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Treatment of Wastewater by *Moringa Oleifera* and *Maize Seeds* as Plant-Based Coagulant

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Abstract. Coagulants are essential in purifying raw water for drinking water safety for consumers. Commonly, aluminium sulphate, a chemical coagulant, is used for water treatment. However, for long-term usage, chemical coagulants can be considered toxic and harmful to the environment due to the accumulation of this substance in the pipeline system, which can create severe health issues if consumed. The natural plant-based coagulant can be a substitute for a sustainable solution in the water treatment coagulation process. This research aimed to determine the efficiency of plant-based materials as coagulants in surface water treatment. Moringa oleifera and maize seeds were chosen as natural coagulants in this investigation since they are both locally available plant-based materials. Here, this research aims to study the ability of moringa oleifera seed and maize seed as plant-based coagulants in enhancing the effluent quality of the wastewater treatment plant of UiTM Dengkil Selangor. A jar test experiment was used to assess the capacity of moringa oleifera and maize as natural coagulants. The results comprise turbidity removal by 92% (mixed of moringa oleifera seed and maize seed), the chemical oxygen demand (COD) of 95% reduction rate using moringa oleifera seed. The biochemical oxygen demand (BOD) for 88% removal by moringa oleifera seed, ammonia-nitrogen removal of 12% (moringa oleifera seed) and total suspended solids (TSS) of 100% reduction rate using mixed moringa oleifera seed and maize seed for the effluent sample. Thus, it can be recognized that moringa oleifera and maize seeds can be an alternative solution to replace the chemical coagulants in the treatment systems.

Keywords: coagulants, effluent, moringa oleifera, maize seed, treatment

1. Introduction

The water of high quality is important for human health, the environment, and ecosystems, together with social and economic development. However, the increase in urbanization, agricultural, and industrial production contributed to the detrimental effect on the quality of our water supply [1, 2]. Aside from human use, water is required for aquatic life as their habitat, and this aquatic life ultimately becomes the source of protein for humans. Despite that, it is becoming more difficult to get enough high-quality water. As a result, the issue of water scarcity will exacerbate, with most of the world's population unable to acquire clean drinking water [3]. Thus, untreated effluents from industries also reduce the quality of groundwater and surface water due to the toxic and undesirable chemical components in this effluent. The liquid would pass through the seepage and be discharged into the river nearby.

Moreover, our world is covered by 70% of water, but only 1% is freshwater, thus raising a demand to recycle wastewater to satisfy our needs [4]. Therefore, to continuously recycle wastewater, something needs to be done to reduce pollution by enhancing the treatment processes. The wastewater has been contaminated with various substances such as human waste, food scraps, oil, soaps, and chemicals. These include water from sinks, showers, toilets, washing machines, and home dishwashers. Many water treatment plants use coagulation, sedimentation, filtration, and disinfection technologies to provide clean and safe water for the environment. In wastewater treatment, coagulation is a process that involves adding compounds that promote the agglomeration of fine particles into larger flocs, making them easier to be separated [5]. Here in this study, plant-based natural coagulants, *Moringa Oleifera* seeds and *Maize* seeds were used to reduce the turbidity, chemical oxygen demand (COD) and Total Suspended Solid (TSS). Moreover, this research paper also obtained the effectiveness of using natural coagulants instead of chemical coagulants.

2. Methodology

2.1. Materials and Methods

This research utilized *moringa oleifera* seeds and *maize* seeds as plant-based coagulants. Both seeds were purchased from a local seller. At the same time, the effluent sample was obtained from the wastewater treatment plant at Universiti Teknologi MARA Dengkil, Selangor, Malaysia.

2.2. Parameter Testing

The experiments for pH and temperature were carried out using a probe meter of conductivity and total dissolved solids (TDS). The turbidity test used a turbidity meter, and the biochemical oxygen demand (BOD) was using dissolved oxygen (DO) meter. To detect ammonia-nitrogen, COD and TSS were analyzed with Spectrophotometer DR 2800. Initial parameter readings were obtained before the sample was treated and mixed with a plant-based coagulant. The samples were then collected into a plastic container with a preservation technique, labelled, and kept at $4^{o}C$ in the refrigerator.

