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Application of swirl type microbubble generator in artificial wastewater treatment

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Abstract
A microbubble generator (MBG) produces tiny air bubbles that remain suspended in water for extended periods. This study investigates the use of MBG to enhance wastewater treatment by increasing dissolved oxygen levels, which are crucial for bacterial breakdown of organic pollutants. The experiment involved varying water discharge (QL) from 40 to 60 Lpm and air discharge (Qg) at 0.5 and 1 Lpm. COD (chemical oxygen demand) was measured to assess treatment effectiveness. Results showed that increasing QL with constant Qg enhanced air transfer and dissolved oxygen, leading to faster COD reduction. Increasing Qg at constant QL increased both bubble size and number, also improving oxygenation, but not as significantly as increasing QL. This highlights the importance of water flow in maximizing the benefits of MBG for wastewater treatment.

Keyword
Microbubble generator, Artificial wastewater treatment, Water flow

Introduction
Water is the basic need of living things. Protection of water quality is very important because it greatly affects the quality of life of living things. The growth of population and industry causes greater water consumption, on the other hand the amount of wastewater from human and industrial activities is also increasing and the availability of clean water is decreasing [1]. Some industries deliberately discharge wastewater that does not meet the required quality directly into the environment. This can cause environmental damage that will ultimately interfere with the quality of life of living things. The main reason cited is the economic reason that waste treatment requires considerable costs and the unavailability of effective wastewater treatment technology [2].

One method of wastewater treatment that has recently been widely used is biological water treatment [3]. Biological water treatment is a water treatment method with the

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help of microorganisms to degrade organic matter in wastewater into more environmentally friendly products. Microorganisms can be divided into two types, namely aerob and unaerob. Aerob microorganisms are microorganisms that metabolize with the help of oxygen. Aerob biological wastewater treatment methods have economic advantages and are more environmentally friendly than chemical and physical methods [4]. However, this method has the disadvantage that it requires a relatively long time. One of the causes is the lack of oxygen supply needed by microorganisms [5]. Oxygen supply for microorganisms is used to degrade organic matter in wastewater into more environmentally friendly products. Therefore, aeration technology is needed that is able to produce oxygen needed by microorganisms in decomposing organic matter in wastewater. Microbubble generator technology is a solution to the problem, because this technology is able to produce micron-sized bubbles that are able to produce dissolved oxygen in water so that water quality becomes improved [3][6][7][8]. Recently, the technology to increase oxygen supply in wastewater using microbubbles has received considerable attention [9][10]. The results of research conducted by Hitachi Research Laboratory (2013) show that the use of microbubble in the water treatment process can reduce operating costs by 20% when the process uses millibubble.

Microbubbles or micron-sized bubbles are defined as bubbles whose diameter is smaller than one millimeter and larger than one micrometer [11][12][13][14]. One of the unique properties of these microbubbles is that they can stay in the water for a long time because of their small buoyancy force, so they are widely used for aeration in fishery ponds or sewage treatment ponds, because they can increase the oxygen content dissolved in water [15][16][17]. Currently, microbubble applications are increasingly attracting the attention of practitioners to explore possible applications in various industrial processes.

Several researchers have conducted research on the development of microbubble generators. Sadatomi et al designed microbubble generator with spherical body (2005) and multi fluid mixture (2012). Sadatomi has conducted fairly complete research on the characteristics of the two microbubble generators. Other researchers who conducted research on microbuble generators include [18], using shirasu porous glass to produce microbubble, [18] conducted a study of swirl jet microbubble generator, [19] conducted microbubble research with venturi structure and [13] conducted microbubble research with an orifice-porous structure, whereas [14] conducted microbubble research with a swirl structure. There has not been much research on microbubble generators applied to wastewater treatment, so it is necessary to conduct more in-depth research on the development of microbubble generators that are suitable for wastewater treatment.

This research on artificial wastewater treatment using a Swirl type Microbubble Generator is expected to increase the data base and research knowledge of water treatment technology applications. The research gap in this study is the use of a swirl type microbubble generator which is different from previous researchers. So, this research can be useful for science and the development of the industrial world in the field of waste water treatment.

