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IMPORTANCE OF PROPER MONITORING AND MAINTENANCE OF ON-SITE WASTEWATER TREATMENT SYSTEMS IN SRI LANKA

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Abstract: While most of industries in Industrial Zones are connected to the centralized wastewater treatment plants, a large number of scattered industries and business facilities are served by on-site (decentralized) wastewater treatment systems (OWTSs) in Sri Lanka. Despite the many benefits, OWTSs may also pose challenges when it becomes operational in the long run. Many operative OWTSs today face difficulties to meet the discharge wastewater quality requirement of National Environmental Standards mostly due to lack of appropriate systems, limited understanding of treatment processes, insufficient process monitoring and maintenance activities. Therefore, adverse impacts could result on public health trough pathogenic contaminations and ecosystems of receiving water bodies due to nutrient pollution. On the other hand, insufficient monitoring and maintenance include the inability of OWTSs to perform as expected and reduce their lifespan. Therefore, it is very important to take proactive interventions for its proper monitoring and maintenance. This paper highlights the quality of treated wastewater from operative OWTSs, public health and environmental concerns related to the operative OWTSs and other aspects of proper monitoring and maintenance of OWTSs.

Keywords: environment; industries; monitoring and maintenance; on-site wastewater treatment systems; receiving water bodies; treated wastewater

1. Introduction

Water is an essential resource for life and good health. However, water scarcity and degrading of the water quality are of concerns currently in Sri Lanka. Rather than having the lack of rainfall due to dramatic climate changes, polluting of existing water bodies is a big challenge to get safe water for public use. Discharging both raw and inadequately treated wastewater from households, commercial facilities, and industries is one of the main polluting sources of surface water bodies in the country. All the people produce wastewater from daily activities such as washing dishes and clothes, bathing, and using the toilets. In addition, commercial and industrial facilities produce wastewater, which include many harmful substances. Therefore, inadequately treated wastewater is responsible for discharging suspended solids, oil and grease, nutrients, pathogens, heavy metals, etc. for receiving water bodies, where treated wastewater indirectly reuse by people for potable and non-potable purposes. Therefore, to protect public health, environmental quality, and aesthetic beauty, wastewater must be treated before it returns to the environment for further use. Wastewater treatment is the process of removing contaminants from wastewater, which includes physical, chemical, and biological processes to remove these contaminants and produce environmentally safe treated wastewater.

All industries, which discharge wastewaters into the environment are required to obtain an Environmental Protection License from the Central Environmental Authority (CEA) in accordance with the standards and criteria prescribed by the CEA. Therefore, in areas where there is no access to centralized wastewater collection and treatment systems, the owner soften use OWTSs to treat their wastewaters. A large number of scattered industries and commercial facilities are currently served by OWTSs in Sri Lanka to collect, treat, and dispose or reuse the wastewater. Onsite wastewater systems treat wastewater at or near the

location in which the wastewater is generated(Crites and Tchobanoglous [1]).Raw wastewater from different industries including garment factories, dairy industries, rice mills, coconut processing industries, printing factories, vehicle service stations, hotels, hospitals etc. is treated by this system prior to discharge wastewater into the environment.

Even though, methods of treatment in OWTSs may differ, treatment processes are basically grouped into four categories including preliminary treatments, primary treatments, secondary treatments (mostly biological and chemical treatments), and tertiary treatments to meet water quality standards. Currently, the biological treatment is widely used to treat sewage and chemical treatment used for some industrial wastewaters like fabric coloring wastewater. The biological treatment processes depend on the formation of sludge flocs, which are the aggregates, which formed by diverse group of microorganisms including bacteria, protozoan, metazoan, viruses, fungi, and algae in which bacteria play a key role in the purification of wastewater(Seviour and Blackall[2]; Liu et al.[3]; Wilén et al.[4]; Snidaro et al. [5]).The flocs (biomass) need to have good settling properties to allow them to separate efficiently from the supernatant in the clarifiers (Sheng et al. [6]; Liao et al. [7]; Nadarajah et al. [8]); Morgan-Sagastume et al [9]; Gunawardana et al [10]).However, this separation requirement does not always meet due to many problems, which developed in the microbial components (Seviour and Blackall[2]; Michael Richard [11].

