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PURIFICATION EXPERIMENTS ON THE PASIG RIVER, PHILIPPINES USING A CIRCULATION-TYPE PURIFICATION SYSTEM

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ABSTRACT: Polluted sludge from the Pasig River generally exerts a very large environmental load to the surrounding area near the vicinity of Laguna de Bay and Manila Bay in the Philippines. Historically, the river was used to be a good route for transportation and an important source of water for the old Spanish Manila. However, the river is now very polluted due to human negligence and industrial development, and biologists consider it unable to sustain aquatic life. Many researchers have conducted studies on the Pasig River, unfortunately, no considerable progress from the point of view of purification process have succeeded. Hence, in this study, the use of fine-bubble technology for the purification of the polluted sludge from the said river is being explored. The critical point in using this technique is on the activation of the bacteria existing in the area using fine bubbles. The sludge is decomposed and purified by activating the aerobic bacteria after creating an aerobic state. In this study, the main objective is to test the performance of the purification system on the sludge and water taken from the Pasig River by comparing the results with the case study conducted in Funabashi Port, Japan. Based on the results of the study, it was established that the use of a circulation-type purification system is very good for it significantly decreased the total nitrogen in the samples from the Pasig River and Funabashi Port. Generally, the said system is considered effective in treating and purifying ocean or river sludge.

Keywords: Fine bubbles, Purification of Sludge, Circulation-Type Purification System, Pasig River, Aerobic Bacteria

1. INTRODUCTION

The Pasig River in the Philippines connects Laguna Lake to Manila Bay and divides the Philippine capital Manila into a northern and southern part. The Pasig River is a tidal estuary and the flow direction depends on the difference in water level between Manila Bay and Laguna Lake. The Pasig River was historically used as a very important transportation route and water source. The river is now very polluted due to a human negligence and industrial development [1]. There are many research papers [2-3] focusing on the investigation of the river, however no study has made considerable progress from the point of view of purification. Previously, one author investigated the COD (chemical oxygen demand) at about 15 points along the river [2] and it is interesting to note that the recent COD measurement conducted in the river showed that the value has almost doubled since the year 2000.

In general, polluted matter in solid form floats in water and polluted matter in water settles to the riverbed when pollution is severe. Hence, it is best to treat both pollution sources without a distinction between solids and water. Moreover, the treatment must be effective for both freshwater and seawater, since the river flows into the sea and is tidally influenced.

In this study, it was presumed that the best treatment method to be used for the treatment of sludge is through decomposition purification system using the circulation of fine bubbles to activate naturally the occurring aerobic bacteria. The system was successfully developed by one of the authors of this paper and is used for the treatment of ocean sludge [3].

Based on the information cited above, the main objective of the study is to demonstrate the effectiveness and efficiency of the circulation-type purification system for the treatment of sludge in the Pasig River.

2. EXPERIMENTAL SYSTEM

2.1 Experimental Devices

As shown in Fig. 1, the experimental device is

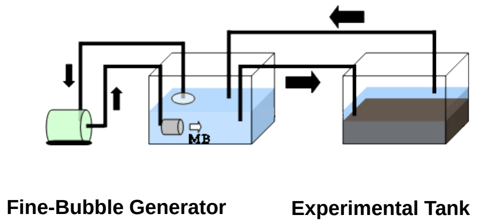


Fig. 1 Schematic Representation of the Experimental Apparatus

composed of two parts. The water circulates through two tanks. In one tank, fine bubbles are generated, using a system based on a previous study [5]. The fine bubbles have micro-size diameters and high solubility. This means that water with a high concentration of dissolved oxygen (DO) circulates through the tanks.

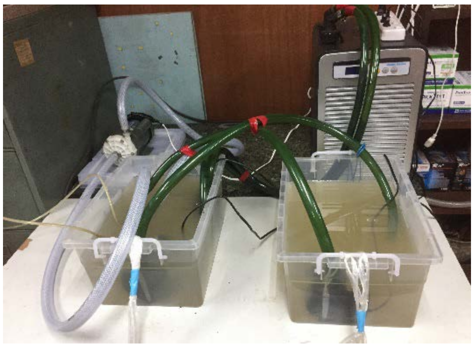


Fig. 2 Picture of the Experimental Apparatus

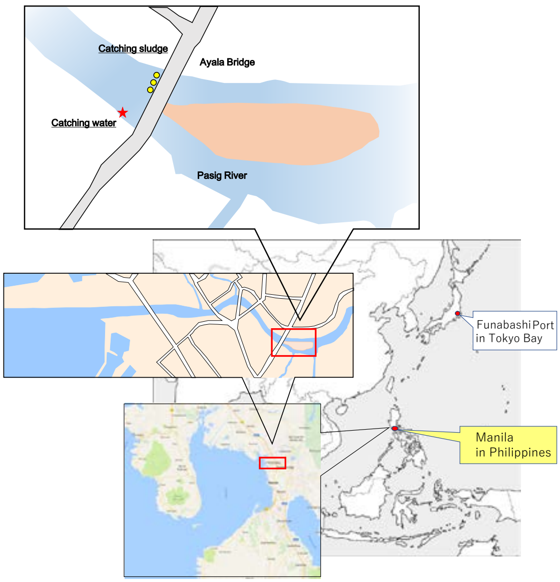


Fig.3 Sludge (Circle) and Water (Star) Sampling Points at the Ayala Bridge on the Pasig River, Manila

