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Enhancement of water quality using natural coagulant in Shah Alam Lakes, Malaysia

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Abstract. Drinking water shortage has become a significant problem in urban areas due to the growth of population and high economic activities. It is known that Shah Alam is the city and the state of Selangor, Malaysia. This city has the most manufacturing sector and services with a huge number of inhabitants. Thus, this urban area needs to have sufficient clean water supply. However, the raw water needs to undergo several water treatments processes before it can safely distribute to the residents. This untreated water from incoming surface waters contains suspended particles that need to go through the water treatment process, and most importantly, the coagulation and flocculation process. Normally, aluminum sulfate (alum) or polymer were added as the coagulant for the treatment of untreated water. However, due to health concerns, natural coagulants have been preferred to replace the conventional method. This natural coagulant is environmentally friendly and has no side effects if being consumed. This research aims to investigate the optimum condition of natural coagulant (*Moringa oleifera*) for the treatment of surface water from Shah Alam Lakes in Selangor Region, Malaysia. These lakes can be a potential source of water if water shortage occurs. At first, the characteristics of the water samples were determined. Later, the sample of surface water from the lakes was examined with the jar test for the coagulation-flocculation process using *Moringa oleifera* with different concentrations. The water quality parameters such as pH, turbidity, suspended solids, phosphorus and chemical oxygen demand were evaluated. From the results obtained, *Moringa oleifera* can be considered as suitable alternatives to replace chemical coagulants for a sustainable water treatment system.

1. Introduction

Safe and affordable drinking water supply is essential for the global population. In urban areas, adequate infrastructure for water treatment plants can be considered as extremely important. Hence, after the raw water has been treated, clean water needs to be distributed to the inhabitants for usage and application for economic activities [1]. However, environmental pollution in surface water has emerged as a critical issue recently. Thus, the dilemma of the deterioration of water quality has greatly impacted the water



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shortage as most of these resources of intake has been imperiled with pollution issues [2]. Thus, it is important to have adequate treatment of water supply and sufficient source of water to overcome the situation.

In sustainable development goals (SDGs) for Goal 6, the target for clean water and sanitation is a must to ensure that equal access to drinking water supply for the people [2]. Therefore, the water resources for drinking water need to be safeguarded to preserve the quality of water. Prolong to that, implementation of green technology to enhance the safer drinking water to the consumers has greatly been appraised. Most of the water purification used chemical coagulant to treat raw water [3]. However, these substances would lead to health issues in the long term [4]. Thus, several bio-coagulant or natural coagulants have been emerging and recognized as the substitutes for coagulation process in the water treatment plant.

One of the natural coagulants that have been recently studied is *Moringa oleifera* [5]. This plant has been considered as one of the most widespread plant species that can grow quickly at a low altitude in many tropical countries around the world. Interestingly, this plant of *Moringa oleifera* can easily be found in Malaysia. This plant can be considered as one of the world's most useful trees [6]. It acts as soil fertilizer and can be used as cooking and lighting oil [6].

This paper aims to focus on the analysis of the water quality in two different water sources in Shah Alam, Selangor, Malaysia. Shah Alam has been recognized as the city of Selangor that has high economic growth and expanding population. The demand for clean water supply is crucial due to the increasing numbers of inhabitants in Shah Alam, Selangor. Moreover, the critical issue of water shortage in Selangor has become a major dilemma to the authority [7]. Thus, surface water availability needs to be explored for the solution of water scarcity. Here, Seksyen 2 Lake and Seksyen 7 Lake in Shah Alam, Selangor, Malaysia have been chosen as the case study. The water quality of the two-sampling points will be evaluated with the jar test method to examine the efficiency of *Moringa oleifera* as a coagulant in the coagulation process. In this research, the potential of *Moringa oleifera* as natural coagulant will be evaluated for the enhancement of water quality in terms of pH, turbidity, and suspended solids.

