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Effects of Aeration System to Water Quality

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Abstract

A study of effect of aeration system to water quality in Sungai Kangka, Politeknik Kuching Sarawak has been conducted to identify the suitable aeration system can be applied in Sungai Kangka as alternative method to reduce pollution level in Sungai Kangka to a safe level for recreational purposes. Through this aim, the main objective of this study is to provide technical data of water quality in Sungai Kangka after been conducted in several aeration test. The parameters that have been evaluated are dissolved oxygen (DO) which contribute to the healthy growth of organisms in river and surrounding, the aerator speed which is rotation per minute (RPM) and the dimensions of the bubble stone aerator (mm). The water sample was taken on two conditions which are the continuously flowing and stagnant point in river stream. Dissolved oxygen levels in flowing river stream were set as benchmarks and the dissolved oxygen level at the stagnant point was enhanced through aeration system which is impeller and fan aeration system and bubble aeration system. Water sampling initially measured in two sampling points, which is 5.31 mg/L and 4.61 mg/L respectively before aeration process conducted on stagnant point sampling. The data obtained shows that impeller and fan aeration system suitable for river stream which ensures the river stream to continuously flowing and reducing stagnant point in river. Although, the increase the DO level in bubble aeration system has higher percentage compared to fan aeration system, it's suitable to use in pond, water treatment plant and sewerage treatment plant.

Keywords: - Pollution, dissolved oxygen, aeration process

1. Introduction

Rivers are utilized for a variety of purposes such as transportation, agriculture purposes, recreation, drinking water and other uses of water. About 70% of the earth is covered by water and only 2.5% is fresh water and only 0.3% is available for human consumption (Central California Area Office, 2020). Therefore, water treatment process is essential to ensure water quality is determined according to the standard requirements.

Among the water treatment processes is aeration process. Aeration is the process in which air is circulated through, mixed, or dissolved in a liquid or substance. Aeration brings water and air into close contact and causes dissolved gases such as carbon dioxide, CO2, to be removed.

Politeknik Kuching Sarawak (PKS) is a higher education institution that accommodates more than 3500 people including students and staff. Sungai Kangka is located inside the Politeknik Kuching Sarawak campus. Sungai Kangka is used for co-curricular activities such as kayaking, fishing, and other water activities. Sungai Kangka pathway is located near palm plantation area. Furthermore, sewerage treatment plant system from Politeknik Kuching Sarawak located next to the Sungai Kangka pathway. Also, water from the final tank is discharged directly to the river. Fig. 1 shows a map of Sungai Kangka, Politeknik Kuching Sarawak that obtained from Unit Pembangunan dan Senggaraan (UPS), Politeknik Kuching Sarawak.

Fig. 1. Demographic of Sungai Kangka

Aeration system is a mechanism used to provide oxygen for bacteria in wastewater and aquatic living in water while they are consuming dissolved oxygen (Mal, 2021) Furthermore, the excessive or insufficient amount of dissolved oxygen level in water may affected the growth of organisms in surrounding of the river (Cao et al., 2021), (Lipizer et al., 2014).

1.1 Problem Statement

As reported in previous work from (Shah et al., 2022), the water quality analysis of Sungai Kangka can be categorized under class II of National Water Quality Standard for Malaysia. This classification indicates that the river is suitable for recreational activities involving bodily contact. However, they have found that a stagnant point along the rivers with low oxygen dissolved value and poor life aquatic living that limit the chances to develop a recreation sector at Sungai Kangka. The improvement of water quality along the Sungai Kangka is required to be conducted before gazetting this river safe for recreational activities of PKS community. Besides, the stagnant point in Sungai Kangka is near with the suggestion area of recreational activities. Fig. 2 shows the non-point source that affects the parameters in stagnant point along the river stream. Therefore, this work is proposed and conducted to study the improvement of oxygen dissolved which indicates the pollution level along Sungai Kangka especially the stagnant point.

Fig. 2. Non-point source along the stream of Sungai Kangka

1.2 Objectives

The specific objectives of this research are as follow:

1. To study the effect of aeration system in stagnant point of Sungai Kangka towards.
2. To provide the technical data for suggestion aeration system in stagnant point of Sungai Kangka

2. Methodology

2.1 Water Sampling

To conduct analysis on the effect of aeration system in Sungai Kangka, PKS, water sampling points were taken in two points as shown in Fig. 3 and Fig. 4. In detail, two stations were selected based on the criteria which flowing and non-flowing. For flowing site on the river, it was set as benchmark for dissolved oxygen level and the point selected on manmade natural aerator, which has elevation on the structure and cause natural waterfall to occur, therefore increase the dissolved oxygen level. For second point, which stagnant point in river pathway about 30 meters from the first point at the corner pathway of the river. The second was chosen based on the geography location on the river, which limited the river stream access the location and caused stagnant point to occur.