The second part of the device is the experimental tank. In this tank, the sample water and sludge are treated. The experimental set-up shown in Fig. 2 was conducted in one of the laboratories of the Integrated Research and Training Center (IRTC) at the Technological University of the Philippines (TUP), Manila.

2.2 Sampling of Points for Sludge and Water

Sedimentary sludge samples were collected using an Ekman-Berge bottom sampler at the Ayala Bridge on the Pasig River as shown in Fig. 3 and Fig. 4. Water samples were collected at the wharf near the sludge sampling points [3].

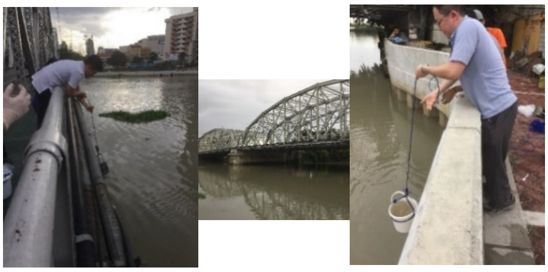


Fig.4 Sampling Sludge and Water in the Pasig River

Samples from Funabashi Port, Japan as shown in Fig. 5 were used to compare the efficiency and effectiveness of the purification system for the Pasig River.

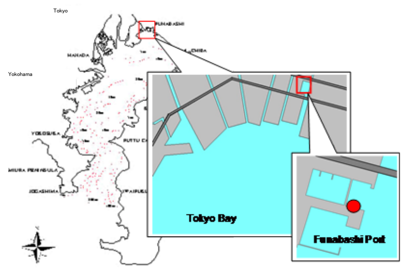


Fig.5 Sampling Point at Funabashi Port in Japan

2.3 Experimental Procedure

The dimensions of the experimental device are shown in Table 1. A sedimentary sludge sample of 0.417 (kg) and 25(L) of river water was collected. The samples were then put in the experimental tanks. The quality of the samples was measured from the moment the fine bubble generator started. After six hours of fine bubble generation, a microorganism activator was added in liquid form. The main component of the activator was kelp with some nutrients and enzymes. The microbial activator was added in a 100 (mg/L) concentration. The measured sample quality parameters were water temperature, pH, DO, ammonia nitrogen (NH_4-N), nitrite nitrogen (NO_2-N), nitrate nitrogen (NO_3-N), total nitrogen (T-N), and COD. Measurement of these parameters were conducted at 24, 48, 60, and 72 hours from the time the fine-bubble generator started. Water temperature and DO were measured using a multi-parameter water quality meter (portable fluorescent dissolved oxygen meter). A digital water analyzer; Digital Pack Test (Kyoritsu Chemical-Check Lab., Corp.) was used to measure NH_4-N, NO_2-N, NO_3-N, and T-N.

Table 1 Dimension of the Experimental Devices

Water = 25 L, Sludge= 0.417 kg
Size of Water Tank = 200x270x370 mm
Flow Rate for Fine Bubble Generator = 43 L/min
Flow Rate for Circulation Water Pump = 10 L/min
Microbial Activator = 100 mg/L

3. RESULTS AND CONSIDERATIONS

3.1 Water Temperature, pH and Dissolved Oxygen

The measured results of water temperature, pH, and DO are shown in Fig. 6. From the figure, the water temperature stabilized at 30 degree Celsius, pH was constant at around 8.0, and the DO stabilized around 6.0 mg/L.

The water temperature, pH, and DO are the basic environmental conditions of the experiment and should be kept constant as much as possible for proper interpretation of the other measured parameters.

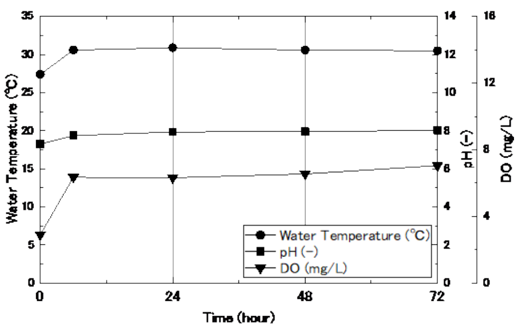


Fig. 6 Changes in Water Temperature, pH, and Dissolved Oxygen during the Experiment

3.2 Results of DIN (Dissolved Inorganic Nitrogen) and T-N in the Pasig River

The DIN is the totality of NH4-N, NO2-N, and NO3-N. Figure 7 shows the results of the measured DIN and T-N. Clearly, it can be observed that there is a significant decrease in DIN after 24 hours until 72 hours. DIN has slightly decreased after 6 hours but rapidly decreased after 24 hours. Therefore, it can be deduced that bacterial denitrification occurred in the system.

