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Application of Phycoremediation using Microalgae *Scenedesmus sp.* as Wastewater Treatment in Removal of Heavy Metals from Food Stall Wastewater

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Keywords—Phycoremediation, Food Stall Wastewater, Microalgae *Scenedesmus sp*. , heavy metals; Ferum, Copper and Zinc.

Abstract - This paper represents the results of using phycoremediation technology in treating the wastewater produced from food stall activity by using microalgae of *Scenedesmus sp*. in removal of heavy metals. Phycoremediation has advantages over physic-chemical approaches as it is can completely degrade organic pollutants without destroy the surrounding flora and fauna. Aim of this study is to determine the effectiveness of microalgae *Scenedesmus sp* to assimilate the pollutant load based on the optimum time and concentration. Characteristics of food stall wastewater need to be identified and analyse before phycoremediation process taken place. The wastewater sampling was collected at food stall during peak time i.e. at 8 a.m. and 4 p.m. Microalgae *Scenedesmus sp*. to be injected to the batch reactor based on five (5) different concentration cells. The results shows that the optimum removal of heavy metals are dominant by concentration no. 1 (C1) compare to other concentration in the treatment i.e. removal of Ferum by 88.22% and 69.63%, Copper by 60% and 53.85% at both sampling time while removal of zinc is dominant by concentration no.4 (C4) by 75.61% and 76.63% respectively.

Introduction

Phycoremediation is the use of microalgae (Bioremediation) in the removal of pollutants from wastewater. Applications of algae plant is one of good solutions in solving environmental problems such as global warming, depletion of ozone layer and climate changed whereby the algae consume carbon dioxide through photosynthesis process in producing more oxygen and glucose. Furthermore, algae based technology applicable in treating wastewater simultaneously whereas in conventional methods, separate methods or stages of treatments are used. Moreover, algae is known to be versatile since its can easily adapt in any environmental conditions [1]. The used of microalgae has been commercialized since 75 years ago in application to wastewater treatment resulting in mass production of strains such as *Chlorella* and *Dundiella*, food, fertilizers, source of energy, pharmaceuticals; nutraceuticals, cosmetics and aquaculture purpose and pollutions control [2]. In attempt to studying the potential used of microalgae *Scenedesmus sp* in treating food stall effluents, many previous researchers has focus on remediate varies of wastewater from food industries in using other type of microalgae such as *Dundiella* in treating the industrial wastewater – brewing, soy sauces pulp and paper, dairy and poultry [3], *Pithophora sp*. and Algae (singular algae), in treating the dairy effluents [4, 5]. and *Scenedesmus obliquus, C. vulgaris* used to treat brewery effluents [6, 7]. From the above, microalgae *Dundiella* has the highest removal of BOD, COD, ammonium from nitrogen and orthophosphate from phosphorus nutrients. Meanwhile, microalgae *Pithophora sp*. evidently suitable in treating the dairy effluents as it decreased all the nutrients levels i.e. TS (39.82%), TDS (30%), TSS (92.22%), COD (61.65%) and BOD (64.67%). However, few studies have focus on the use of microalgae *Scenedesmus sp*. in treating the food stall

wastewater specifically. According to [2], *Scenedesmus sp.* can be found everywhere especially in stagnant water as it is components of fresh water plankton. Scenedesmuss spp lives in colonies and scientifically known as *Chlorophyceae* whereby it grows well in fresh water but also can endure in sewage environment. As stated by [5], concentration of 30% wastewater is the optimum growths that are most suitable for algae growth.

Experiment Details

A. Material and sampling preparations

In this study, microalgae of *Scenedesmus sp*. were used for phycoremediation process through culturing in Bold's Basal Medium, BBM. The wastewaters from food stall effluents was collected in two different times i.e. at 8 a.m. and 4 p.m. at UTHM Arked food stall, as it is been chosen based on the peak time of the food stall activities. For this experiment, 5 Litres, (5l) of wastewater from food stall effluent was collected by the procedure of grab sampling. The samples were taken at 30cm depth and keep some distance from the edge. The wastewater samplings and handle are according to standard methods.