Methods

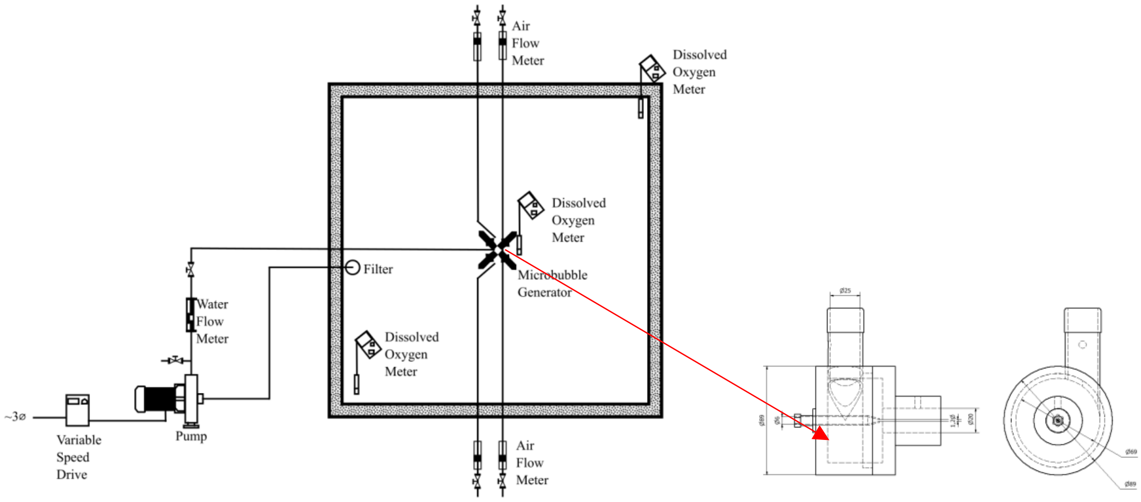

Figure 1. Schematic of research equipment for the application of swirl type microbubble generator in reducing chemical oxygen demand of wastewater

Schematic of research equipment

The schematic of the equipment for the microbubble generator application research on the reduction of chemical oxygen demand of wastewater is shown in Figure 1. The test section is a pool with a size of 300 cm wide, 300 cm wide with a depth of 1 meter containing artificial wastewater with a depth of 40 cm. Artificial wastewater is circulated in a closed manner using a 3-phase centrifugal pump. The wastewater circulation discharge is regulated by adjusting the pump rotation. Variable speed drive is used to adjust the rotation by changing the frequency of the input power source to the pump electric motor. To generate bubbles in the sewage treatment process, 4 swirl type microbubble generators are used. Microbubble generators are placed in the center of the pond at a depth of 20 cm from the water surface. To reduce uneven water discharge, the four microbubble generators are mounted on a header. A rotameter-type water flow meter is used to measure the discharge of wastewater flowing through the microbubble generator. Air flows into the microbubble generator naturally. The air discharge flowing in each microbubble generator is regulated by using a valve.

COD testing

COD value testing was carried out on artificial wastewater with a composition of tapioca starch 4800 grams, sugar 320 grams, urea 320 grams and potassium diphosphate (KH_2PO_4) 480 grams dissolved in water with a volume of 3.6 m^3 (3m x 3m x 0.4m). The test steps are as follows: 1) Breeding (start-up) bacteria, the bacteria used are aerobic bacteria in the form of activated sludge obtained from wastewater disposal sites in the Cepu landfill for 1 month. The addition of granulated sugar to active sludge can produce multicultural bacteria and accelerate bacterial development. The development can be seen from the active sludge that has been mixed yellow as shown in Figure 2.

Figure 2. Start-up bacteria

2) Filling the basin with water with artificial wastewater with the composition as described in point 1, 3) Putting the start-up bacteria into the basin, 4) Aerating wastewater with a microbubble generator for 5 days (120 hours) for each variation of air discharge and water discharge, 5) Wastewater samples for COD analysis were taken every 12 hours, 6) Inserting artificial waste with the composition as described above was carried out for each change in the variation of air discharge and water discharge. Measurement of chemical oxygen demand (COD) of artificial wastewater samples was carried out using the colorimetric closed reflux method at the Service Technical Implementation Unit of Environmental Laboratory of the Environmental Agency of Blora Regency, Jalan Wilis No. 24 Blora Regency, Central Java.

Results and Discussion

One indicator of the success of wastewater treatment is the reduction of COD (chemical oxygen demand) of wastewater. COD is used as an indicator of the amount of organic content of wastewater. With the help of bacterial microorganisms, the organic content in wastewater can be converted into simpler substances such as CO_2 and H_2O. In the conversion process, bacteria require sufficient dissolved oxygen in the water. Microbubble generator in this case serves to increase dissolved oxygen in water.

