evaluating the biodegradability of organic wastes loaded with FOG by composting. The lipid content was reduced by 70% over a processing period of 10 days. Moreover, the volatile solid content was reduced by 20%. Moreover, instantaneous FOG digestion by using ELEC is more environmental-friendly as the process consumes less energy and resources as compared to other method such as composting, anaerobic digestion and chemical treatment of FOG.

However, results showed that the FOG removal efficiency decreases with ELEC dosage mainly due to other limiting factors such as microbial activities limitation and FOG concentration variations. Nevertheless, the average FOG removal efficiency can be estimated based on the average values as 2.02g FOG removed/g ELEC.

The smell of sample treated with ELEC also showed much reduction in bad odour. FOG tends to stick to the surface of drain and sewer pipes causing clogging that restricts the flow of sewage and may lead to sanitary sewer overflow (SSOs). SSOs cause unpleasant odors and insect and rat infestation, and the sewage may make its way into water sources causing ground and surface water pollution. They are very unpleasant and require quick action from the municipalities to clear the deposition to allay public concerns. Moreover, FOG deposition can cause corrosion of sewer lines under anaerobic conditions, thus reducing the lifetime of the pipe and demanding earlier repair and replacement of the pipe.

On the other hand, the biological treatment of waste water with a high concentration of FOG suspended on the surface may be hindered by sticking of FOG to the pipes and clogging of the strainer and filter, thus affecting the treatment unit operations. At the last stage of the waste water treatment

process, FOG is deposited in the sludge making it viscous and waxy, and thus reducing the sludge-dewatering efficiency.

It is important to note that ELEC helps to impact the characteristics of triglycerides (composition of fat) by breaking down the long chain fatty acid into short-chained Free Fatty Acids (FFA) and reducing the number of double bonds. However, the Free Fatty Acid (FFA) analysis is beyond the scope of the present study.

The unsaturated FFA is therefore soluble in water and are ready to be decomposed by bacteria in water and converted into carbon dioxide through microbial activity (with the presence of oxygen). Alternatively, the FFA can also be easily reduced via chemical processes (eg. acid-hydrolysis or acid-catalysed esterification) to turn FFA into ester with sweet smell.

Result from the present study is in agreement with previous research done by Dong, Y (2015) from Michigan State University, showing that pretreatment of restaurant wastewater using an in-situ enzyme would prevent the clogging and premature drain field aging.

Conclusion

From present study, application of ELEC in waste water sample in GT resulted in up to 92.8% FOG removal within 4 days.The average FOG removal efficiency can be estimated based on the average values as 2.02g FOG removed/g ELEC. FOG removal by using ELEC produced faster result as compared to other methods such as composting, anaerobic digestion and chemical treatment. In a nutshell, application of ELEC in GT's FOG removal is more preferable due to its lower carbon footprint and environmental friendliness.

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