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Fate of Pathogen Indicators During Extended Aeration Wastewater Treatment

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Abstract: Pathogen indicators normally used in water quality indicator because large numbers of the bacteria are always present in the faeces of humans, but are not naturally found in water. Since these bacteria don't live long in water once outside the intestine, their presence in water means there has been recent contamination through effluent discharges or other sources. Like other enteric pathogens, a common mode of transmission for *E.coli* is via contaminated water, food and by direct person to person contact. Infection often causes severe bloody diarrhea, abdominal cramps, and possibly fever. In some cases, infection can lead to kidney failure and possibly death. In order to evaluate the effieciency of extended aeration wastewater treatment plant (EAWWTP), the microbial analyses such as enumeration of *E.coli* and total coliform were measured. Besides, this study also involved the measurements of pH, turbidity, DO (Dissolve Oxygen), BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand) and TSS (Total Suspended Solid). This study summarized that each treatment process provides important roles to overall effiecіency of EAWWTP. The secondary treatment was proved sufficient not only on reducing pathogen indicators but for all examined parameters. Significantly, this study conclude that numbers of pathogen indicators discharges in effluent meet the regulated standard guideline after treated through the EAWWTP.

Keywords: Pathogen indicators, total coliform, *E. coli*, extended aeration wastewater treatment plant

1. Introduction

Wastewater is a combination of water (99.9%) and solid waste (0.1%) generated by human daily activities such as human waste, food scraps and many others. Approximately 70% of solid waste in the wastewater consists of organic matter and the rest is inorganic matter [1]. For organic matter, it consists of 65% protein, 25% carbohydrate and 10% fat. While the inorganic matter consists of grit, salt and metal. Typically, the organic part consists of proteins, carbohydrates and fats. These compounds, especially proteins and carbohydrates are bacteria food, the microscopic organism that is used by the sanitary engineer for the biological treatment of wastewater. In addition to this chemical compound, faeces and urine contain millions of intestinal bacteria and a small number of other organisms. Although the rate was slightly lower for urine, many organisms are harmless and beneficial to human [2]. However, a small group of microorganisms can cause dangerous diseases. Wastewater is generally contaminated by the presence of *E.coli*, chemicals and suspended or dissolved solids [2]. It is necessary to treat human waste for many reasons, but the most important reason is to avoid from any diseases spread and water pollution. Untreated human waste contains of *E.coli* that are disease-causing organisms [3]. The presence of these in the environment transmits various types of diseases. Thus, the wastewater is exposed to the risk of contamination that should be studied carefully to avoid threaten human health and environmental quality [4]. Wastewater management practices in Malaysia can be divided into three main sequence: collection, treatment and finally disposal.

Collection at first stage involves the design similar like sewer system (sewer lines) to discharge the wastewater from collections to treatment plants. Based on the effect of gravity system is commonly used for the flow of wastewater to reduce operating costs [5].

The second stage in the wastewater management practices involving the treatment process in treatment plants. This stage is important because the concentration level of pollutants in the wastewater sewage effluent will be reduced to achieve the required emission standards. Treatment plant will be designed in this case to conform to the concentration of sewage water resources, local people; the standards should be achieved as well as economic factors. In Malaysia, extended aeration treatment system is commonly used in the treatment plant [5]. Institutional wastewater treatment plant at Universiti Tun Hussein Onn Malaysia (UTHM) also uses the extended aeration systems which the treated wastewater discharged into the water course.

The third stage involves the removal or better known as the discharge of effluent into the existing watercourse. After being treated in treatment plant, the

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effluent usually has reached the discharge standard. With this, the control of the treatment process is essential that discharge of effluent as a source of reuse should be studied and examined based on the suitability of effluent discharge standards for the existing treatment plant with potential users.

Wastewater characteristics generally related with the quality of the physical, chemical and biological. Physical parameters, including color, taste and odor, temperature, turbidity and solids content. Solids content can be categorized into suspended solids and dissolved solids in the form of organic or inorganic. Chemical parameters of wastewater is usually viewed from two main categories, namely in the form of organic and inorganic. Category of organic chemical parameters including biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total oxygen demand (TOD), protein, carbohydrates, fats and oils. In the form of inorganic chemical parameters include pH (acidity and alkalinity), heavy metals (mercury, lead, chromium and zinc), chlorine, nitrogen, phosphorus and sulfate.

