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The study on Nannochloropsis oculata and Chlorella Vulgaris microalgae freely suspended technique for heavy metal removal in Palm Oil Mill Effluent

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Abstract: Wastewater recycling provides significant environmental benefits. Treating wastewater with microalgae is environmentally friendly. This research is about using biosorption process to treat wastewater. The main objective of the research is to compare the effectiveness of using microalgae in removing heavy metals in POME. Two different types of microalgae are used which are Nannochloropsis oculata and Chlorella vulgaris to study their effectiveness on treating POME under different concentrations. From the data, it shows that both the microalgae can treat the POME in their respective concentration. Immobilization of algae can solve the problem POME remediation and bioenergy cogeneration. For Nannochloropsis oculata and Chlorella vulgaris, they best treat heavy metal magnesium in POME. The percentage of magnesium concentration in POME after the treatment are reduce 85% to 95%.

Keywords: POME, Nannochloropsis Oculata, Chlorella Vulgaris

1. Introduction

Discharging industrial wastewater into environments such as rivers, lakes and the sea is one of the steps in recycling process water. However, this wastewater contains organic matter and harmful heavy metals that can affect human health, especially aquatic life, and should be treated first. The biosorption technique is another way to remove heavy metals from wastewater. The ability of biological materials to accumulate or absorb heavy metals through physio-chemical or metabolically mediated pathways of uptake from wastewater is referred to as biosorption. Micro-algae are one of the probable heavy metals biosorbents.

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According to earlier study, the potential of micro-algae to absorb heavy metals ranges between 60 and 100 percent. The ability of micro-algae to absorb heavy metals is determined by the chemical makeup of the heavy metals, which is derived from the cell wall composition of the organism. It is critical to know what heavy metals are present in the wastewater and their concentrations to select the most appropriate micro-algae for a certain type of micro-algae.

1.1 Heavy metal pollution in wastewater

Most heavy metals are known to be toxic and carcinogenic and pose a serious threat to the human population and the intake of aquatic animals and plants. Heavy metals tend to bioaccumulate in the environment and become persistent pollutants. Non-degradable and persistent heavy metals can harm both humans and aquatic organisms if the wastewater is not removed and is discharged into the receiving channel. Heavy metals are the main pollutants in the environment because they are toxic and pose a danger to high concentrations of organisms and humans. Copper is highly toxic due to its non-biodegradability and carcinogenicity. Nickel poisoning can cause everything from skin irritation to lung, nerve, and mucous membrane damage.

2. Materials and Methods

2.1 Materials

The material used in the research were salt, coffee stock, growth nutrients for both microalgae. Besides, the chemical substances used were Palm Oil Mill Effluent (POME), Nannochloropsis oculata, Chlorella vulgaris, distilled water and standard solutions for calibration methods. The equipment used were centrifuge, Atomic Absorption Spectroscopy (AAS), pH meter, DO meter, TOC & TN Analyzer, hemocytometer, fume cupboard and microscope.