2. Material and methods

2.1 Sampling collection

The water samples from surface water were taken at two selected areas of the case study, which was Seksyen 2 Lake and Seksyen 7 Lake in Shah Alam, Selangor, Malaysia. The quantity of both samples taken was 20 L each to perform the jar test experiment.

2.2 Parameter testing

The tests for pH, turbidity, suspended solids for both samples were carried out on-site using portable HORIBA instruments [8]. Later, the samples were collected into the plastic container with a preservation method [9], labelled, and stored in the refrigerator at 4°C. In the laboratory, the water samples were tested for phosphorus concentration and chemical oxygen demand (COD) following the Standard Methods [9]. All the water samples were tested in triplicate.

2.3 Preparation of natural coagulant

Natural coagulant of *Moringa oleifera* was obtained from Kanchong Darat Village, Banting, Selangor, as shown in figure 1. The seed of *Moringa oleifera* was taken out and dried in the oven for about 103°C in 24 hours [6]. The dried seeds were ground into a fine powder using a blender. The fine powder of *Moringa oleifera*'s seeds was weighed for 10 g, 20 g, and 30 g of dried powder. Later, the weighed *Moringa oleifera*'s seeds were dissolved in 1-litre deionized water (DI), respectively. The suspension was stirred using a magnetic stirrer at room temperature for 60 minutes. After that, the insoluble material was filtered using filter paper (Whatman no. 1) [6]. The clear solution was then used as a coagulant for the jar test experiment.

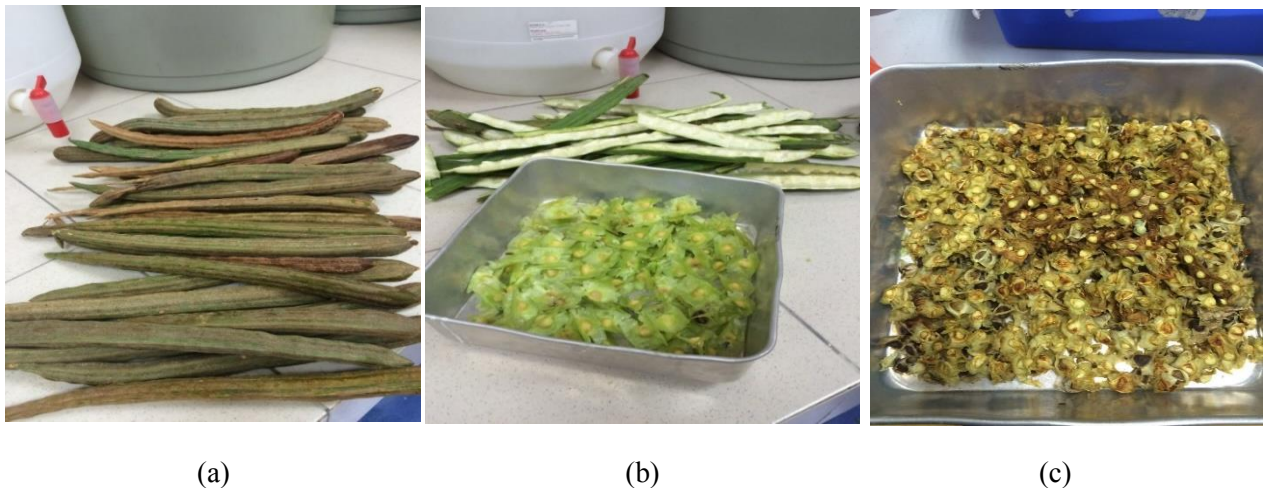


Figure 1. (a) *Moringa oleifera*, (b) *Moringa oleifera*'s seed before dried in the oven and (c) *Moringa oleifera*'s seed after dried in the oven.