Biological parameters of wastewater analyses including enumeration of coliforms, fecal coliforms, pathogens and viruses [7]. Clearly, the biological parameters related to the presence of bacteria and microorganisms. This need to be handled with care thus, it can play an important role in the treatment process and being no threat to human health. Previously, the effectiveness of same EAWWTP was only measured on physical and chemical parameters (data not reported). Therefore, this study was carried out to complete the pollutant measurements by analyzing the removal of pathogen indicators after through several treatment processes in EAWWTP.

2. Methods and materials

The EAWWTP is located at UTHM, Batu Pahat, Johor. There are 4 stations for wastewater sampling that are inlet (influent), primary, secondary and outlet (effluent) station. For wastewater characteristics analysis, the parameters examined such as pH, turbidity, DO (Dissolve Oxygen), BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand) and SS (Suspended Solid). These parameters were performed accordingly to the Standard Methods for the Examination of Water and Wastewater [8]. The samples are fresh collected and tests were performed immediately on the same day.

The samples were carried out for microbiological analyses for 7 times at different days. The Total Direct Count method was utilized for enumeration of pathogen indicators by using ChromoCult® Media Agar from Merck KGaA. This method was US-EPA approved as alternative method for detection of total coliforms and *E.coli* in wastewater [9]. The Chromocult® Coliform Agar contains Tergitol7 as an inhibitor of Gram-positive bacteria which has no negative effect on the growth of the targeted coliforms/*E.coli*. The preparation of media agar was followed the manufacturer instructions. Then, incubate the inoculated dishes aerobically at 35–37 °C in an inverted position for 24 hours. After incubation, the plates were counted for the presence of typical colonies of *E. coli* (appeared as blue to violet color) and total coliforms (appeared as salmon to red color).

3. Results and Discussion

Fig.1 shows that the pH level at different sampling location of EAWWTP. The pH level is increased from acidic then reached to neutral level from inlet until outlet. The effluent at outlet samples was meet the effluent standard which is within the range of 5.5 to 9.0 pH in Standard B (Environmental Quality Act, 1974). [10]. This indicated that EAWWTP able to treat pH values of wastewater.

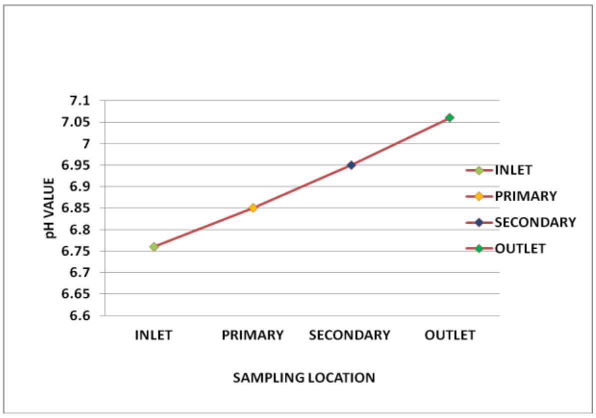

Fig.1 pH level at different sampling locations of EAWWTP

Turbidity is a “measure of the relative clarity of water”. Turbidity in water is caused by suspended and colloidal matter, such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. However, turbidity is not a direct measure of suspended particles suspended in the water. It is, rather, a measure of the scattering effect that such particle have on light. Fig. 2 shows the turbidity values that obtained during different process of wastewater treatment. It shows that turbidity in the wastewater was reduced for each treatments. At inlet treatment, turbidity value at 37.9 NTU. Then, it was reduced after primary treatment at 35.4 NTU. After through the secondary treatment, the turbidity decrease to 23.1 NTU and yet it also decrease to 19.2 NTU at outlet sampling point. The reduction of turbidity values proved that EAWWTP is function appropriately. The effluent examined was conform with the National Water Quality Standard at CLASS IIA [11] whereas the range of turbidity should be less than 50 NTU.

The dissolved oxygen (DO) is commonly regarded as one of the most important measures of water quality [2]. The DO content of wastewater is influenced by the source, raw water temperature, treatment and chemical or biological process that taking place during treatments process. Hence, analysis of DO is an important step in wastewater treatment process and control. The graph in Fig. 3 presents the result of this parameter. The results indicated that DOs generally decreased during all treatment processes. According to the National Water Quality Standard it comply with the CLASS IIA [11] for the range of DO is approximately at 5-7 mg/L. This shows the effluent fulfill the regulated standard guideline.