The measured T-N showed that the quality of the sample greatly improved. The temporary increase in T-N at about six hours may have been due to a slight delay in the inclusion of the microbial activator. After inclusion of the activator, T-N decreased significantly after 72 hours. Thus, it can be concluded that the purification system performed very well since the concentration of T-N after 72 hours was about 50% of the starting value.

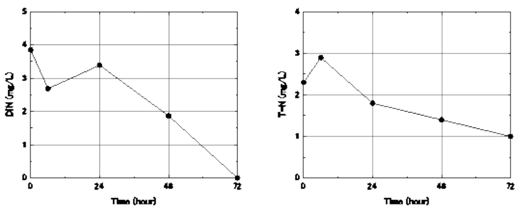


Fig. 7 Changes in DIN and T-N in the Pasig River

3.3 Comparison of the Purification Results for T-N with Funabashi Port in Japan

To compare the results obtained at Funabashi Port and the Pasig River, experiments were conducted to better understand the effect of the ratio of the sludge and water. The experimental conditions, with variable amounts of water and sludge, are shown in Table 2. The usual parameters used at Funabashi Port in Japan are 1 kg of sludge and 30 L of water and the total experimental time is 120 hours. Case 1 was treated as the standard ratio of sludge, Case 2 was half the standard sludge ratio, and Case 3 considered a lower volume of water. These sludge and water were taken from Funabashi Port.

Table 2 Experimental Condition for Comparison of the Sludge Ratio

Case1: Water = 25L, Sludge = 0.84kg ; Standard
Case2: Water = 25L, Sludge = 0.42kg ; 1/2
Case3: Water = 20L, Sludge = 0.42kg ; 1/2

Figure 8 shows the results of the T-N for the three cases. It was estimated that the purification of the samples in Case 2 as shown in Fig. 8 was completed half the time of Case 1 according to the ratio of sludge.

However, there is no significant changes in the performance due to the difference in water volume between Case 2 and 3.

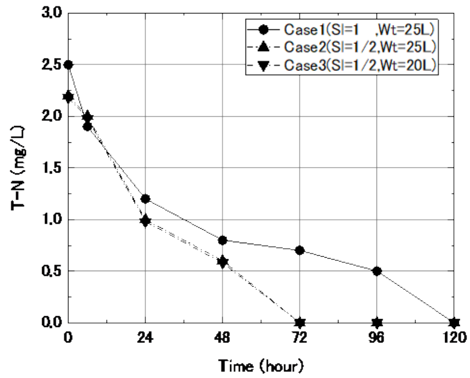


Fig.8 Comparison of T-N with Different Sludge Ratios

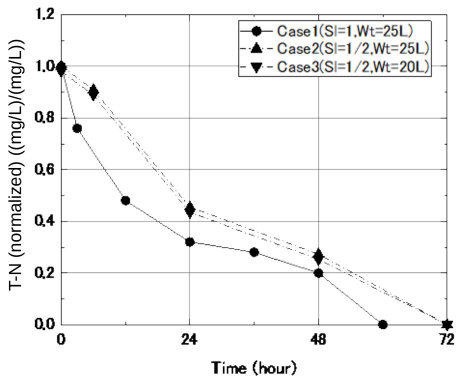


Fig. 9 Normalized T-N in Samples with Different Sludge Ratio

Based on the above condition, Fig. 9 presents the results for Case 1 half the run time, i.e. 60 hours instead of 120 hours. Thus, a linear relationship can be obtained and the y-axis shows the normalized expression.

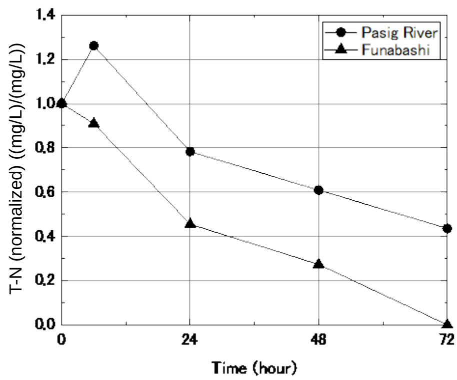


Fig. 10 Comparison of T-N in the Pasig River with Funabashi Port

Figure 10 shows the comparison of the T-N results between Funabashi Port and the Pasig River. From the said results, the circulation-type purification system in general exhibited the same trend and showed a good purification performance.