The test results of the microbubble generator application in artificial wastewater treatment are shown in Figure 3. In the figure, it can be seen that dissolved COD (SCOD) has decreased after aeration using a microbubble generator.

In Figure 3, it can be seen that an increase in QL at a constant Qg of 1 x 4 lpm will increase Kr or l/(mg SCOD/hour. An increase in QL will increase the rate of mass transfer of air to water. An increase in the amount of dissolved air in the water will increase bacterial metabolism, thus increasing the rate of decrease in SCOD. Increasing the air flow from 0.5 lpm to 1 lpm at a constant QL of 50 x 4 lpm also increases Kr. Increasing Qg will increase the bubble diameter, but on the other hand the number of bubbles also increases. Research results for clean water in QL 50 lpm, an increase in Qg from 0.5 lpm to 1 lpm will increase the volumetric mass transfer coefficient. This can be interpreted as an increase in dissolved oxygen in the water.

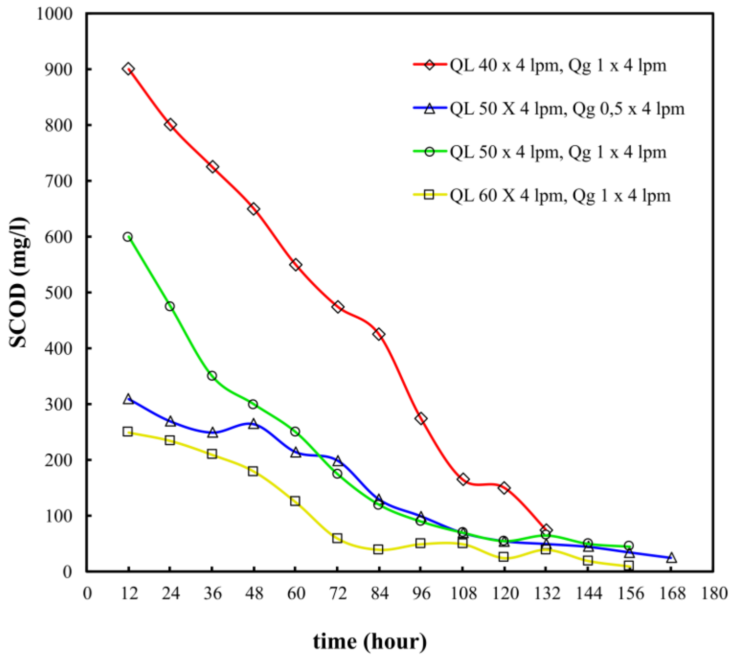

Figure 3. SCOD changes in the aeration process with microbubble generator

Figure 3 cannot be used to determine the combination of Q_L and Q_G that produces the greatest SCOD reduction rate. This is because the test was conducted continuously, making it difficult to equalize the initial SCOD for each Q_L and Q_G variation. The rate of SCOD reduction depends on bacterial metabolism, sufficient nutrients will accelerate the development of bacterial culture so that the rate of SCOD reduction will be faster [20]. To analyze the bioprocesses occurring in the effluent treatment pond (reactor), a mathematical model was developed [3] is based on mass balance as follows:

[substrate input rate] – [substrate output rate] = [substrate concentration rate] (1)

The substrate in this case is SCOD. The substrate output rate is in the form of products produced by bacterial metabolism and new breeding bacteria. The rate of SCOD decrease depends on the number of bacteria in the water. When the substrate concentration is still high, the bacteria will multiply quickly and the substrate conversion process will be higher so that the SCOD reduction rate is higher. At low substrate concentrations, bacterial proliferation is slow, some bacteria will die or survive but not multiply.

Conclusion

Swirl type Microbubble Generator, is a technology that produces micron-sized bubbles that can increase the oxygen content in waters. In the aerobic waste processing process, this is very useful because it can reduce dissolved chemical oxygen demand

(SCOD) in waste water. The decrease in the SCOD value is an indicator of the success of wastewater treatment, so it can be concluded that the SCOD value decreased after aeration was carried out using a microbubble generator, and the rate of decrease in SCOD in artificial wastewater was influenced by the water discharge and air discharge through the microbubble generator. Equating the initial conditions when testing a microbubble generator is very difficult, so the value of l/(mg SCOD/hour can be used as an indicator of the performance of the microbubble generator. Furthermore, for further development research, the performance of the microbubble generator can also be seen in terms of the power required.

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