The temperature was reported influences the level of DO [2]. Temperature inversely possibly controls the solubility of oxygen in water; as temperature increases, oxygen is less soluble. Directly downstream from where wastewater effluent is discharged to a river, DO content often decreases because of the increase in growth rate of bacteria that consume the organic matter contained in the effluent. The proper aeration of EAWWTP can keep levels of DO in the high effluent. Overall, these results shows the DOs were in the safe level. This is because concentrations at below 5 mg/L may adversely affect the functioning and survival of biological communities and at below 2 mg/L it may lead to the death of most fish [7].

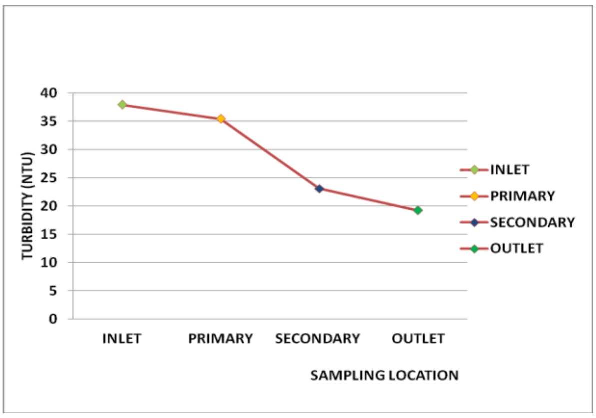

Fig. 2 The turbidity value at different sampling location of EAWWTP

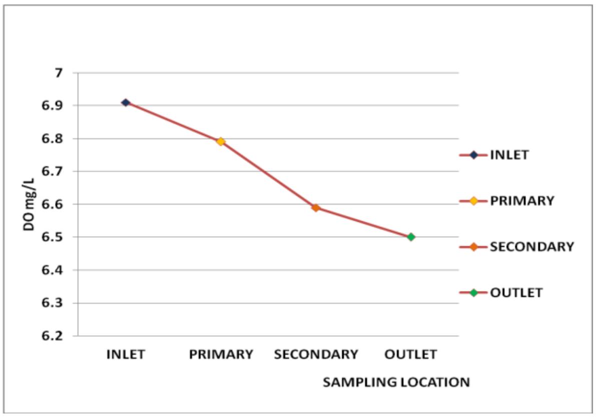

Fig. 3 Dissolved oxygen at different sampling location of EAWWTP

The suspended solids (SS) is an important indicator of water quality. In river, most metals attached to the suspended particulates and ultimately accumulate in sediments at the bottom of the water bodies. The SS consists of silt, clay, fine particles of organic and inorganic matter, soluble organic compounds, plankton and other microscopic organism. The Fig. 4 shows the value of SS decreased for all treatments. The effluent conform with the standard guideline which is below 100 mg/L in Standard B [10].

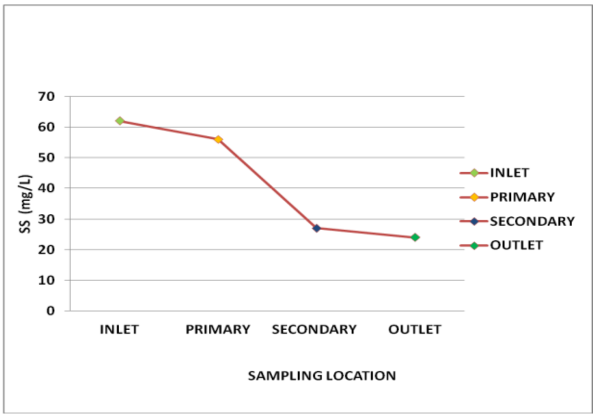

Fig. 4 Suspended solid at different sampling location of EAWWTP

The chemical oxygen demand (COD) measurement is the way to detect the water being polluted by chemical subtances from human activities. According to the results obtained, the highest COD level was measured at inlet while the lowest was at the outlet. Overall, of result shows the improvement of COD level (Fig. 5). All COD results after passing the treatment process were comply with DOE Standard (in Standard B) [10]. The requirement enacted told that the maximum of COD level of effluent is below than 100 mg/L.