B. Microalgae *Scenedesmus sp*. culturing

Microalgae *Scenedesmus sp*. was collected from freshwater algae and to be cultured in the room temperature where it's best growth in this conditions. The microalgae were cultivated in Bold's Basal Medium, BBM with the stock solutions. 10ml of stock solutions together with 1 ml of micronutrient stocks were added into 940ml of distilled water and autoclave for 15 minutes. The microalgae then were placed under direct sunlight for 7 days in order to observe the cultivation process.

C. Laboratory batch reactor preparations

10 sets of 170 ml beaker fill with food stall wastewater and different concentration of microalgae *scenedesmus sp*. were prepared. Every set of batch reactor were measure the amount of heavy metals: Ferum (Fe), Copper (Cu) and Zinc (Zn). All batch reactors were placed under direct of sunlight for duration of 8days covered with white cloth at the tip of the beaker. The sample were analysed for every alternate days i.e. 0th, 2nd, 4th, 6th and 8th days for heavy metals and concentration analysis such as Ferum (Fe), Copper (Cu) and Zinc (Zn). Culture Treatment Design: Wastewater volume in reactor = 1/3 from total volume of reactor. The volume of microalgae *scenedesmus sp.* per volume reactor for concentration 1 is 1.235E6 cells/ml of microalgae, concentration 2 is 1.224E6 cells/ml of microalgae, concentration 3 is 1.220E6 cells/ml of microalgae, concentration 4 is 1.213E6 cells/ml of microalgae and concentration 5 is 1.203E6 cells/ml of microalgae.

Testing and Equipment

A. Characteristics of Food Stall Wastewater before and after phycoremediation process

All the parameters from the food stall wastewater were identified before and after in determined its characteristics and removal effectiveness of the lab reactors. The characteristics of food stall wastewater that needs to be identified before and after the experiment with the right equipment. All the testing is done through standard procedure in environmental laboratory, UTHM.

Results and Analysis

A. Characteristics of food stall wastewater and microalgae scenedesmus sp.

The characteristics of food stall wastewater are presented in Table 1. As shown, there are 10 parameters were selected in categorising the food stall waster. However, the heavy metals of Ferum, Copper and Zinc from the sampling of food stall wastewater are at allowable effluents set by Indah Water Konsortium, IWK. Other data of previous study from [8, 9] which the sources of wastewater in their study is from students canteen was taken into account for comparison in justify the effluents quality level from food stall wastewater.

Table 1: Characteristics of Food Stall wastewater with comparison with previous study and IWK

Parameter	Food Stall Wastewater		Canteen Wastewater		IWK	
(mg/l)	Sample 1 (8 a.m.)	Sample 2 (4 p.m.)	Data from previous study	References	Standard	
					A	B
pH	7.25	7.3	6.82-8.76	Chen et al., 2000	6-9	5.5-9
BOD	220	250	545-1630	Chen et al., 2000	20	50
COD	320	360	900-3250	Chen et al., 2000	50	100
TSS	33.3	100	124-1320	Chen et al., 2000	50	100
TN	55.8	21.5	1280	Ji et al., 2013	-	-
TP	2.18	2.68	4.3	Ji et al., 2013	-	-
TOC	173	284	-		-	-
Ferum, Fe	0.0256	0.0148	0.2-0.4	Ji et al., 2013	1	2
Copper, Cu	0.0012	0.0013	0.5-0.8	Ji et al., 2013	0.2	1
Zink, Zn	0.0177	0.0254	0.02-0.04	Ji et al., 2013	1	1

Table 2: Characteristics of Microalgae *Scenedesmus sp.*

Parameters	Values
pH	6.38
Total Suspended Solid, TSS (mg/L)	375
Turbidity (NTU)	77.8
Sulfate, SO_4^{2-} (mg/L)	35
Dissolved Oxygen, DO (mg/L)	16.38
Total Chlorine, Cl^- (mg/L)	-0.07
Total Nitrogen, TN (mg/L)	308.9
Total Phosphorus, TP (mg/L)	0.75
Total Organic Carbon, TOC (mg/L)	38.01
Ammonia Nitrogen, NH_3-N (mg/L)	1.95
Zink, Zn (mg/L)	0.47
Copper, Cu (mg/L)	1.24