2.2 Methods

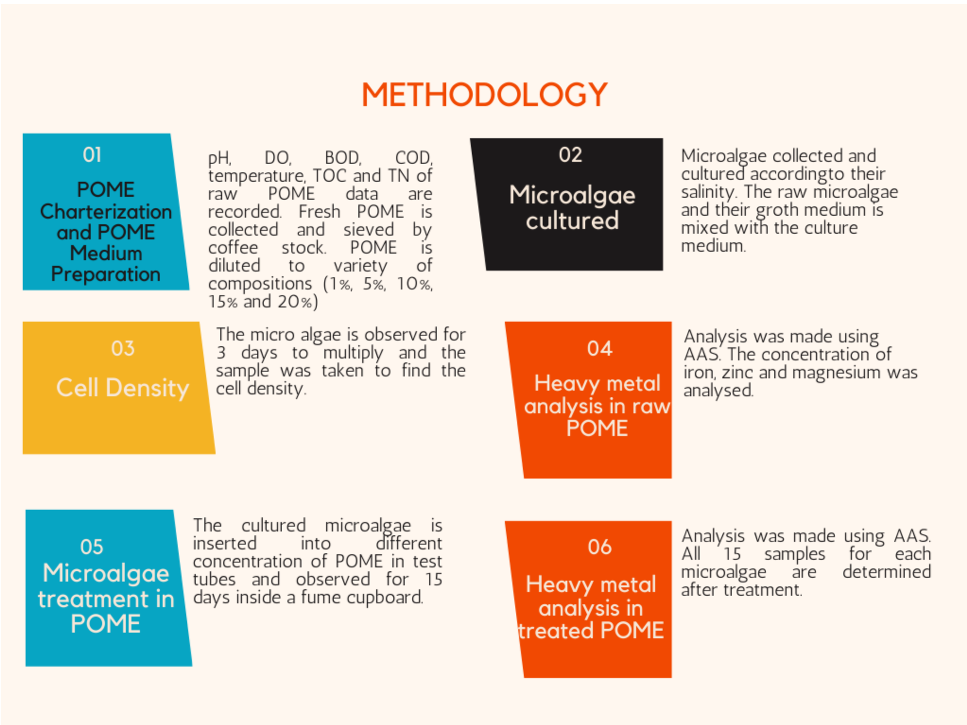

Figure 2.2 shows the methodology of the study.

Fresh POME is collected and sieved several times with coffee stock to remove the impurities and large substances in it. The data of raw POME is collected and recorded. Raw POME is diluted to variety of compositions such as 1%, 5%, 10%, 15% and 20%. The two types of microalgae which are Nannochloropsis oculata and Chlorella vulgaris are collected and used for medium culturing. The medium is cultured with different salinity respectively. The microalgae are left for few days to grow in it and its cell density were recorded. The concentration of heavy metals in raw POME such as magnesium, zinc and iron are analyzed using AAS. The diluted POME is treated using the microalgae medium in test tubes and left for 15 days in a fume cupboard under room temperature to see the result. All the samples are analyzed using AAS to determine the final concentration of the heavy metals in POME left after the treatment.

2.3 Equations

The equation stated below is used to determine the efficiency of the heavy metals that have been removed from the treated POME. The data of the heavy metals in the raw POME that have been recorded previously will also be used in the equation.

Removal efficiency (%):

$$\frac{A_i - A_f}{A_i} x 100 \qquad Eq. 1$$

Where Ai = initial parameter concentration

A_f = final parameter concentration

3. Results and Discussion

3.1 Results

Table 3.1 shows the comparison data of efficiency of Nannochloropsis oculata and Chlorella vulgaris

Microalga Species	Efficiency			
	Sample (%)	Iron, (Fe)	Zinc (Zn)	Magnesium (Mg)
Nannochloropsis oculata	1	91.31	179.41	119.70
	5	75.78	120.59	119.32
	10	60.06	82.35	121.59
	15	53.86	73.53	118.56
	20	31.54	35.29	120.08
Chlorella vulgaris	1	90.33	167.65	119.70
	5	85.16	132.35	121.97
	10	63.67	91.18	119.70
	15	29.88	70.59	82.95
	20	12.21	35.29	120.45

Based on the above tabulated results, it is proven that microalgae can remove heavy metals from POME. It can be clearly seen in table 2.2 where the efficiency of each type of microalgae in removing the heavy metals. Clear differences can be seen with the data obtained before the treatment and after the treatment.