2.4 Jar test experiment

The coagulation process was conducted using a jar test (JLT 6 Velp Scientifica, Usmate, Italy) in Environmental Laboratory, Faculty of Civil Engineering, Universiti Teknologi MARA, Shah Alam, Selangor. An amount of 500 mL of the raw water samples was poured into six beakers of 1 litre, separately. After that, the coagulant was added into those beakers at a different dosage. The natural coagulant of *Moringa oleifera*'s seeds powder was used in the experiment for the two sampling points, as explained earlier in the previous section. Then, it was stirred at a rate of 120 rpm for rapid mixing at about 1 minute. Later, the beakers were stirred with slow mixing at a rate of 40 rpm for 25 minutes. Lastly, the paddles were then withdrawn from the beakers, and the flocs particles were allowed to settle by gravity for 30 minutes. Then, the results of turbidity, pH, suspended solids, phosphorus and COD for all the samples were determined (9).

3. Results and discussion

3.1 Results of the parameters before jar test

The water parameters analyzed include turbidity, suspended solids (SS), pH, phosphorus and COD. Table 1 shows the raw water quality of two samples from Seksyen 2 Lake and Seksyen 7 Lake in Shah Alam, Selangor, Malaysia.

Table 1. Raw water quality for two samples of Seksyen 7 Lake and Seksyen 2 Lake in Shah Alam, Selangor, Malaysia.

Parameters	Raw water	
	Section 2 Lake	Section 7 Lake
Suspended Solids (SS), mg/L	91	83
Turbidity, NTU	92.8	133
pH	7.19	7.44
Phosphorus (mg/L)	0.41	1.97
COD (mg/L)	23	16

In table 1, the result of suspended solid from Seksyen 2 Lake is 91 mg/L, higher than the suspended solid in Seksyen 7 Lake. However, both samples have higher suspended solids than the standard of

Water Quality Index (WQI) for Class IIA and IIB (50 mg/L) [10]. The turbidity results for the two water samples were 92.8 NTU and 133 NTU for Seksyen 2 Lake and Seksyen 7 Lake, respectively. The turbidity results for both samples were also higher than WQI for Class IIA and IIB (50 NTU) [10]. The pH value for Seksyen 2 Lake was 7.14, and Seksyen 7 Lake was 7.44, both water samples were in the range of WQI (pH range of 5 to 9) [10]. Phosphorus and COD values were not of primary concern as the concentrations were small. However, adequate treatment is important to enhance the water quality of both samples from Seksyen 2 Lake and Seksyen 7 Lake in Shah Alam, Selangor, Malaysia.

3.2 Results of parameter after jar test

Suspended solid is one of the physical characteristics that indicates the existence of inorganic materials, bacteria, algae, and other contaminants in water sources [11]. Suspended solids could decrease the clarity of the water. Figures 2 and 3 show the different readings of suspended solids of *Moringa oleifera* at three different concentrations, 10 g/L, 20 g/L and 30 g/L for both samples of Seksyen 2 Lake and Seksyen 7 Lake.

From the results obtained in figure 2, the best optimum dosage for suspended solids is 20 g/L for Seksyen 2 samples. However, in figure 3 (Seksyen 7 samples), the 10 g/L is a better dosage compared to the other two dosages (20 g/L and 30 g/L). It can be identified that *Moringa oleifera* can react as the coagulant for the water samples. From the jar test, a significant reduction from initial concentration can be observed for both samples.