2.3. Preparation of Coagulant

Moringa oleifera and *maize* seeds were washed, dried, ground, and sieved through various preparation steps. *Moringa* and *maize* seeds were often cleaned with distilled water to remove dirt and pollutants before being dried in an oven to absorb all the water content in the seeds. Both seeds are dried in an oven at 102ºC for 24 hours. The *moringa* seed was blended using an ordinary blender to produce powder of the substances. However, a laboratory ball mill was used to blend the *maize* seed due to the texture of *maize* which was harder than *moringa*.The *moringa oleifera* and *maize* powders were then sieved through a 400 mm aluminium sieve to remove large particles, and later these substances were produced as the plant-based coagulant. The fine powder of *moringa oleifera's* and *maize's* seeds was weighed for 40 g of dried powder, and the fine powder of the mixture for both plant-based with the ratio of 1:1, 1:2 and 2:1. For example, *moringa* and *maize* were weighed to produced 20 g: 20g (1:1), 20 g: 40 g (1:2) and 40 g: 20 g (2:1), subsequently. This coagulant was later used for the jar test experiment.

Figure 1. (Left) *Moringa oleifera* Seeds and (Right) *maize* seeds.

Figure 2. (Left) Both seeds were dried in an oven (Right). Both seeds were ground into powder.

2.4. *Experimental Run*

2.4.1. *Jar Test Experiments*

A jar test was used to perform the coagulation process. Separately, 500 mL of wastewater samples were put into the six 1-litre beakers. Following that, the coagulant concentration was applied to each beaker. In this experiment, the plant-based coagulant concentration employed were10 mg/l, 20 mg/l, 30 mg/l, 40 mg/l, 50 mg/l and 60 mg/l, respectively. As a control, one beaker of effluent was prepared without adding the coagulant (considered a blank sample). Later, the initial turbidity was measured. The mixture was then agitated at a rate of 60 rpm for approximately 3 minutes to ensure fast mixing. Afterwards, the beakers were swirled for 20 minutes at a gentle mixing rate of 30 rpm.

Finally, the paddles were removed from the beakers, and the flocs particles were allowed to be settled for 20 minutes. Then, the turbidity, pH, TSS, ammonia-nitrogen, COD, and BOD were determined for each sample.

Table 1. Dosage for Different Types of Coagulants.

No. of Jar	1	2	3	4	5	6
Moringa oleifera (40 mg/L)	10	20	30	40	50	60
Maize (40 mg/L)	10	20	30	40	50	60
Moringa oleifera + *maize* (1:1)	10	20	30	40	50	60
Moringa oleifera + *maize* (1:2)	10	20	30	40	50	60
Moringa oleifera + *maize* (2:1)	10	20	30	40	50	60

3. Results and Discussion

3.1. Result of parameters after jar test experiment

3.1.1. Effect of various coagulant dosages on turbidity

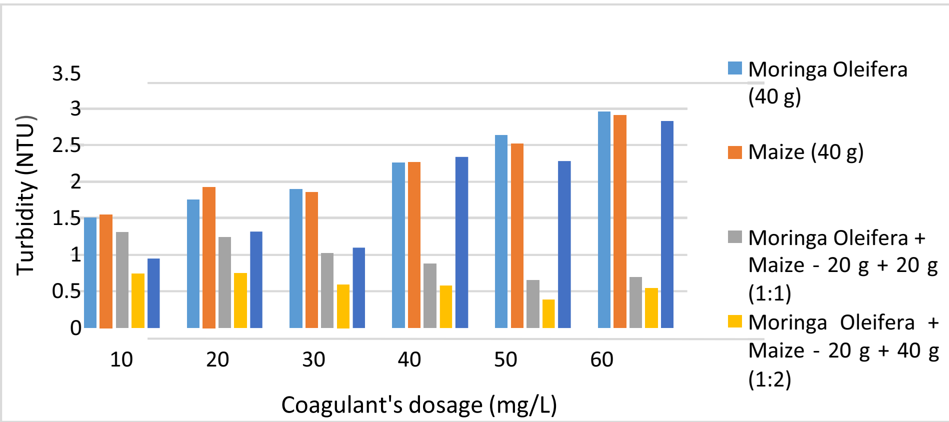

Figure 3. Results of turbidity for various coagulant dosages.

All plant-based concentrations can be used as a coagulant in wastewater treatment. The results obtained showed a positive outcome. It shows that the value turbidity for six types of coagulants dosage is lesser than other plant-based concentrations. High turbidity is where the coagulant did not absorb the number of suspended solids, and the results obtained before and after treatment were

4.64 NTU and 0.39 NTU, respectively. For *moringa oleifera* mixed with *maize*, 20 g + 40 g (1:2) showed the best results after coagulation treatment.