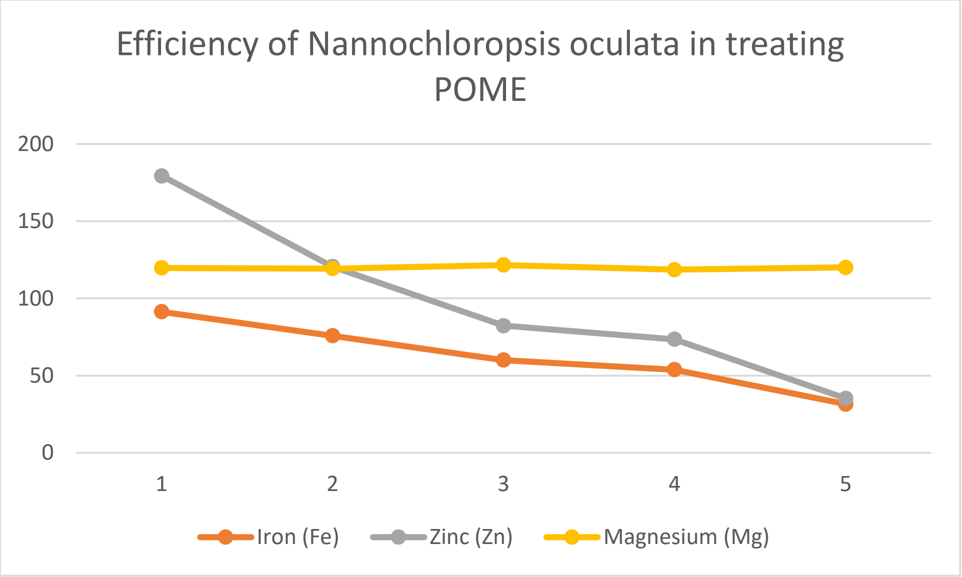

Figure 3.1: Efficiency of Nannochloropsis oculata in treating POME

Figure 3.1 shows the efficiency of the three metals which are magnesium, zinc, and iron in treating POME in different concentrations. From this figure it can be seen that Nannochloropsis oculata has a high attraction to magnesium as its efficiency of removing it has a steady result.

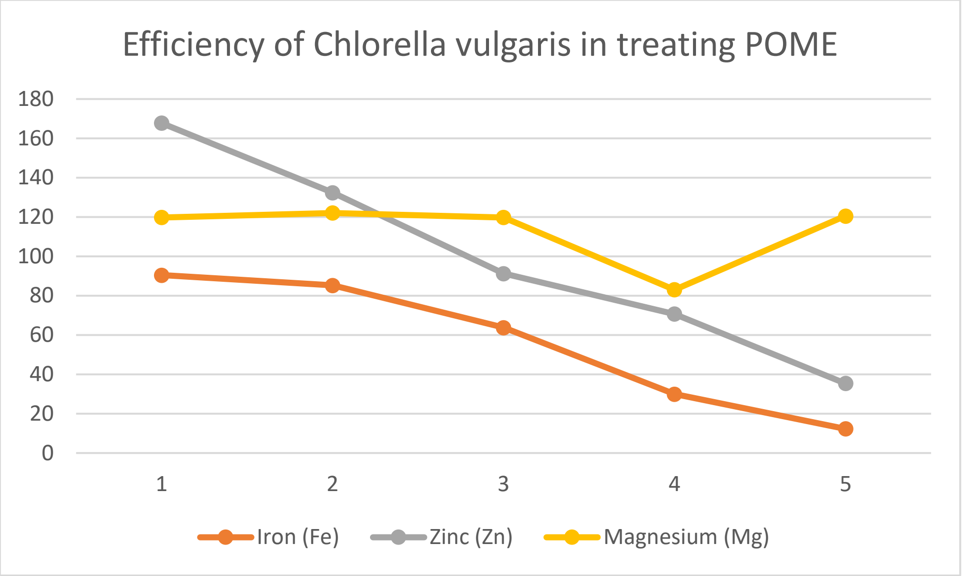

Figure 3.2: Efficiency of Chlorella vulgaris in treating POME

From figure 3.2 it is clear that Chlorella vulgaris eliminates zinc metal the most efficiently from POME while the least iron metal the least efficiently. As per calculated Chlorella vulgaris also steadily removes magnesium from POME.

3.2 Discussions

Firstly, for iron (Fe), Chlorella vulgaris shows a higher efficiency in removing the heavy metal at the concentration 15 to 10% POME. However, the efficiency abruptly dropped from 63.67% to 12.21% when the concentration reached t0 15% POME. The efficiency results shown by Nannochloropsis oculata is much better even when POME concentration reached 20% which is 31.54%. Thus, for removing the heavy metal iron (Fe), at low concentration, chlorella vulgaris, gives a better result. As for high concentration, Nannochloropsis oculata is much better suitable in removing the heavy metal.