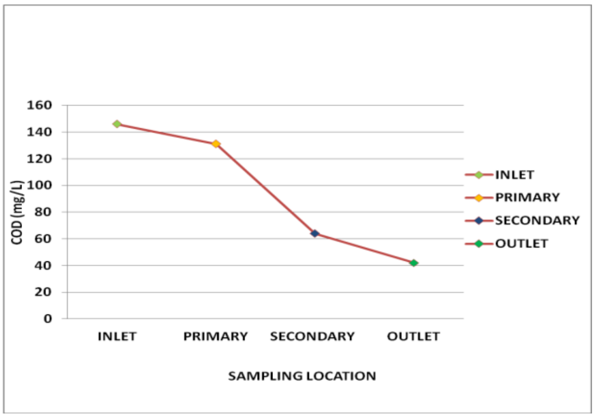

Fig. 5 COD at different sampling location of EAWWTP

The BOD_5 test results for every treatment sampling location analysed and plotted in Fig. 6. According to Fig. 3.6, the inlet has the highest BOD_5 level as compared to the others. The results examined shows that only BOD_5 from inlet and primary treatment batch was not comply with wastewater standard requirement which in Standard B [10]. The requirement enacted in Standard B stated that the maximum of BOD_5 level should approximately less than 50 mg/L. However, after secondary treatment the BOD_5 was decreased to the safe level. The final effluent for BOD_5 was at 18 mg/L. Therefore, this indicates that the EAWWTP well operated to treat BOD_5 level.

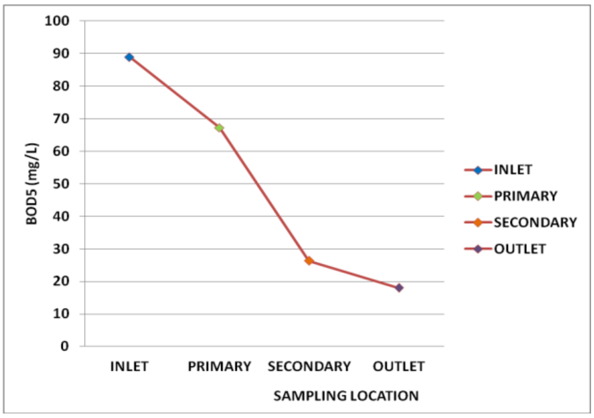

Fig. 6 BOD_5 at different sampling location of EAWWTP

The enumeration of *E.coli* and total coliform by using Chromocult Coliform Media Agar was conducted for 7 times at inlet, primary, secondary and outlet. Each test was examined at different days to observe the difference levels of *E.coli* and to study the efficiency of treatment processes. Fig. 7 shows all treatment contain *E. coli*. Overall, the results shows that the higher of *E.coli* level was at the inlet for all samples. The *E.coli* enumeration was slightly decrease from inlet to after through primary treatment.

The most significant reduction for overall sampling days was for secondary treatment. The *E.coli* levels was reduced drastically shows the effectiveness of biological process mostly at secondary treatment. Overall, the effluent meet the Interim Marine Water Quality Standard [5] that *E.coli* should below 100MPN/100mL. This concluded that EAWWTP is well operated to reduce the level of this specific pathogen indicator.

Fig. 8 shows the results of total coliform examined in this study. The enumeration of total colifom was conducted on the same day with *E.coli* test. Similar to *E. coli* level, the total coliform is highest at inlet for all days. This is because, raw wastewater enters the inlet contains varying quantities of floating and suspended solids. It gradually decreased after primary treatment. Meanwhile, the most decreased of total coliform level was after passing the secondary treatment. This proved that the biological treatment process was mainly occurred at secondary treatmet. The secondary treatment process removed up to 95 percent of suspended solids in the wastewater therefore it significantly related in removing total coliform from wastewater. Overall, the effluent meet the National Water Quality Standard for Malaysia [10] that total coliform should below than 100MPN/100mL.

The results of pathogen indicators then proceed for percentage of removal (as shown in Fig. 9 and Fig. 10). The results shows that secondary treatment more significant in reducing the pathogen indicators compared with primary treatment. The samples treated at primary treatment shows the reduction were up to 31% and 42% for *E. coli* and total coliform, repectively. Meanwhile, ater passing the secondary treatment the reduction for both pathogen indicators were increased up to 100%. Overall, the number of these pathogen indicators present in the effluent is successfully reduced to 100% as compared with the influent. This represents the reduction amount of pathogen indicators in effluent after passing through several treatment processes in EAWWTP available in UTHM.