3.1.2. Effect of various Coagulant Dosage on pH

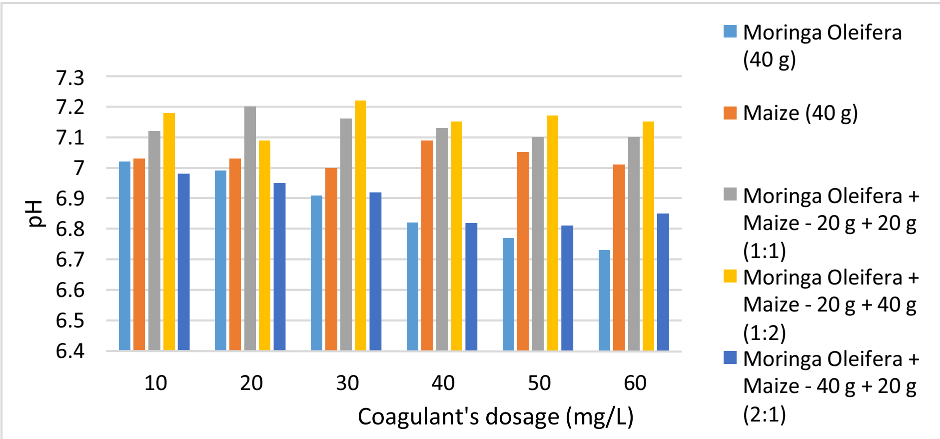

Figure 4. Result of pH for various coagulants dosage.

It shows that from the experiment, the effluent sample tends to be alkaline. The lower the number of pH units below 7 is acidic water. On the other hand, the higher number of pH units that is above 7, the water will be alkaline.

3.1.3. Effect of various coagulants dosage on ammonia-nitrogen (NH_3-N).

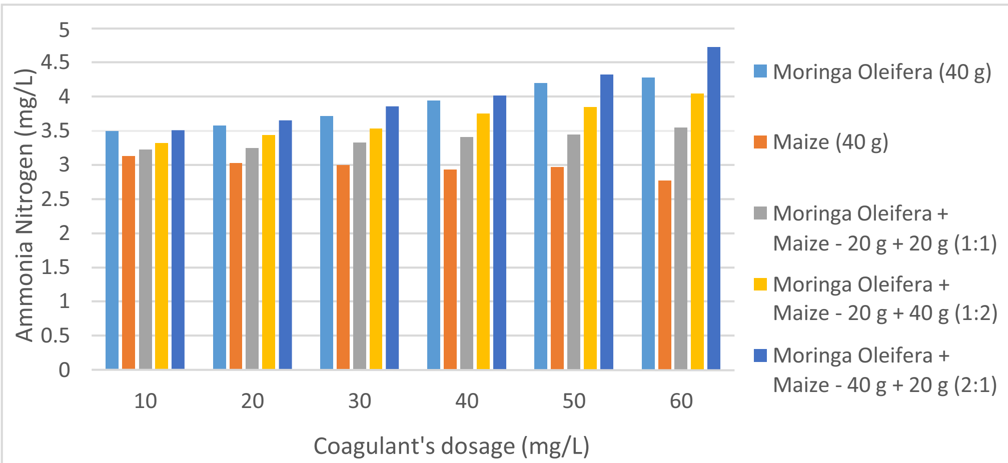

Figure 5. Result of ammonia-nitrogen for various coagulants dosage.

Ammonia-nitrogen (NH_3-N) value for *Moringa oleifera* + *maize* – 40 g + 20 g (2:1) is constantly increased than other plant-based concentrations and coagulants dosages values. In contrast, the value of *maize* is decreased than other plant-based concentrations and coagulant dosages, especially for 60 mg/L dosages of *maize*. It shows that the value for the 60 mg/L dosages of *maize* is 2.77 mg/L, which is less than the treatment previously. Unfortunately, the reading of ammonia-nitrogen (NH_3-N) still did not achieve the required standard of Water Quality Standard (WQI) when the value exceeds Class V (>2.7) [6].