Table 3.2: Comparison results between Nannochloropsis oculata and Chlorella vulgaris

Before Treatment			**After Treatment**						
Raw Samples			**Sample (%)**	**Nannochloropsis oculata**			**Chlorella vulgaris**		
Fe (ppm)	**Zn (ppm)**	**Mg (ppm)**		**Fe (ppm)**	**Zn (ppm)**	**Mg (ppm)**	**Fe (ppm)**	**Zn (ppm)**	**Mg (ppm)**
5.12	0.17	1.32	1	0.445	-0.135	-0.260	0.495	-0.115	-0.260
5.12	0.17	1.32	5	1.240	-0.035	-0.255	0.760	-0.055	-0.290
5.12	0.17	1.32	10	2.045	0.030	-0.285	1.860	0.015	-0.260
5.12	0.17	1.32	15	2.365	0.045	-0.245	3.590	0.050	-0.225
5.12	0.17	1.32	20	3.505	0.110	-0.265	4.495	0.110	-0.270

Various result was shown for heavy metal zinc (Zn). Both Nannochloropsis oculata and Chlorella vulgaris shows good result in removing the heavy metal. From 1% to 10% POME concentration, the efficiency range of removing the heavy metals if from 82.35% to 179.41%. this shows that in low concentration POME, both microalga is very effective in removing the heavy metal. However, when the concentration of POME increased to 15% to 20%, the efficiency dropped gradually as the microalga cannot withstand the toxicity level in the POME and started to die. Although that happened, the results still give great range at 20% POME concentration which is 35.29% for both the microalga.

The best results obtained is when magnesium was being removed from the POME. At any concentration from 1% to 20%, the efficiency of removing the heavy metal is more than 100% for both the microalga. This show that both microalgae are very effective and suitable from removing the magnesium content in the wastewater. From the data, it can be said that this heavy metal has the highest tendency for both microalgae to remove it.

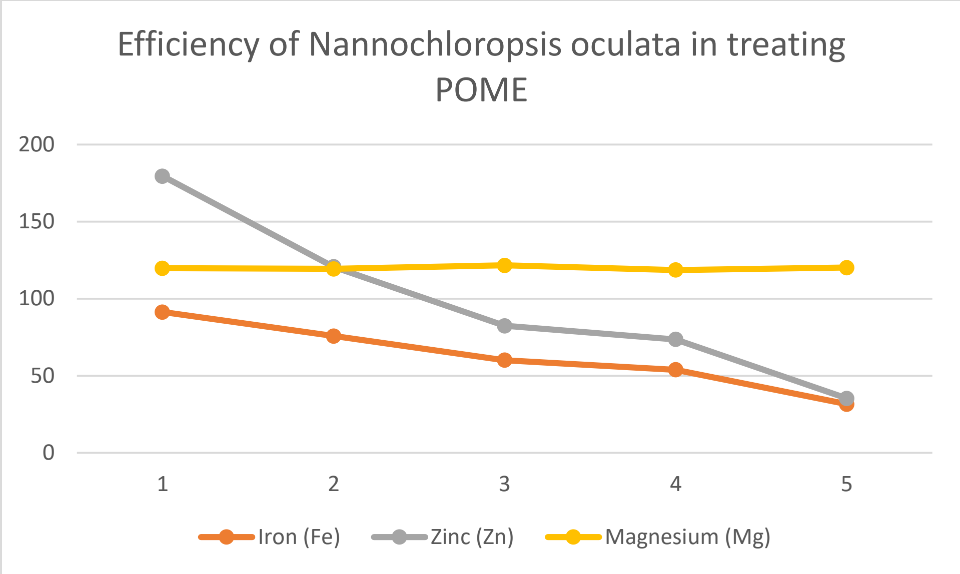

Figure 3.1: Efficiency of Nannochloropsis oculata in treating POME

From the figure above, heavy metal iron is being treated the least in various concentrations compared to zinc and magnesium. This is because of the effect of nitrate and phosphorus present in Nannochloropsis oculata. The higher the amount of nitrate and phosphorus in microalgae, the lesser the efficiency of the microalgae in treating iron metal.

