Performance Evaluation of Waste Water Treatment Plant: an analysis of FOG removal efficiency.

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Abstract— The present study has been under taken to evaluate the efficiency of a waste water treatment plant. In this case study, a small scale waste water treatment plant that used to treat the waste water from vehicle service station has been considered. The primary function of the waste water treatment plant is to treat the fat, oil and grease (FOG) and the system described in this study enables operators to meet the treatment goals and guarantees that the quality of the discharge in the receiving environment is compatible with standard regulatory requirements. Waste water samples were collected at different times of disposal and analysed for the major water quality parameters, such as Fats, oil and grease (FOG), biological oxygen demand (BOD), pH, turbidity and dissolved oxygen (DO). Overall performance of the treatment plant has been estimated. The obtained results were very much useful in identification of present status of treatment quality and rectification of operational and maintenance problems as well as the future expansion to be carried out in the plant to meet the increased loadings.

Index Terms— Waste water treatment plant, FOG, Fats, Oil, Grease, removal efficiency, Biological Oxygen Demand, Dissolved Oxygen.

1 INTRODUCTION

Wastewater is essentially the water supply of the community after it has been fouled by a variety of uses [1]. The water supplied to a community receives a range of chemical substances, FOG (fats, oil, and grease) and microbial flora during its use such that the wastewater acquires a polluting potential and becomes a health and environmental hazard. Communicable diseases of the intestinal tract such as cholera, typhoid, dysenteries and water borne diseases like infectious hepatitis etc., can be spread from uncontrolled disposal of waste water, and therefore prevention of communicable diseases and protecting public health attracts the primary objective of safe waste water disposal [1], [2].

Water resources are being overexploited and their use is being reduced due to bad quality problems caused by discharges of contaminated water and runoff and thus, water scarcity became one of the vital issue in every continent of the world [3]. One activity that has a high environmental relevance is the extraction and processing of crude oil as most of the yearly environmental emergencies that affect water and soil are directly related to it [4]. The different procedures needed for oil extraction and processing require a great amount of water and, as a consequence, a big volume of wastewater is generated. Wastewater coming from refineries is normally composed of fats, oil, grease and many other toxic organic compounds that can be very harmful to the environment [5].

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According to the Water Environment Federation's Pretreatment of Industrial Wastes, Manual of Practice FD-3, "Grease is a general classification for grouping such materials as fats, oils, waxes, and soaps according to their effect on wastewater collection and treatment systems or their physical (semisolid) forms." For the purpose of this document, the acronym "FOG" is used as a general term for fats, oil, and grease.

Now-a-days amount of FOG discharge is increasing day by day in many urban cities and that pollutes the environment as well as water sources severely [6], [7]. The concentration of dispersed FOG is an important parameter for water quality and safety. FOG in water can cause surface films and shoreline deposits leading to environmental degradation, and can induce human health risks when discharged in surface or ground waters. Additionally, FOG may interfere with aerobic and anaerobic biological processes and lead to decreased wastewater treatment efficiency [8]. The presence of oil and grease in the treated water discharged into water bodies is detrimental for the aquatic life as a layer of oil is formed in the water surface that decreases the penetration of light and consequently reduces photosynthetic activity and oxygen production. Also, this layer decreases the dissolution of oxygen from the atmosphere into the water affecting the amount of dissolved oxygen present and impacting the amount of species that can survive under those conditions. Furthermore, environmental health is affected as several of the compounds that are found in oil contaminated water are detrimental for life, mutagenic and carcinogenic [7].

In the past decade, the main focus has been on control of industrial waste discharges and discharges from service stations. With the state pretreatment program at maturity, time and resources can now be directed toward addressing this type of waste. By minimizing the contribution of oil and

grease to the collection system, the risk of sewer line blockages and sewage backing up into service laterals can be reduced up to 50% by some estimates [9]. Regulatory bodies worldwide set limits in order to control the amount of FOG entering natural bodies of water or reservoirs through industrial discharges, and also to limit the amount present in drinking water [8].