3.1.4. Effect of various coagulants dosage on Total Suspended Solid (TSS).

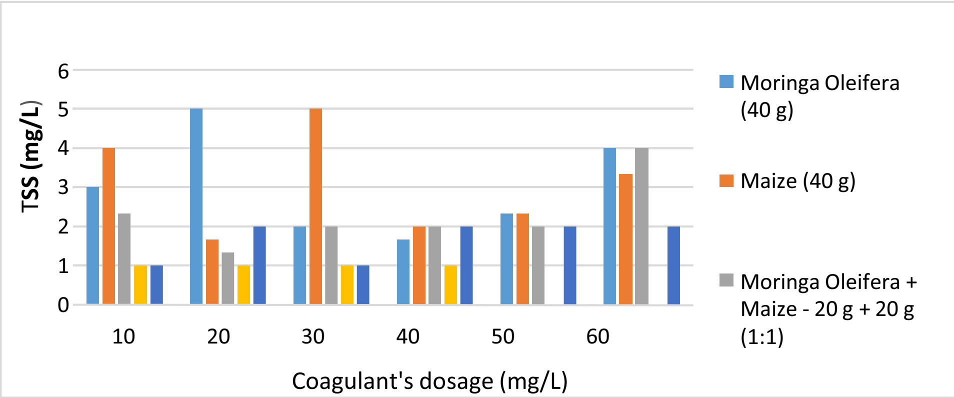

Figure 6. Result of TSS for various coagulant dosages.

The effect of various plant-based concentrations and coagulant dosages showed different values of TSS before and after treatment when most of the TSS-treating sample values slightly decreased from 6 mg/L to 0 mg/L. *Moringa oleifera* + *maize* – 20 g + 40 g (1:2) is value significantly decrease, when TSS for coagulant's dosage for 10 mg/L, 20 mg/L, 30 mg/L, 40 mg/L is 1 mg/L and 50 mg/L and 60 mg/L is 0 mg/L. As a result, the fewer particulates in the water, the clearer the water becomes.

3.1.5. Effect of various coagulants dosage on Chemical oxygen demand (COD).

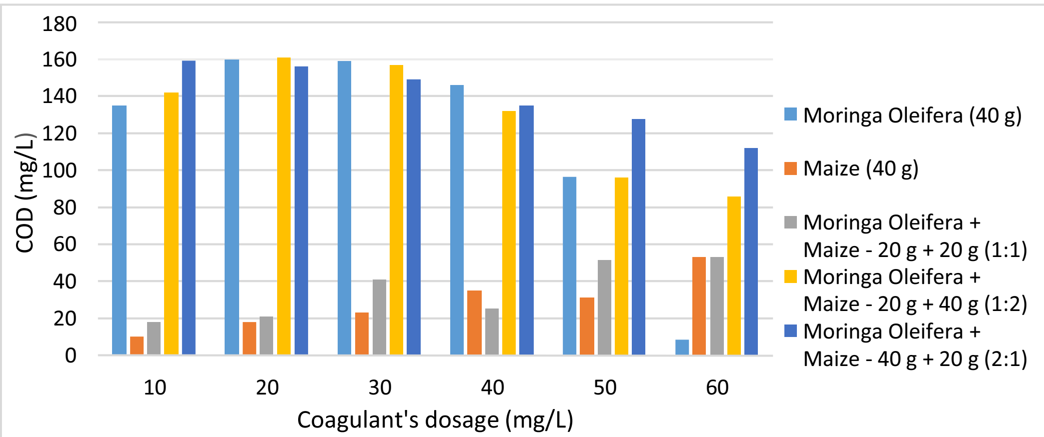

Figure 7. Result of COD for various coagulant dosages.

This outcome shows that the amount of coagulant dosage and different types of plant-based concentration affect the reading of COD parameters. It is shown that *moringa oleifera* – 40 g has been effective in drastically decreasing the value of COD. When the coagulant's dosage of 60 mg/L, the value of COD is 8.33 mg/L. For *maize* - 40 g is also among decreasing values when the coagulant's dosage of 10 mg/L and the value of COD is 10 mg/L. At the same time, the other coagulant's dosage slightly increased the value of COD but was still lower among coagulant concentrations. Thus, compared to WQI, it can be categorized as Class I (10 mg/L) and meets the required standard [6]. Other plant-based concentrations have a slight reduction in the reading of COD but still exceed the range of requirements from the WQI Standard [6].