Table 2 shows the characteristics of microalgae *scenedesmus sp.* that was used for phycoremediation process of food stall wastewater. Microalgae *scenedesmus sp.* are capable to reduce nutrient, heavy metals and other compounds by converting the sunlight to the carbon as a source to live in the contaminated wastewater.

B. Heavy metals removal analysis

Three heavy metals were analysed i.e. Ferum (Fe), Cooper (Cu) and Zink (Zn). The results are shown in Fig 1 to Fig 6.

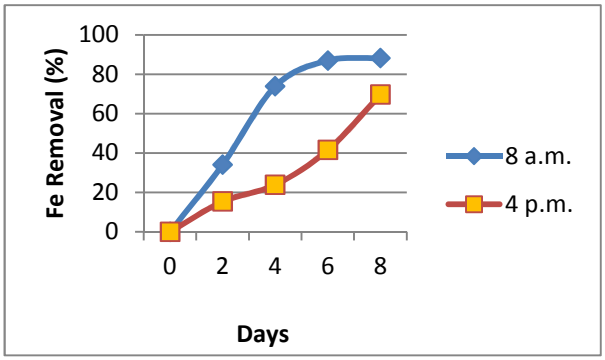

Figure 1: The percentage removal of Ferum (Fe) of two sampling times (8 a.m. and 4 p.m.) of microalgae growth time (day)

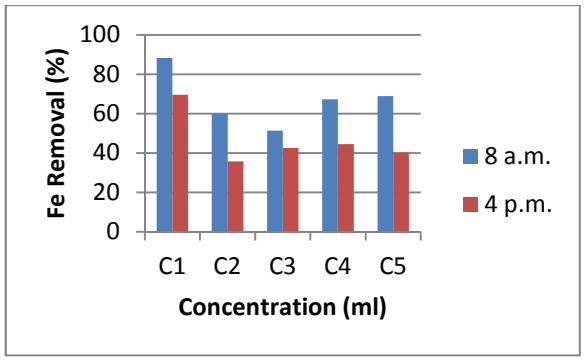

Figure 2: The percentage removal of Ferum (Fe) at different concentration

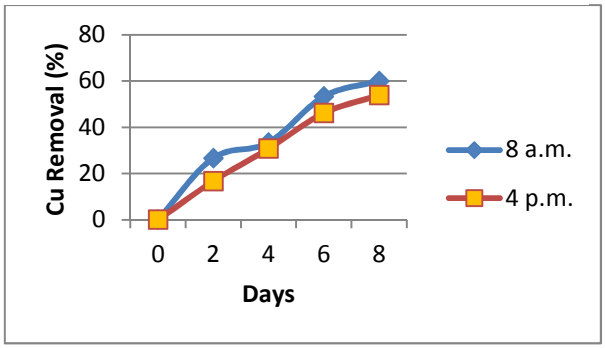

Figure 3: The percentage removal of Copper (Cu) of two sampling times (8 a.m. and 4 p.m.) of microalgae growth time (day)