Despite the numerous benefits, OWTSs may also pose challenges when it becomes operational in the long run. Many operative OWTSs today do not meet the discharge wastewater quality requirement of National Environmental Standards mostly due to lack of appropriate systems, limited understanding of the processes, insufficient process monitoring, and maintenance activities. Thus, adverse impacts could result on public health trough pathogenic contaminants (Sahlström et al [12]; Walter et al [13]; Amahmid et al [14])and ecosystems of receiving water bodies due to nutrient pollution However, the physiochemical and microbial quality of water and sediments in receiving water bodies are rarely measured in Sri Lanka.

The World Health Organization (WHO) estimates show that three million people, two-thirds of them children die from waterborne diseases each year. In 2006, the highest rates of Shigellosis cases were recorded in the districts of Ampara, Badulla, Moneragala and Vavinya districts in Sri Lanka (WHO. [15]). Use of nitrate-contaminated drinking water to prepare infant formula is a well-known risk factor for infant (Knobeloch et al. [16];Gunatilake and Iwao [17]).

On-site wastewater systems have also contributed to an overabundance of nutrients in ponds, lakes, and coastal estuaries leading to overgrowth of algae and other nuisance aquatic plants. When Nitrates and Phosphorus discharged in excessive amounts to surface water bodies such as lakes or reservoirs, these nutrients may cause algae and aquatic plants to overgrow and the phenomena is named as eutrophication. Eutrophication is often accompanied by increases in populations of decomposer bacteria and reduced dissolved oxygen levels for fish and other organisms. In addition, excessive growth of blue green algae courses bad taste and odor problems reduces light penetration, dissolved oxygen depletions and toxin production (Magana Arachchi and Liyanage [18]).

Under this context, this study is conducted to investigate quality of treated wastewater from operative OWTSs, public health and environmental concerns related to the operative OWTSs and various aspects of proper monitoring and maintenance of OWTSs.

2. Materials and Methods

2.1. Treatment performance

The data was collected by analyzing the quality of treated wastewater from number

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of operational OWTSs in industries. These OWTSs were operated as biological treatment process including the main treatment steps of primary treatment followed by aeration, gravity settlement, and sand filtration with sewage as influent wastewater. The samples were obtained in the beginning of year 2014to middle of year 2016.

2.2. **Analysis of treated wastewater samples**

Wastewater samples were collected in properly cleaned glass bottles. The samples were then placed in an ice box before being transported to the laboratory. All the samples were placed in refrigerator at 5^0C and were analyzed for Biochemical Oxygen Demand (BOD_3), Chemical Oxygen Demand (COD), pH, Total Suspended Solids (TSS) Total Dissolved Solids (TDS), and oil and grease. The samples were processed for BODon the same day of the samples were collected.

The standard methodswere followed to analyze the treated wastewater samples for above parameters (APHA, 2007[19]). Biochemical Oxygen Demand (BOD_3) CODof the samples were analyzed using HACH brand COD vials and HACH spectrophotometer. Total suspended solids was measured by filtering 100 mL of sample through a pre-weighed Glass Microfiber Filter papers with specified pore size (Whatman 47 mm; (GF/C™) and weighing of the filter paper again after filtered the sample and drying. Oil and grease was measured using Hexane extraction (gravimetric)method. Data was obtained from 100 treated wastewater samples.

3. Results and Discussion

3.1 Quality of treated wastewater from operative OWTSs

The results of the analysis of treated wastewater for BOD_3, COD, TSS, and Oil and grease are shown in Figure1. According to the results, most of the samples analyzed were within the tolerance limits of wastewater discharge for irrigation purposes (250 mg/L, 400 mg/L, 2100 mg/Land 10 mg/l respectively) according to the National Environmental Regulations made under National Environmental Act of Sri Lanka. However, the levels of BOD_3 in many samples were above the tolerance limit (30 mg/L) of wastewater discharge into surface water bodies. Similarly to BOD, the COD levels of some samples were also above the tolerant limit (250 mg/L) of wastewater discharge into surface water bodies. The levels of TSS of some samples were also above the tolerant limit (50 mg/L) of wastewater discharge into surface water bodies.