It is very important that water of good quality is discharged into the water bodies and treated wastewater is reused in order to preserve the natural resource. Therefore, it is highly suggested to have individual scale treatment system at each and every discharging unit of fats, oil and grease. However, most of the industrial units, service stations, restaurants and industrial units are being incorporated with the individual treatment systems, to date there are very limited number of FOG treatment plants meet the requirement for the sfety disposal level of treatment [10], [11]. As such, it's ighly essential to analyse the performance of the treatment system in order to make necessary improvements and modification for the efficiency improvements.

Therefore, this research study primarily focuses on analyzing the performance of a process wastewater treatment plant that primarily used to treat the FOG, incorporated with the heavy vehicle service station.

2 CASE STUDY

2.1 Introduction

A vehicle service station waste water plant that is primarily used to remove the FOG (fats, oil and grease) has been adopted for the research study. The vehicle service station is located in central part of Katugastota city, Sri Lanka. An average of 20 number of light vehicles and 5 number of heavy vehicles have been found to be incorporated for cleaning and conditioning in a usual day. Average waste water inflow has been found to be 15-20 MLD.

2.2 Treatment Units

The waste water collected at the vehicle service station can be expected to consist of fats, oil, grease, soap, scum and silt. Therefore, it has been sent through many treatment units in order to treat different type as well as different level of wastes. All the units are shown as a flow diagram in Fig. 1. and descriptions are briefly as follows.

2.2.1 Drainage

All the water that used to wash and condition the vehicle is properly collected underneath the washing unit by the drainage system. Drainage system has been designed promptly to send the collected waste water gradually to the treatment units.

2.2.2 Silt trap tank unit

Firstly, the collected waste water underneath the washing unit, diverted to the silt trap tank through the drainage. The primary function of the silt trap tank is to trap the silt particles that have been collected with water while washing process.

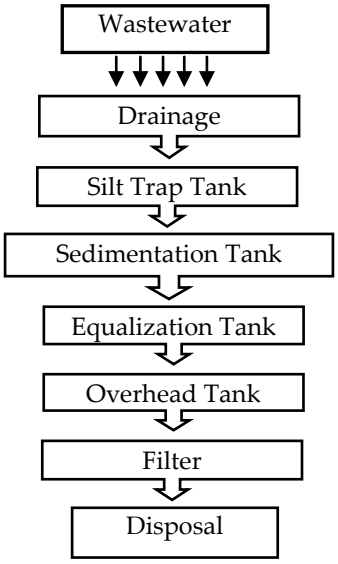

Fig. 1. Flow chart of the Treatment uits.

In this water treatment plant, there are two silt trap tanks have been incorporated and are shown in Fig. 2. Initially water is directed to the first silt trap tank and allowed to retain for some time inorder trap the large silt particles at the bottom of the tank.

Fig. 2. Silt trap tanks

After the trapping of silt in first tank, water is directed to the second silt trap tank through the top exit and allowed to retain more time inorder to make settle and trap the smaller grain size of silt particles.

2.2.3 Sedimentation tank unit

After the process of silt trapping, effluent water is directed to the sedimentation tank unit through the top exit of silt trap tank in order to avoid the entrance of the trapped silt particles again.

Fig. 3. Sedementation tank

Sedementation tank is the major unit that plays a vital role in this treatment plant system and is shown in Fig. 3. The FOG (fat, oil and grease) are separated from the waste water at this treatment unit. In addition, the silt particles that escaped from the silt trap tanks are allowed to settle in this sedimentation tank. Water directed from silt trap tank, is allowed to retain in the sedimentation tank for about 4-6 hours and FOG layer is allowed to float at the suface of the water in the tank. And the effluent is allowed to exit through the bottom of the sedimentation tank in order to avoid the FOG.