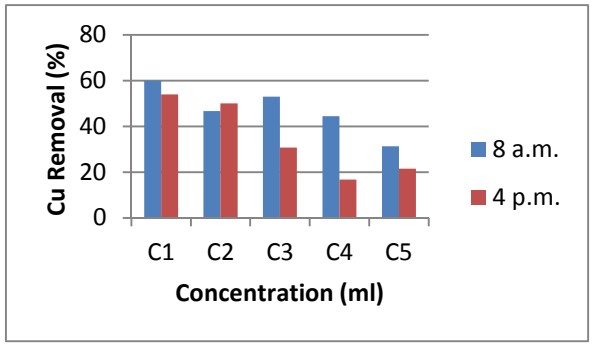

Figure 4: The percentage removal of Copper (Cu) at different concentration

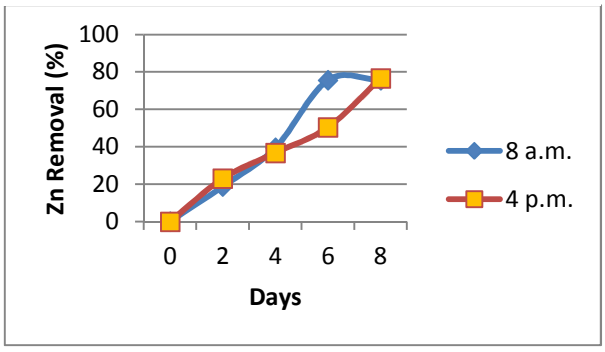

Figure 5: The percentage removal of Zinc (Zn) of two sampling times (8 a.m. and 4 p.m.) of microalgae growth time (day)

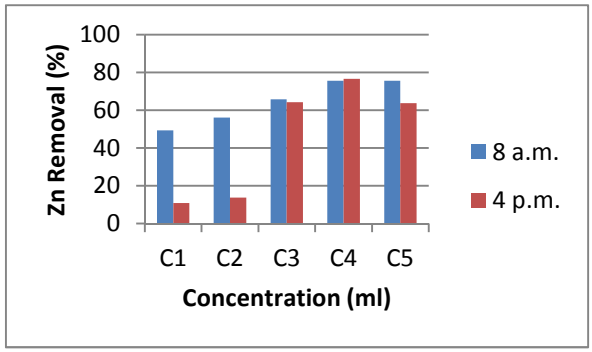

Figure 4: The percentage removal of Zinc (Zn) at different concentration

A significant removal of Ferum (Fe) can be seen in Fig. 1 and Fig. 2 as the percentage of removal is increased in time for both sampling. The highest removal of ferum is on concentration no. 1, C1; 88.22% and 69.63% at 8 a.m. and 4 p.m. respectively. According to [10], study show 100% of Fe was removed from wastewater at 25th day of treatment. This is due to the microalgae consume salts from wastewater which is co-related with the uptake of other heavy metals. The complete removal of Fe can be achieved if the treatment day to be prolonged. Fig. 3 and Fig. 4 showed an increment in Copper (Cu) removal using microalgae. The result shows that the concentration no.1 has the highest reading compare to other concentration i.e. 60% and 53.85% at 8 a.m. and 4 p.m. respectively. Based on study conducted by [10], full removal of the Cu can be achieved at 20th day of treatment. Furthermore, the capability of the microalgae in absorb the heavy metals elements to sustained is essentials for the treatment. However, the efficiency of elements removals are varies with the microalgae concentration. In terms of pH, pH value at 8.0 is the most suitable range for optimum performance of microalgae [11], in order to promote bivalent metal precipitation. The

results for removal of Zinc (Zn) are increased in time and the highest removal percentage is at concentration no.4 for both sampling time i.e. 75.61% and76.63% respectively. As compared with study done by [8] showed 94% Zn was removed using microalgae chorella within 10 days of treatment. These indicate the potential of microalgae is significantly high in treating wastewater prior discharge to environment.

Conclusion

The results obtained from the experimental had shown and proved that phycoremediation process using microalgae *scenedesmus sp.* are able to remove heavy metals pollutant from food stall wastewater effectively subject to optimum time and microalgae *scenedesmus sp.* concentration of the treatment as expected by [9]. The results shows that the optimum removal of heavy metals are dominant by concentration no. 1 (C1) compare to other concentration in the treatment i.e. removal of Ferum by 88.22% and 69.63%, Copper by 60% and 53.85% at both sampling time while removal of zinc is dominant by concentration no.4 (C4) by 75.61% and 76.63% respectively. As conclusion, microalgae *scenedesmus sp.* are capable in reducing the pollutant in food stall restaurant as reported by in the previous study by [9, 10, 12].

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