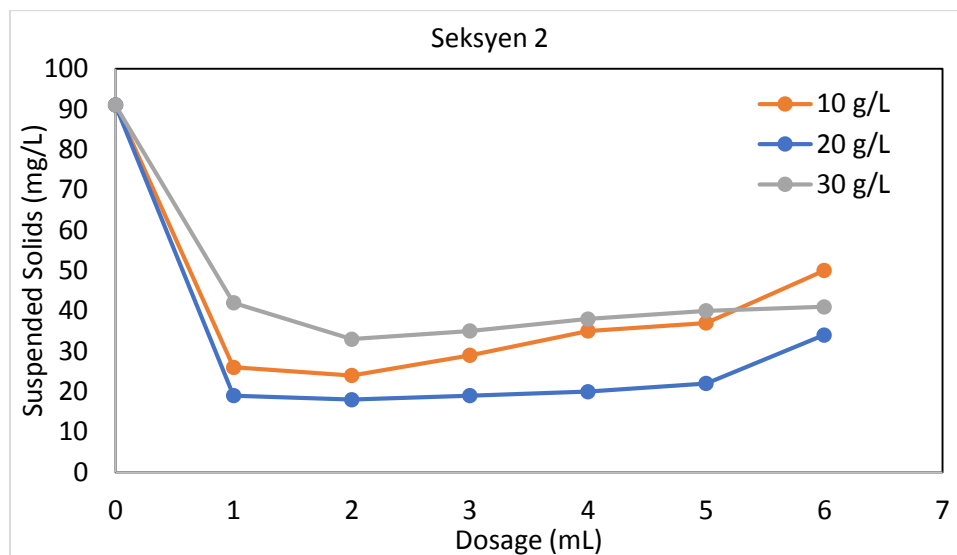


Figure 2. Result of suspended solids for the concentration of 10 g/L, 20 g/L and 30 g/L of *Moringa oleifera* for Seksyen 2 sample.

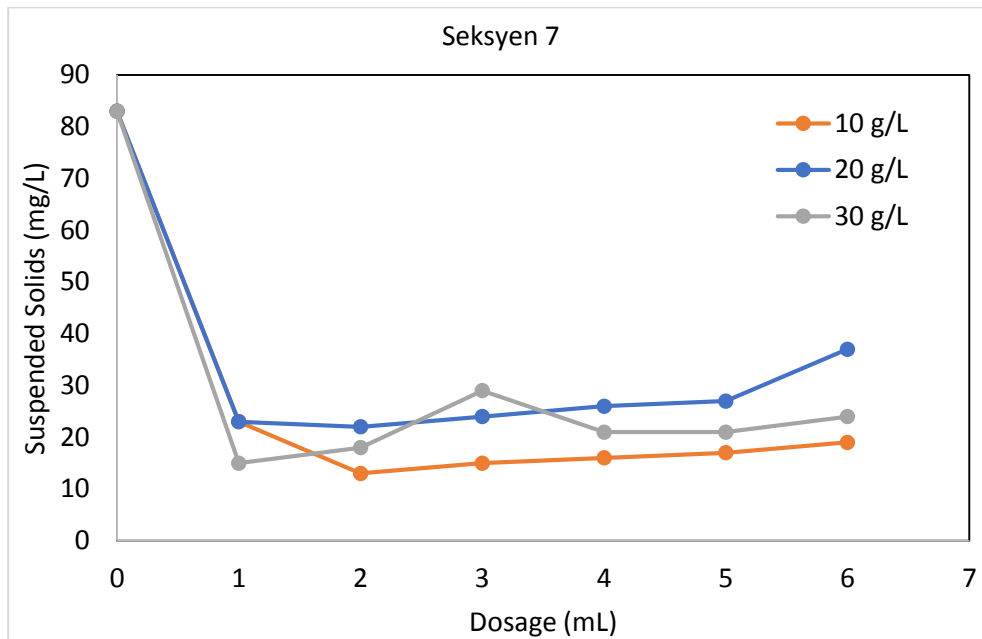


Figure 3. Result of suspended solids for the concentration of 10 g/L, 20 g/L and 30 g/L of *Moringa oleifera* for Seksyen 7 sample.