2.2.4 Equalization tank unit

After the removal of FOG, the water is directed to the Equalization tank (Fig. 4.) unit where the soap scum is neutralized. Neutralizing of soap scum is also one of the essential treatment that should be properly attempted prior to the disposal of waste water to the environment. Here, chemical treatment (compound consisting Chlorine dioxide) has been incorporated in this neutralization.

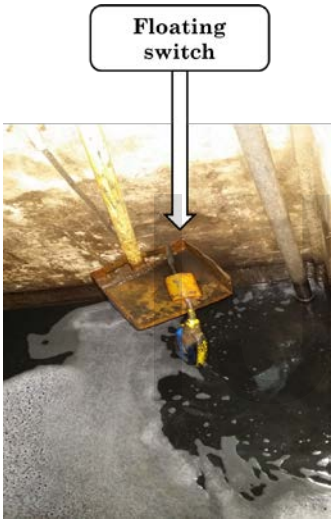

Fig. 4. Equlization tank unit

Moreover, partially treated water is pumped to the overhead tank unit from this equalization tank unit. The pumping mechanism used to pump the water to overhead tank is automatic where the floading switch system is incorporated to operate the pump automatically depending on the water level in equalization tank.

2.2.5 Overhead tank unit

In this wastewater treatment plant system, overhead tank unit (Fig. 5.) is incorporated to provide the required pressure force to facilitate the filtration process. There are two overhead tanks to store the pumped treated water and from the overhead tank, pressurized water is sent to the filter unit.

2.2.6 Filter unit

Filter unit is the final treatment unit in this vehicle station treatment plant. Filter unit helps to do the extra cleaning of the water before it is disposed to the stream. Gravel layers and sand layers (particle size ranging from 0.15 to 0.35 mm) are used to facilitate the filtering process in this treatment unit. The rapid sand filter set up has been adopted in this filter unit and it is designed to operate at an approximate rate of 10 meters/hour. The partially treated water from the overhead tank enters to the filter from the top level and exit through the bottom level where the outlet pipe system is incorporated with the filter unit.

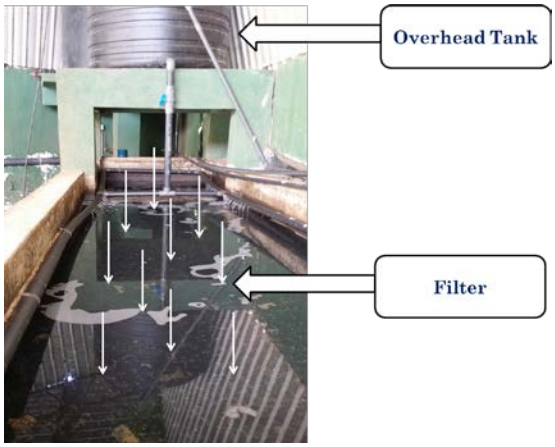

Fig. 5. Overhead tank and filter units

Fig. 5. clearly illustrates the actual setup of the overhead tank and the filter unit. After the filtration process, the effluent water is directly disposed to the environment. The FOG sludge that collected from the sedimentation tank is disposed in the stream.

In addition, the detail layout of the treatment unit system with their dimenstions according to the scale is shown in the Fig. 6. and Fig. 7. In Fig. 6., the sequence of treatment from collection of wastewater to equalization tank are illustrated clearly and in Fig. 7., the treatment sequence from overhead tank to disposal shown clearly.

3 RESEARCH METHODOLOGY

Performance appraisal has been carried out by comparing the concentrations of pollutants at the inlet and outlet of the treatment system. The wastewater samples were collected at the inlet and outlet of the treatment plant system and analysed as outlined in the standard methods for the examination of wastewater [12]. In accordance with standardized testing methods, all samples for FOG testing were collected as grab samples. Composite samples were not used because of the accumulation of the FOG inside the tubing and components of the sampler, thus lowering the FOG readings. The grab samples were collected in a specially cleaned, 1 L widemouth glass container. The samples were preserved with the addition of hydrochloric acid to a pH of less than 2.0. until the testing.