Fig. 3. Continuous flowing river

Fig. 4. Stagnant point and near to non-point source

2.2 Magnetic Stirrer

Water evaluation has been conducted after been applied aeration system fan blade concept by using magnetic stirrer as shown in Fig. 5 where water sample been place inside the beaker for 300mL and been stirred using magnetic stirrer for 10 minutes. This method applied the concept of aeration system on small scale before applying on large scale which is on the river pathway. Parameters used in this concept are the speed of the stirrer, where 200 rpm, 400 rpm, 600 rpm and 800 rpm were set. As for constant variable, water sampling and time set were 300mL and 10 minutes respectively.

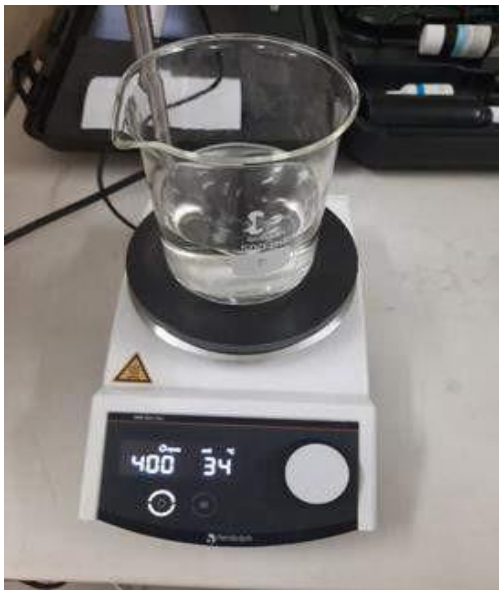

Fig. 5. Magnetic stirrer

2.3 Bubble Aerator

Application of bubble aerator which using stone aerator is commonly used sewerage treatment plant, for example, used at Kuching Centralized Sewerage Treatment Plant as site visit was conducted. The concept of aeration system is where the air injected into water will produce an increase of dissolved oxygen level as shown in Fig. 6. Components involved in this aeration system concept are an air pump, hose and stone aerator which simulate the real-life aeration system. The specification of air pump used produce 2.5 Watts of power, 3L/min of volume flow rate and 0.02MPa of air pressure. The stone aerator used in the analysis has three dimensions to indicate the difference of dissolved oxygen level.

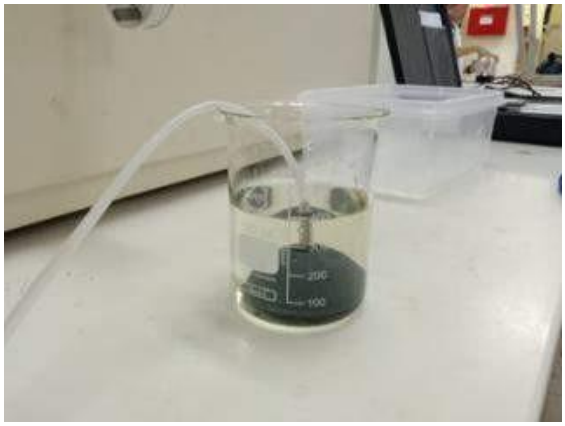

Fig. 6. Bubble aerator

2.4 Dissolved Oxygen Meter

For dissolved oxygen level evaluation were tested using Dissolved Oxygen meter (Brand: HANNA HI98193) on sampling station and on the lab after analysis conducted as shown in Fig. 7. Each water sampling was evaluated using a DO meter to determine the DO level and effect of aeration system for both types. Dissolved Oxygen were calibrated before conducting the analysis to reduce error and increase the efficiency of the value.

Fig. 7. Dissolved oxygen meter

3. Result and Discussion

The level of dissolved oxygen in Sungai Kangka was measured at two different points. The first point was measured at flow point and second point were measured at stagnant point in the river which value at 5.31 mg/L and 4.61 mg/L respectively. The first point was higher than the second point due to the human build structure that produces aeration system and increase flow rate as presented in Figure 4. It indicates that the creation of natural aeration and build structure for improvement of dissolved value significantly promote a better water quality with high levels of oxygen dissolved to improve the water quality of effluent domestic wastewater in PKS which discharges into this river.