3.4 Visualization of Results

Figure 11 shows the experimental conditions at 0, 24, 48, and 72 hours. Changes in the color of the water in the tank can be visually observed, which demonstrates and manifests the purification effects.

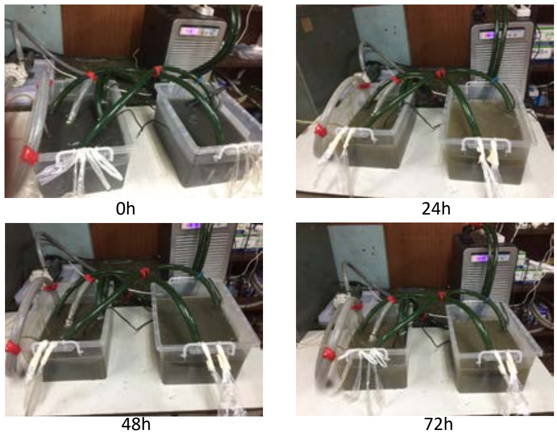


Fig. 11 Photos of the Experimental Tank with Time

3.5 Comparison of the Solid Results for the Pasig River and Funabashi Port

3.5.1 Comparison of EDX (Energy Dispersion Type X-ray Analysis Device) Results between the Pasig River and Funabashi Port

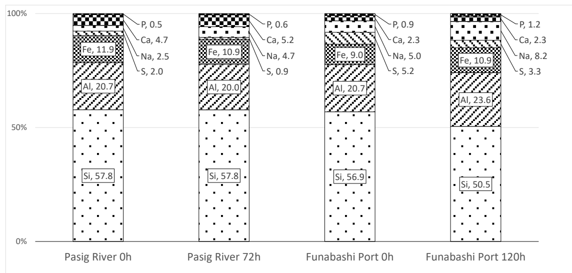
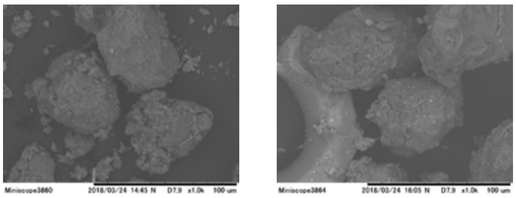


Fig. 12 EDX Results from the Pasig River and Funabashi Port

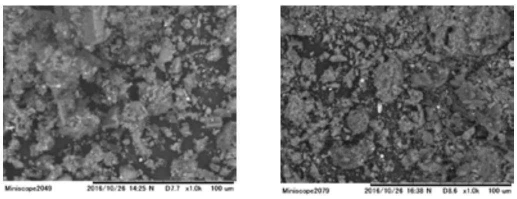
Figure 12 shows the comparison of the EDX results from the Pasig River and Funabashi Port. By comparison, the S (sulfur) decreased and Na (sodium) slightly increased at the end of the experiment. It is noteworthy to mention that there is a significant difference in Si (silica) between the two locations; no significant change was observed in the Pasig River sample. However, the proportion of Si in the Funabashi Port sample has slightly decreased. It appears that the Si (silica) ratio in Funabashi Port sample slightly decreased with the relative increase in Al and Fe. The other results showed the same trends for both locations.

3.5.2 Comparison of SEM (Scanning Electron Microscope) Results for the Pasig River and Funabashi Port he third level headings

Figure 13 shows a comparison of the SEM results from the Pasig River and Funabashi Port, at a magnification of 1000 times. By comparison, there is no significant change in the Pasig River sample at the end of the experiment.



(Pasig River; 0 h) (Pasig River; 72 h)



(Funabashi; 0 h) (Funabashi; 120 h)

Fig. 13 SEM Results from the Pasig River and Funabashi Port

The diameter of the sludge particles from the Pasig River is relatively large, thus, they are more resistant to abrasion. On the other hand, the diameter of the sludge particles from the Funabashi Port is relatively small, hence, at the end of the treatment process a significant decrease in diameter can be observed.

4. CONCLUSIONS

The effectiveness and efficiency of the circulation-type purification system in treating the sludge of the Pasig River was successfully established.

1) The purification efficiency was notably good as demonstrated by the decrease in DIN and T-N concentrations for both locations.

2) The purification performance was very good, as shown by the decrease in T-N in both the Pasig River and Funabashi Port samples.

3) The water color in the tanks over time also visually demonstrated very good purification results. In addition, the results of the EDX, the weight ratio of the matter in the solid dry sludge was successfully calculated. Moreover, it was clearly established through SEM analysis that there is a significant change in the diameter of the sludge particles at the end of the test.

4) Generally, it appears that the system can treat both polluted sludge and water which is very useful for application to the Pasig River.

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