Similar patterns can be observed for the turbidity in both samples of Seksyen 2 and Seksyen 7 shown in figures 4 and 5 respectively. The use of 20 g/L *Moringa oleifera* has again primarily caused a higher decrease in turbidity in the Seksyen 2 sample. For the Seksyen 7 sample, 10 g/L concentration achieved far better results compared to 20 g/L and 30 g/L concentration of *Moringa oleifera*. However, the *Moringa oleifera* of 30 g/L can slightly give the same turbidity result for the Seksyen 7 sample. The higher turbidity of water represents high pollutants concentration and would greatly affect the human body. Turbidity could occur by the release of contaminants and degradation of wastes into the surface water [11]. Turbidity removal shows positive results where the value of turbidity has lessened until it meets the optimum dosage. *Moringa oleifera* is suitable to be used as a coagulant in the water treatment process as this substance has been proved to be an effective natural clarifier for untreated pathogenic and highly turbid in surface water [6].

The pH values could determine the reactions of chemical and biological activities. Typically, the pH values for drinking water purpose is pH 7 (neutral). The determination of pH value depends on the number of hydrogen ions (H^+) and hydroxyl ions (OH^-). The lower number of pH that is below 7, the more acidic the water, while the higher the number of pH that is above 7, the water tends to be alkaline. After the coagulation process, the pH value changes to be more acidic. After the jar test using *Moringa oleifera*, the pH value has become slightly acidic. All of the samples have pH values that are greater than six but lower than 7, as shown in figures 6 and 7. Further treatment using calcium carbonate can be implemented to treat water with a pH greater than 6.

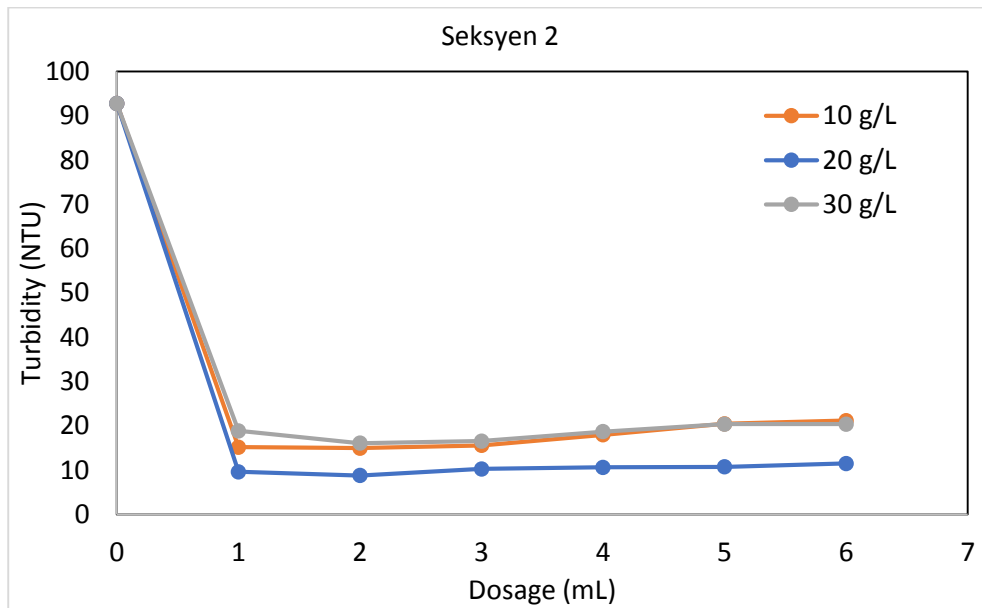


Figure 4. Result of turbidity for the concentration of 10 g/L, 20 g/L and 30 g/L of *Moringa oleifera* for Seksyen 2 sample.