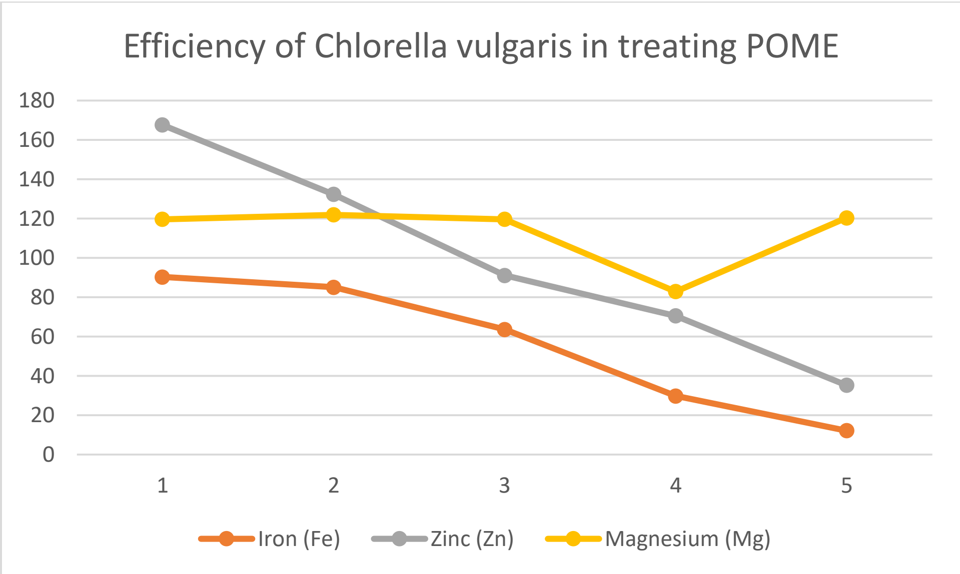

Figure 3.2: Efficiency of Chlorella vulgaris in treating POME

From the figure above, it is shown that Chlorella vulgaris treats heavy metal magnesium more effectively than heavy metal iron and zinc. Both the microalgae treat magnesium more because magnesium content is not significantly affected by the cultured media and the nitrate and phosphorus content in it.

3.3 Tables

Table 3.2: Comparison Results between Nannochloropsis oculata and Chlorella vulgaris

Before Treatment				After Treatment					
Raw Samples			Sample (%)	Nannochloropsis oculata			Chlorella vulgaris		
Fe (ppm)	Zn (ppm)	Mg (ppm)		Fe (ppm)	Zn (ppm)	Mg (ppm)	Fe (ppm)	Zn (ppm)	Mg (ppm)
5.12	0.17	1.32	1	0.445	-0.135	-0.260	0.495	-0.115	-0.260
5.12	0.17	1.32	5	1.240	-0.035	-0.255	0.760	-0.055	-0.290
5.12	0.17	1.32	10	2.045	0.030	-0.285	1.860	0.015	-0.260
5.12	0.17	1.32	15	2.365	0.045	-0.245	3.590	0.050	-0.225
5.12	0.17	1.32	20	3.505	0.110	-0.265	4.495	0.110	-0.270

4. Conclusion

The best and most efficient method for eliminating heavy metals from wastewater is to use microalgae. According to the results, freshwater type microalgae are more suitable and efficient at removing the heavy metal iron (Fe) at low concentrations, but seawater type microalgae are significantly more effective at removing it at high concentrations because they can handle wastewater with a higher iron content. Both varieties of microalga may completely remove the heavy metal zinc (Zn) at low concentrations. However, at high concentrations, both microalga's efficiency gradually decreased but they were still capable of removing a sizable amount of the heavy metal. Both microalgae could remove the heavy metal Magnesium (Mg) 100%.

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