According to the results shown in Figure 2, pH of most of analyzed samples were fluctuated around 6-9. The level of pH in few samples were below 6. The tolerant range of pH for discharging wastewater into surface water is 6.0 – 8.5.

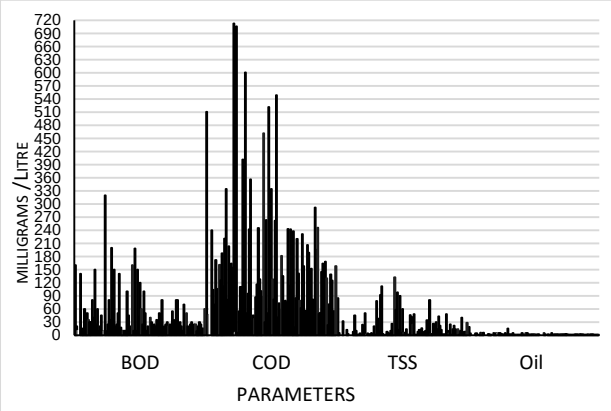

Fig. 01. Results of the treated wastewater samples analyzed for BOD_3, COD, TSS, and Oil and grease.

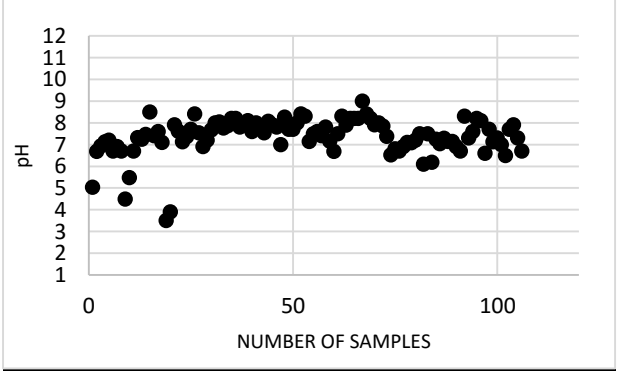

Fig. 02. pH of the treated wastewater samples analysed

3.2 Public health and environmental concerns related to the operative OWTSs

When wastewater treatment plants are properly operated, public health and the state's water bodies are protected. However, according to the author's experience, the common problems in OWTPs are the poor settlement conditions and sludge comes to the top of the settlement tanks. Therefore, suspended solids are high in treated water. According to the data analysis, the BOD, COD, and TSS levels in considerable number of samples were above the tolerant limits of wastewater discharge into surface water bodies. In Sri Lanka, we are experiencing the outbreak of waterborne diseases in each year. However, in most of OWPSs, treated wastewater discharged to receiving water bodies without applying any disinfection method. On the other hand, testing of Fecal Coliforms are not yet regularly monitored in wastewater quality testing in Sri Lanka. Therefore there is a high possibility for spreading the water borne diseases.

Current OWTSs also contributed to an overabundance of nutrients in ponds, lakes, and coastal estuaries leading to overgrowth of algae and other nuisance aquatic plants because of no proper mechanisms are incorporate to reduce Nitrates and Phosphorus during the wastewater treatment process in most of treatment plants. Currently, most of lakes in Sri Lanka are suffering from Eutrophication condition.

3.3. Common problems associate with operating OWTPs

On-site treatment systems are effective and economical when they properly designed, installed and maintained. Although, the design and construction of OWTSs will be done under proper standards, there are many aspects to be considered when it becomes operational in the long run. The difficultly that many of these industries face is that effluent treatment is not a part of their daily businesses. Therefore, the construction, maintenance and troubleshooting are also new experiences for responsible personals.

Most of operative OWTSs in Sri Lanka has numbers of operational problems due to lack of appropriate systems, limited understanding of treatment processes, insufficient process monitoring and maintenance activities. However regular and proper monitoring is essential to obtain the better quality effluent to meet the national wastewater discharge standards in order to obtain or renew the Environmental Protection License (EPL).