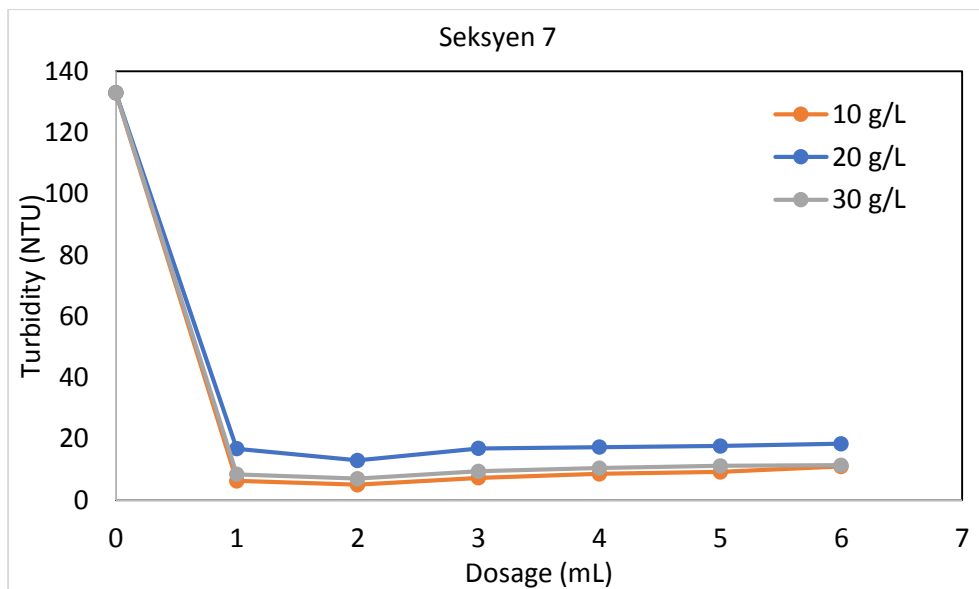


Figure 5. Result of turbidity for the concentration of 10 g/L, 20 g/L and 30 g/L of *Moringa oleifera* for Seksyen 7 sample.

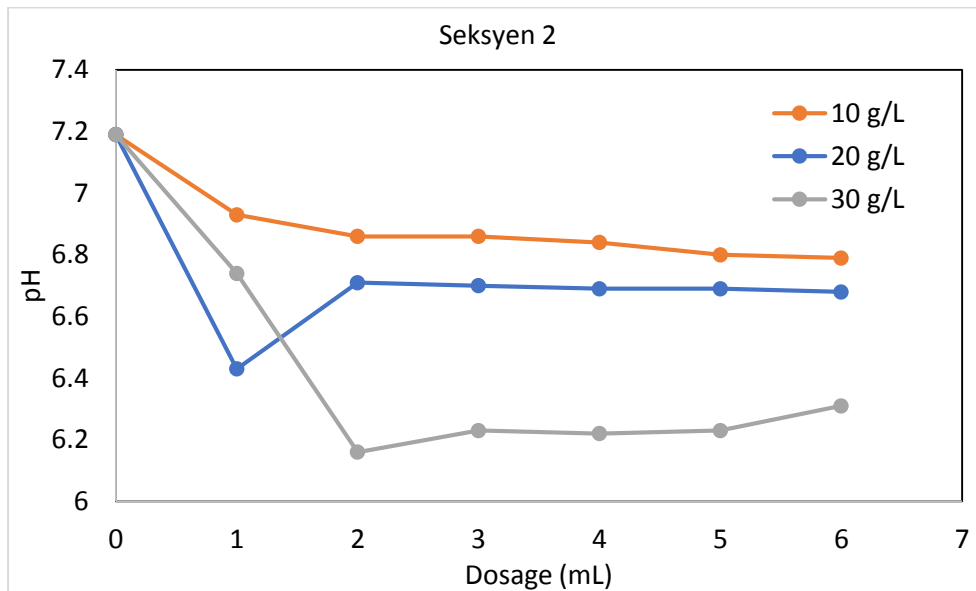


Figure 6. Result of pH for the concentration of 10 g/L, 20 g/L and 30 g/L of *Moringa oleifera* for Seksyen 2 sample.