3.1.6. Effect of various coagulants dosage on biochemical oxygen demand (BOD).

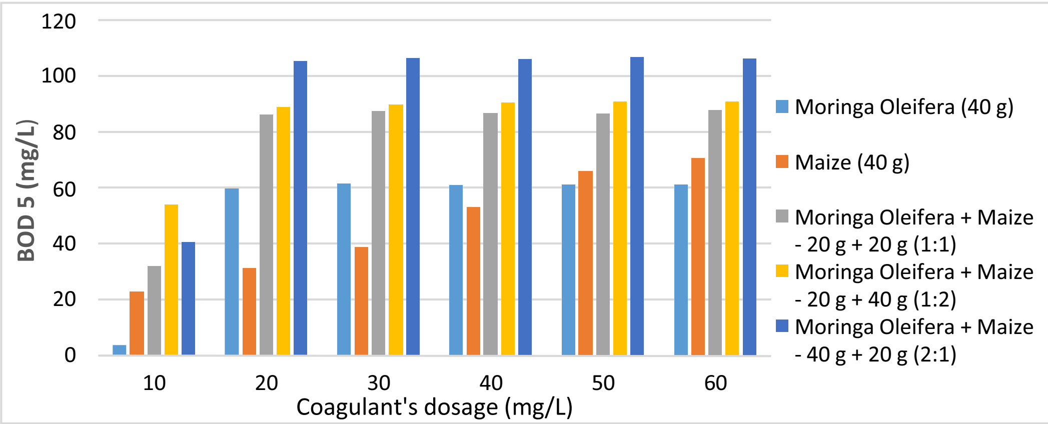

Figure 8. Result of BOD for various coagulant dosages.

This assessment aims to determine the quantity of organic matter in the water because the larger the amount of organic matter in the water sample, the less oxygen is available for microbes to break down. It also requires nutrients from water dilution. The best value for BOD_5 is a sample of solution plant-based *moringa oleifera* – 40 g when at 10 mg/L coagulant's dosage, BOD_5 is 3.6 mg/L. It shows that it has less value of BOD_5 than other plant-based dosages. Meanwhile, *maize* – 40 g also decreased the BOD_5 value to 22.72 mg/L, then the initial reading before treatment, 30.40 mg/L. Hence, compared to WQI, the value of BOD_5 was 3.6 mg/L between Class IIB and Class III (3-6 mg/L) [6].

3.2. Summary of the best result of the effectiveness

Table 2. Summary of the best result of the effectiveness

No.	Parameter Testing	Plant-based coagulant	Coagulant's dosage (mg/L)	Reduction efficiency (%)
1.	Turbidity	*Moringa oleifera* + *maize* – 20g + 40g (1:2)	50	91.59
2.	pH	*Moringa oleifera* – 40g	60	1.03
3.	Ammonia Nitrogen	*Maize* – 40g	60	12.06
4.	TSS	*Moringa oleifera* + *maize* – 20g + 40g (1:2)	60	100
5.	COD	*Moringa oleifera* – 40g	60	95.36
6.	BOD	*Moringa oleifera* – 40g	10	88.16

4. Conclusion

Based on the data acquired and the experiments' results, wastewater treatment using plant-based *moringa oleifera* and *maize* as coagulants was successfully conducted. The findings revealed that *moringa oleifera* and *maize* seeds were effective in the coagulation treatment of wastewater effluent obtained from the WWTP UiTM Dengkil, Selangor. Significant reductions and removals are evidenced in turbidity, chemical oxygen demand (COD), and total suspended solids (TSS). Thus, *moringa oleifera* and *maize* – 20g + 40g (1:2) combined have a significant potential for coagulation of turbid water, with turbidity reduction reaching up to 91.59% at 50 mg/L coagulant doses. Hence, when *moringa oleifera* – 40 g was combined with a coagulant dose of 60 mg/L, the COD elimination effectiveness was determined to be 95.36%. The TSS removal efficiency was found to be higher when *moringa oleifera* + *maize* - 20 g + 40 g (1:2) at a coagulant's dosage of 60 mg/L reached 100% removal efficiency. Meanwhile, ammonia-nitrogen has been reduced slightly by 12.06%. For plant-based *maize* – 40g on coagulant's dosage 60 mg/L. *Moringa oleifera* and *maize* seeds, as plant-based coagulants, have been identified to be a substitute for replacing chemical coagulants for the effective treatment of wastewater effluent.

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