3.1 Magnetic Stirrer

Evaluation of aeration system to water quality using magnetic stirrer with different speed is conducted by using different water sampling point of stagnant point of Sungai Kangka. Table 1 shows the relationship of aeration power by speed towards the dissolved oxygen value. The magnetic stirrer process was simulated by the natural aeration concept in beaker with magnetic stirrer as impeller mixing to increases the dissolved oxygen level in water. Several speeds were used and dissolved oxygen significantly increased from initial dissolved value at 4.61 mg/L. From this data, the percentage of dissolved oxygen gradually increased up to 38% from initial value.

Table 1. Percentage of dissolved oxygen increment by magnetic stirrer

Water Sample	**A**	**B**	**C**	**D**
Speed (RPM)	200	400	600	800
Percentage of dissolved oxygen increase, %	17	24	38	38

It indicates that the suggestion specification can be applied for aeration system in Sungai Kangka, PKS is around 400 rpm to 600 rpm. The main factor of this specification selection is due to the consumption of electricity and lifespan of the aerator which is impeller or fan blade used in aeration system. Besides that, referring to Table 2, the difference of dissolved oxygen level between 600 rpm and 800 rpm is slightly different. Therefore, considering the energy consumption of the aeration process, 400 rpm to 600 rpm is suitable for this type of aeration system.

3.2 Bubble Aerator

The analysis conducted on this type of aeration is where air was injected into water through stone aerator. Basically, the type of aerator used for aquatic living increases the dissolved oxygen level in water. The analysis was conducted with sample of water is the constant variable, maintained at 300mL and 10 minutes of each analysis. For every analysis conducted, a new sample was used that has been collected on the same site at Sungai Kangka, PKS. Based on Table 2, the data analysis was recorded and categorized on three different dimensions of stone aerator. From this data, it shows that the level of dissolved oxygen increases alongside the dimension on the aerator due to the larger surface area. Based on the suitability in Sungai Kangka, the bubble aerator as sample B suits the aeration system where the dissolved oxygen level was increased to 48%.

Table 2. Percentage of dissolved oxygen increment by bubble aerator

Water Sample	A	B	C
Stone Aerator Dimension (mm)	60 × 46 × 5	80 × 50 × 5	170 × 85 × 5
Percentage of dissolved oxygen increase, %	26	48	81

Based on the analysis obtained, impeller aeration system which is fan blade or impeller is suitable to be used to ensure river stream continuously flowing. This method will reduce stagnant point water along river pathway. Theoretically, will cause turbulence effect in river stream and increase dissolved oxygen level in Sungai Kangka, PKS (Marcy et al., 2010). On the downside of this type of aeration system, this equipment will use various mechanical parts such as bearing, motor, floating device, and others. If this aerator is not well maintained, it tends to have a short lifespan due to immersing in water and will cause corrosion. Compared to bubble aerator, which has fewer parts compared to blade aerator, which led to less maintenance activities conducted on side. Furthermore, bubble aerator increases the level of dissolved oxygen higher compared to fan blade aeration system. The purpose of the analysis conducted was to determine ways to increase the efficiency of water aeration process (Amano et al., 2013). The objective of the analysis was achieved using propeller and fan blade designs and air diffuser. Standard Oxygen Transfer Efficiency (SOTE) were analyzed and indicated a decrease in impeller and fan blade aeration system compared to standard model air diffuser (Amano et al., 2013).

Compared to bubble aerator which induced air into water to increase the dissolved oxygen level, more mixing causes an improvement of Standard Oxygen Transfer Efficiency (SOTE) for the system (Boyd, 1998). These facts were supported with data obtained from Table 2 after analysis conducted. Dissolved oxygen, which indicates the quality of the water, is one of the most essential factors to sustain healthy life for organisms in aquatic (Sombatjinda et al., 2011).

4. Conclusion

Data obtained from the analysis conducted shows that aeration system gives an immediate effect of dissolved oxygen level in certain amount of time. For both types of aeration system used in the analysis, it can be concluded that fan aerator suitable for ensuring river stream to continuously flowing and reducing the possibilities of the stagnant point, hence increase the level of dissolved oxygen. Although bubble type aeration system also has the same purpose which increases the dissolved oxygen, based on the data obtained, this type of aeration increases the dissolved oxygen level more quickly compared to fan aeration system. On the downside, this type of aeration system is suitable to use in ponds such as water treatment plant or sewerage treatment plant due to its ability to ensure river stream to continuously flowing.

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