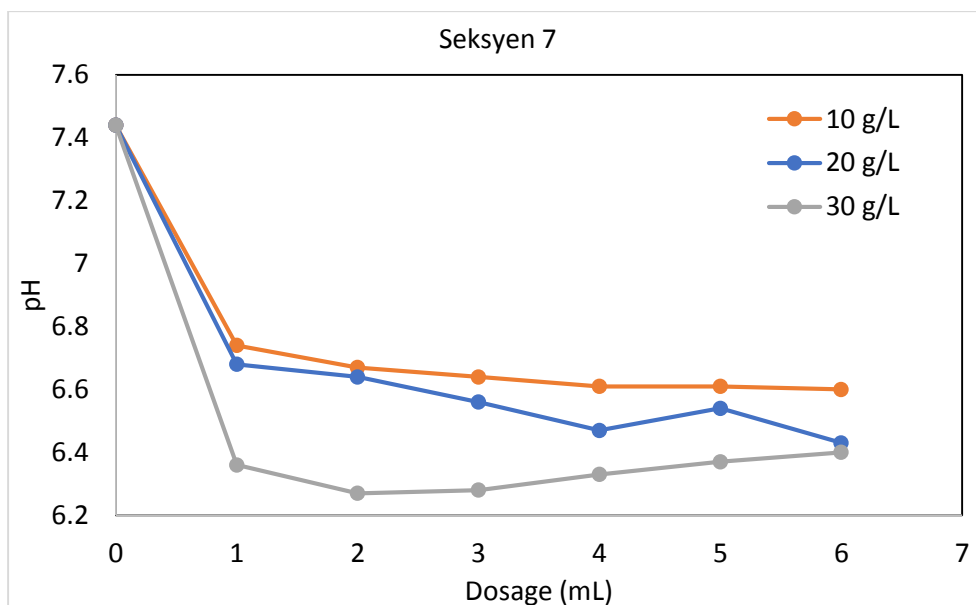


Figure 7. Result of pH for the concentration of 10 g/L, 20 g/L and 30 g/L of *Moringa oleifera* for Seksyen 7 sample.

Table 2 shows the result of phosphorus and COD after treatment with 10 g/L, 20 g/L and 30 g/L of *Moringa oleifera*. It can be seen that the reduction rate of phosphorus and COD are not significant compared to the suspended solids and turbidity. However, the natural coagulant of *Moringa oleifera* can be replaced as an alternative coagulant that can reduce the operating cost of water treatment as this plant can be found abundantly in Malaysia [12]. Several other materials such as rice husk, palm oil fruit bunch, sugarcane bagasse can also be considered to be potential coagulants. Moreover, the replacement of *Moringa oleifera* and other natural coagulants compared to chemical coagulant would bring a high impact in the implementation of green technology in the water treatment plant in Malaysia.

Table 2. Phosphorus and COD for 10, 20 and 30 g/L of *Moringa oleifera* concentration.

Parameters	Section 2 Lake			Section 7 Lake			
	Location	10 g/L	20 g/L	30 g/L	10 g/L	20 g/L	30 g/L
Phosphorus (mg/L)		0.41	0.38	0.40	1.97	1.90	1.96
COD (mg/L)		23	18	20	16	7	14

4. Conclusion

Based on this study, it can be concluded that *Moringa oleifera* shows a high potential to be used as an alternative coagulant for water treatment purposes. This natural coagulant can replace the chemical coagulant of alum significantly. It can be considered as a green product for sustainable water treatment. Furthermore, if *Moringa oleifera* is consumed by human in moderate quantities, this will not bring harm to health in contrast with alum that can be poisonous if ingested. The use of natural coagulants derived from *Moringa oleifera* can improve the quality of life for human being as this substance can lower the blood sugar levels. This natural coagulant is safer to be used compared to the chemical coagulants and has potential to be commercialized. Moreover, *Moringa oleifera* can be easily found in Asian countries. Thus, it is important to have further research on this natural coagulant for the future development of green technology in the water treatment process.

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