3.3.1 Aspects of proper monitoring and maintenance of OWTPs

It is apparent that huge investment in establishing a OWTSs does not guarantee the expected outcome unless all the strategies are in place to ensure that the plant is operated as planned without any problems. However, there are many potential problems, which would adversely impact on the efficiency of treatment process with associated operation and maintenance issues. Therefore, it becomes required to identify such operational problems and factors, which are responsible for them in advance and take necessary measures so that anticipated problems could be avoided.

The main problems associate with OWTPs can be grouped into three primary areas: (1) insufficient funding and public involvement; (2) inappropriate system design and selection processes; and (3) poor monitoring and maintenance failures. These problems can directly and indirectly contribute to significant human health risks and environmental degradation.

Major mechanical maintenance problems of current OWTSs include blower or mechanical aerator failure, pump and pipe clogging, electrical motor failure, corrosion or failure of controls, and electrical malfunctions. In addition failures also occurred due to age of the system and hydraulic overloading. Some of current systems are also relying on outdated and underperforming technologies.

The careful attention to maintaining a schedule will reduce these problems and alleviate operational problems due to distress of biological process. Emphasis should be placed on adequate maintenance checks during the first two or three months of operation. In addition, proper maintenance work reduces the maintenance cost.

The successful operation of the biological processes relies mainly on a rapid and complete separation of liquid phase from the biomass mostly by using the gravity clarifiers. The flocs need to have good settling properties to allow them to separate efficiently from the supernatant in the clarifiers. However, unfortunately, this separation requirement is not always met due to many problems develop in microbiological components of the process. In many plants, filamentous bulking, accumulating of foam and scum, and formation of pin-flocs, dispersed growth of bacteria (non-settleable are the most common problems that cause discharge of biomass with treated effluent due to poor settleability. These problems adversely affect the quality of effluent and treatment efficiency.

As temperature is relatively high in months like July and August in Sri Lanka, the denitrifying bacteria can be preferably proliferated resulting rising/floating sludge clumps on the clarifier surface due to trap of nitrogen gas in flocs. Therefore, sludge floated on the top of clarifier and thus sludge discharged with treated effluent resulting very turbid effluent.

3.3.2 Monitoring and operational control

Several parameters are used to monitor the performance of the biological wastewater treatment processes on routinely basis. Although, the process is a biological one, the monitoring still uses chemical and physical parameters rather than the microbiological parameters for routine analysis. The importance and value of each of the individual chemical parameters measured will depend on the plant configuration and the model to be used. The parameters includes influent characteristics such as amount of organic loading, total nitrogen, alkalinity and pH, hydraulic retention time, mixed liquor suspended solid and mixed liquor volatile suspended solids, sludge loading or food microorganisms ratio (F/M ratio), and sludge retention time.

3.3.3 Importance of influent wastewater characteristics for better performance

Beside to the major operational practices in the plant, the characteristics of influent wastewater and environmental conditions play an important role in the process. Normally, wastewater for sewage treatment plant composed of human body wastes (faeces and urine) together with the water used for flushing toilets, personal washing, laundry, food preparation and the cleaning of kitchen utensils which provides food for microorganisms in the system; thus sewage mainly contains organic pollutants and tracer amount of inorganic pollutants.

In an ideal situation, microorganisms help to treat pathogenic organisms and other pollutants in wastewater and ensure trouble free operation of wastewater treatment plants. However, when wastewater mixed with wastewater from industrial process, the characteristics of wastewater significantly changes from ideal situation due to contain the large quantities of oil, pharmaceutical drugs, detergents, bleach chemicals, paints and other harmful substances.

While moderate quantities of the chemicals substances are acceptable in wastewater, excessive amounts may have adverse effects on a wastewater treatment system. These substances will badly affect for maintenance of equipment and the healthy growth of microbial population that treat pollutant in wastewaters. The public health effects also are associated with the possible chemicals in treated wastewater.

In addition to the problems created in microbial components, fat, oil and grease have many negative effects on plant equipment and operations. Oil that is rinsed down drains sticks to sewer pipes and

solidifies, causing clog pipes, valves and pumps, builds up in wells of basins in treatment plant and make offensive odours. Pipes that have build-up must be cleaned or replaced more frequently and thus incurring large expenses for the wastewater utility.