The samples were analysed for various parameters such as pH, Turbidity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and FOG (fat, oil and grease). For the FOG measurement, standard method of EPA Method 413.1 was incorporated. Depending on the results, the performance efficiency of the treatment system was evaluated.

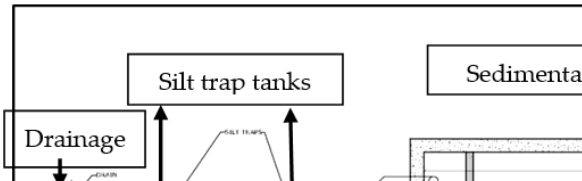

Fig. 6. Detail layout of treatment system from collection to equalization tank unit

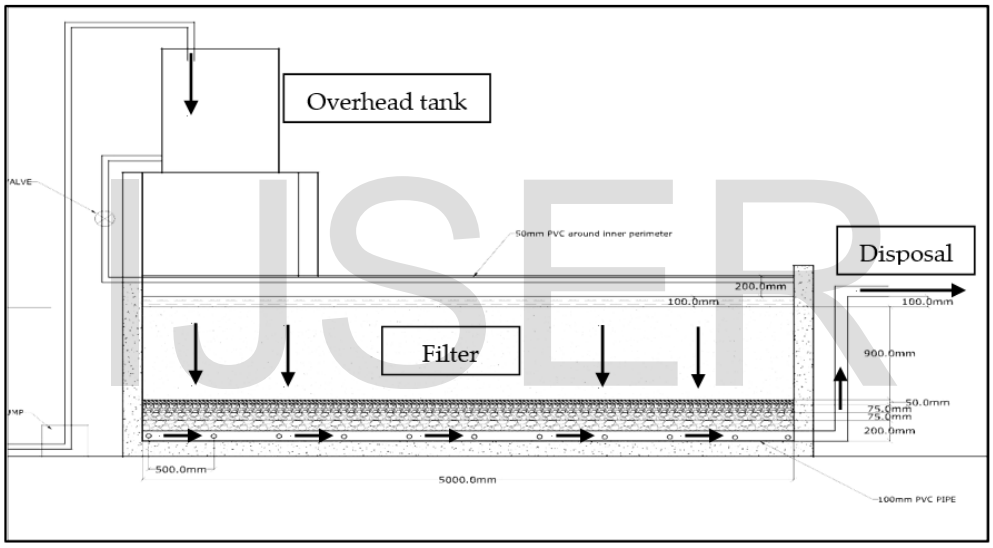

Fig. 7. Detail layout of treatment system from overhead tank to disposal

4 RESULTS AND DISCUSSION

A number of influent and the effluent samples were seperately collected for different tests and tests were conducted in the laboratory, University of Peradeniya, Sri Lanka.

The evaluation of performance efficiency of the plant was undertaken in terms of effluent quality. The evaluation was based on the plant operation data such as pH, Turbidity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and FOG (fat, oil and grease). For each testing analysis, a minimum number of five samples were tested and average obtained from the testing were incorporated for the performance evaluation. The following are the tests and the results that we obtained.

Table 01 shows the average pH values of influent and effluent wastewater samples obtained from pH meter testing. The average pH value of the effluent is 7.29 and it satisfies the standard disposal requirement that is between 6 and 9. In addition, it can be predicted that the reduction in pH is due to the neutralization of the soap scum.

TABLE 01
Average pH values

Influent	Effluent
7.52	7.29

TABLE 02
Average Turbidity (NTU)

Influent	Effluent
689.8	32.45

Table 02 shows that the influent turbidity value is significant (689.8 NTU) and it is due to the presense of the excess silt pa-

ticles in the washed wastewater. In terms of turbidity, treatment efficiency is pretty much and the treatment efficiency is around 95.3 %.