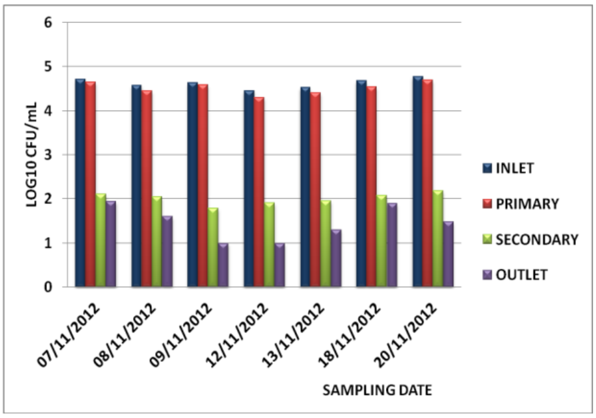

Fig. 7 The enumeration of *E.coli* at different sampling date

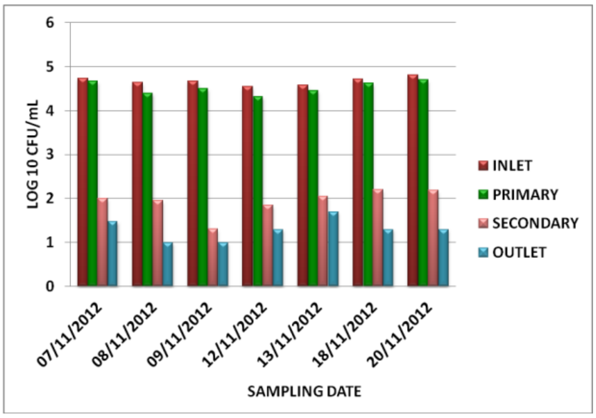

Fig. 8 The enumeration of total coliform at different sampling date

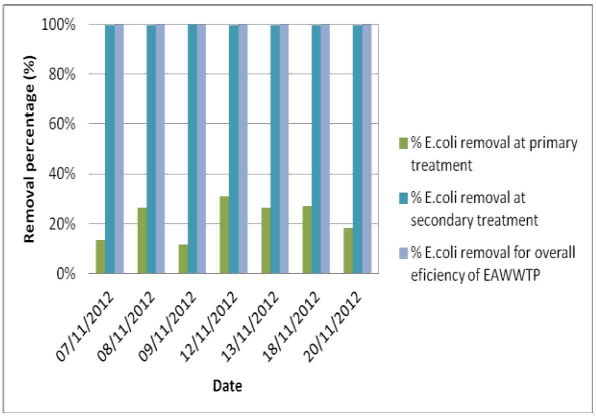

Fig. 9 Removal percentage of *E. coli* at EAWWTP

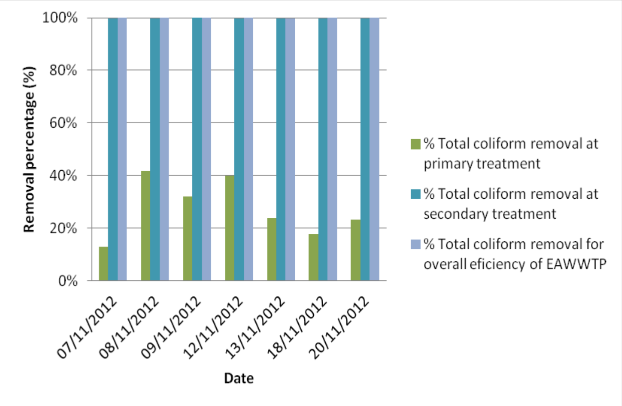

Fig. 10 Removal percentage of total coliform at EAWWTP

4. Summary

This study shows that each treatment process provides significant roles to overall effieciency of EAWWTP. The secondary treatment was proved sufficient not only on reducing pathogen indicators but for all examined parameters. The effluent of wastewater is one of the most important factors that affected the river water quality. This study summarized that the numbers of pathogen indicators that discharged in effluent conform with the regulated standard guidelines [5,10,11] after treated well by EAWWTP.

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