3.3.4 Importance of using disinfection devices prior to discharging treated wastewaters

The successful operation of widely use biological process mainly depends on a rapid and complete separation of effluent from sludge (biomass), which treat pathogenic microorganisms and other pollutants in wastewater. However, this separation requirement does not always meet due to many problems, which developed in the microbial components. In such situations, effluent contains large amount of suspended particles (biomass) due to poor settling and also freely living bacteria Therefore, pathogenic organisms will also discharge with effluent causing severe health related problems. Therefore, disinfecting the treated wastewaters prior to discharge into environment is essential. However, the disinfection devices such as chlorinators, ultraviolet lamps used in tertiary treatment are hardly used in the current OWTSs in Sri Lanka for disinfecting the treated wastewaters prior to discharge into environment.

Even though, the tolerant limit of Faecal Coliforms is given in the national environmental regulations, Fecal Coliforms are not yet regularly monitored in wastewater quality analysis. However, from the health perspectives, Coliforms are widely used as indices of fecal pollution in water.

In many places, the treated wastewater is used for gardening and other agriculture purposes. When treated wastewater discharged to receiving water bodies without applying the disinfection, there is a high risk for spreading the water borne diseases, where people indirectly or directly reuse it for potable and non-potable purposes. The pathogens also can be transported for significant distances in ground water or surface waters. Therefore, it is very important to use disinfection method to kill the pathogenic microorganisms present in treated wastewaters and very important to test biological component in discharging wastewaters.

3.3.5 Public involvement and education

Mostly use biological treatment technologies in today require more intensive management and monitoring. Even conventional gravity-based systems require routine pumping, monitoring, periodic inspection of sludge, etc. Therefore, **i**n order to facilitate efficient treatment processes and avoid problems in technology, knowledge about hydro-ecology, microbiological communities and biology of microorganisms that take part in wastewater treatment process is necessary. **S**pecialized education or training is required for all practitioners, planners, and owners responsible for operating and maintaining of OWTSs. Probationary training for new employees is also mandatory. Certification or licensing for all practitioners to maintain standards of competence and conduct is essential.

In most cases, OWTSs are formulated and implemented by owners of industries without significant involvement and education of other staff members and workers. However, educational activities directed at increasing general awareness and knowledge of onsite wastewater management efforts can improve the probability that simple routine operation and maintenance tasks. Importance of the reduction of wastewater generation, prevention of depositing solid materials such as hair, disposable diapers, facial tissues, cigarette butts, and other non-decomposable materials to the septic tanks, reduction of excessive use of cleaning chemicals (detergents, bleaches, drain cleaners, etc.), preventing the dispose of fats or grease to wastewaters should be understood by all who served by a OWTS.

Currently, it is a positive sign that many industries are also making progress in

establishing and operating their own wastewater treatment plant to comply with national and international buyer's requirements and also because of increased personal awareness of the negative impacts of untreated effluent. The difficultly that many of these industries face is that effluent treatment is not a part of their daily businesses.

4. Conclusion

There are vast numbers of operative OWTSs in Sri Lanka to produce environmentally safe treated wastewaters. Despite the many benefits, OWTSs may also pose challenges when it becomes operational in the long run. Many operative OWTSs today face difficulties to meet the discharge wastewater quality requirement of National Environmental Standards and thus adverse impacts could result on public health and ecosystems of receiving water bodies. The current problems faced are mostly due to lack of appropriate systems, limited understanding of treatment processes, insufficient process monitoring and maintenance activities.

Therefore, it is very important to identify such operational problems and factors, which are responsible for them in advance and take necessary measures so that anticipated problems could be avoided. As most of responsible people for system operation is lack of proper idea and also take less care, specific educational and training activities directed at increasing general awareness and knowledge of onsite wastewater management efforts is required to improve the possibility of simple routine operation and maintenance tasks.

As mostly use biological treatment technologies in today require more intensive management and monitoring, awareness and training is required for all practitioners, planners, and owners responsible for operating and maintaining of OWTSs. In addition, certification or licensing for all practitioners to maintain standards of competence and conduct is essential.

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