Furthermore, average values of Dissolved Oxygen (DO) for the influent and effluent are summarized in Table 03. The DO level shows a small amount of reduction in effluent than influent wastewater but as the redction seems to be not significant, treatment efficiency could not be evaluated by considering only this measure.

TABLE 03
Average DO (Dissolved Oxygen) values (mg/l)

Influent	Effluent
2.88	2.02

Moreover, it has been observed that the overall treatment efficiency for the BOD_5 removal is 57.7%. As shown in Table 04, BOD_5 measures shows a significant amount of treatment and efficiency in BOD_5 removal is high in this wastewater treatment plant system.

TABLE 04
Average BOD_5 values (mg/l)

Influent	Effluent
6.24	2.64

The International Finance Corporation (IFC) of the World Bank Group establishes guides on environment, health and safety for different types of industries [13]; these guides serve as a technical reference as they contain certain examples of the current and recommended international practices that would help to have a good environmental performance. In the guide for the oil refining industry, they determine the limit concentration for certain pollutants in the effluents coming from refineries (Table 05).

TABLE 05
Limits for pollutants found in effluents coming from refineries according to the World Bank Group [13]

Pollutant	Value
pH	6-9
BOD_5	30 mg/l
FOG	10 mg/l

It is obvious that the Ph value and BOD5 value of the effluent completely satisfy the limit proposed by the The International Finance Corporation (IFC) of the World Bank Group.

On the other hand, average value of FOG for the influent and effluent wastewater are summarized in Table 06. It has been observed that the overall treatment efficiency for the FOG removal is 3.06%. Based on the limits for pollutants suggested by the the World Bank Group (see Table 05), the allowable amount of FOG in the effluent can be 10 mg/l. But the average FOG of the effluent of this vehicle station treatment plant has been found to be 54 mg/l and this value is about 5 times of the allowable limit.

TABLE 05
Average FOG (fats, oil and grease) values (mg/l)

Influent	Effluent
66	54

On the whole, the overall treatment plant used to treat the wastewater from the vehicle service station is having a limited efficiency of treatment. Based on the experimental results, it has been found that the individual unit that used to separate the FOG (sedimentation tank) is consisting lack of efficiency in its function. At the same time, all other treatment units have been designed in an effective manner and hence, it's highly recommended for the modification and advancement in the FOG removal system prior to the disposal to environment.

5 CONCLUSION

Evaluation on the overall treatment efficiency of the wastewater treatment plant used to treat the FOG (fats, oil and grease) was conducted using sampling and laboratory testing methods. The following conclusions can be drawn based on the outcomes of this research:

1. The experimental results show that the wasterwater treatment plant incorporated with vehicle service station is with a moderate efficiency level in treating the wastewater.
2. Though the primary purpose of the wastewater treatment plant is the removal of FOG (fats, oil and grease), the FOG treatment efficiency level is only about 3% and the effluent consists a significant amount of FOG which is more than 5 times higher than the allowable effluent level based on Internationla effluent standards. Hence, advanced FOG treatment or modification in the FOG removal systemis highly necessary.
3. It has been found that the water used to clean the vehicle is polluted and with high turbidity, which is not effective to use for the vehicle conditioning and therefore, preliminary treatment for the source water is recommended.
4. It has been found that he collected FOG and scum are being disposed into the river and it's found as a wrong practice for the sustainable environment. Thus, it's recommended to use the collected FOG for industrial purposes, mould oil and anti-corrosive purposes alternatively.
5. In addition, selection of the treatment system and methods play very important roles in a treatment plant. It depends not only on the treatment efficiency required for the disposal, but also depends on the content in the wastewater to be treated.

ACKNOWLEDGMENT

The valuable thanks goes to Environmental Laboratory, Department of Civil Engineering, University of Peradeniya, Sri Lanka for the support in Laboratory testings and WaSo project of University of Jaffna for guidance and other support.

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