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Performance of *Typha Angustifolia* and *Lepironia Articulata* For Upgrading Domestic Wastewater in An Integrated Phytogreen System

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Abstract

Treating wastewater is the way to overcome water shortage due to the water pollution problems. Wastewater is any water that has been adversely affected in quality by anthropogenic influence while clean water is produced from varies of wastewater treatment system. Therefore, this study is conducted to analyze the effectiveness of both bioremediation and phytoremediation in upgrading the wastewater treatment process by using two types of aquatic plants as phytoremediation agents; *typha angustifolia* and *lepironia articulata*. Phytogreen system reducing the main cost and maintenance cost of treating wastewater without ignoring the effectiveness of the system itself. Nevertheless, the aquatic plants itself is the important agents and the percentage interaction between absorption and adsorption to prove the effectiveness of this system.

Keywords: *Phytogreen, Phytoremediation, Bioremediation, Adsorption, Absorption, Contaminants, Wastewater Treatment.*

1. Introduction

70.9% of earth surfaces is comprises by water but only 2.5% of this water is fresh water and the easiest to be found and process ; only 0.3% of the fresh water can be found from rivers, lakes and atmosphere. With this amount of fresh water that cannot be wasted to ensure the continuity supply of fresh water, wastewater is treated through many stages [20].

Wastewater is defined as the most adversely affected water quality by anthropogenic influence. Wastewater has been treated for multipurpose usage [25]. Traditional technologies of treating wastewater has proved their effectiveness, yet from the view of the cost and man power required is not very effective. In most cases of contaminated soils, there are problems rose but the most encountered is to minimize the environmental side effects [17]-[18].

Recently, new technology of treating wastewater by using aquatic plants or green plants as the contaminants trapped in the wastewater. This technology is called phytogreen system which is very economical, environmental friendly, safe and also low cost construction. This technology provides more benefits for the communities as it is much more effective for the treatment compared to the treatment by using chemical [16], [20]. The aquatic plants used as the phytoremediation agents can increase the oxygen in water for decomposition by bacteria and lowering the Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Turbidity reading in the wastewater [2], [8]-[9], [15].

Bioremediation technology is the use of any microorganism to destroy or immobilize waste materials. This technology offers the opportunity to wreck numerous contaminants using natural biological activity. Compared to traditional method, bioremediation method is more economical [4], [21]. It is actually very cheap, low technology techniques and always be carried out on site. It also has a high acceptance from the public. Bioremediation can be generally categorized as in situ or ex situ. In situ bioremediation involves treating the contaminated material at the site, while ex situ involves the removal of the contaminated material to be treated elsewhere [5], [21].

A few examples of bioremediation related technologies are phytoremediation, bioventing, bioleaching, landfarming, bioreactor, composting, bioaugmentation, rhizofiltration, and biostimulation [4], [5]. Bioremediation can happen on its own or can be carried on through the addition of fertilizers to upgrade the bioavailability within the medium. Recent advancements have also proven successful through the addition of matched microbe strains to the medium to increase the resident microbe population's ability to break down contaminants [17], [21], [23].

Microorganisms used to implement the function of bioremediation are known as bioremediators [12]. The control and optimization of bioremediation processes is a complex system of many factors. These factors include: the existence of a microbial population capable of degrading the pollutants; the availability of contaminants to the microbial population and the environment factors [22], [23].

However, this bioremediation technology has its own limitation. A few of contaminants, such as chlorinated organic or high aromatic hydrocarbons, can withstand to microbial attack [22]. The process is either slowly or not occurs at all [4], [5], [23]. Hence, it is uneasy to assume the rates of clean up for a bioremediation exercise. Phytoremediation technology is used to overcome the issue [21], [24].

Phytoremediation technology is an emerging cost-effective [26], [27], non-intrusive, and low cost technology using the awesome ability of plants to concentrate elements and compounds from the nature [28]and to metabolize various molecules in their tissues [7], [10], [11]. Phytoremediation is maximizing the potential of certain plants for waste water treatment. Aquatic plants have ability to remove contamination in waste water, by absorption, decomposition and nutrients intake [1], [3], [6], [19]. Phytoremediation remediate soils, sediments, groundwater environments and surface water polluted with poisonous metals, organics [29], solvents, industrial chemical and other xenobiotic substances [13], [14].

2. Materials and Methods

2.1 Materials

This study is conducted in Oxidation Pond at Taman Anggerik, Johor Bahru where the wastewater samples are collected and tested in Environmental Laboratory of University Malaysia Pahang.

Two types of experiments performed in this study; in-situ (field-based testing) and ex-situ (laboratory testing). Samples collection and handling procedure were performed according to the standard method for water and wastewater examination.

The treatment process were monitored by 10 standard parameters to ensure the objectives of this study achieved. The parameters involved are temperature, pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Total Suspended Solids (TSS), Nitrate, Ammoniacal Nitrogen, Oil and Grease, and Phosphorus.

Fig. 1.1: Site Study

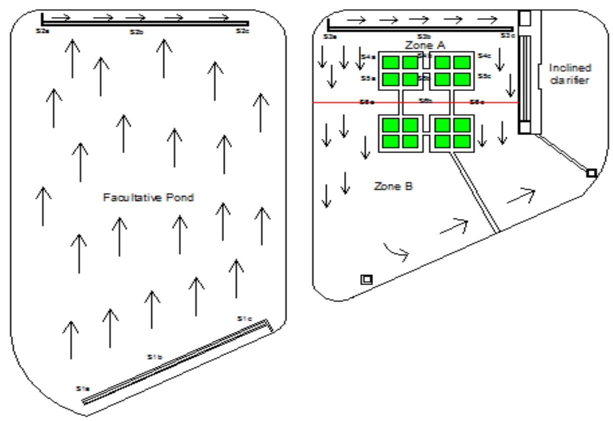

Fig. 1.2: Schematic diagram of site

2.2 Samples Collection

Water samples are collected at several points for 30 times of study period. These water samples then be analysed based on ten parameters. Sample is collected in Zone A phytogreen system.

The in-situ testing at each sampling point S4, S5, S6 in phytogreen zone, the parameters were tested by using multiparameters water quality checker (Model YSI 6600 V2 – Environmental Monitoring System) and the data obtained was recorded accordingly.

Meanwhile, the ex-situ testing for each parameter is performed by using DR5000 – UV – Vis Spectrophotometers and colorimeters, to determine the quality of effluent discharge.

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3. Results and Discussions

Table 1: Average reading of parameters tested

PARAMETERS	S1	S2	S3	S4	S5	S6
Temperature	31.05	30.94	30.80	30.72	30.65	30.57
pH	7.63	7.50	7.34	7.47	7.58	7.75
BOD	482.48	386.99	114.21	51.04	31.3	28.08
COD	685.70	345.08	147.90	108.04	86.53	79.86
DO	2.41	2.15	2.72	3.15	3.3	3.39
TSS	330.96	308.04	100.51	76.41	73.25	69.84
Nitrate	12.99	11.29	9.90	8.87	7.62	7.05
Ammonical Nitrogen	78.47	67.56	52.47	35.50	22.88	17.78
Oil & Grease	44.39	41.78	30.47	27.21	11.25	10.07
Phosphorus	17.12	14.69	12.84	10.92	7.99	6.67

The average reading of the parameters involved are obtained as each of the sampling point we took up to reading to get more accurate reading.

3.1 Biochemical Oxygen Demand (BOD)

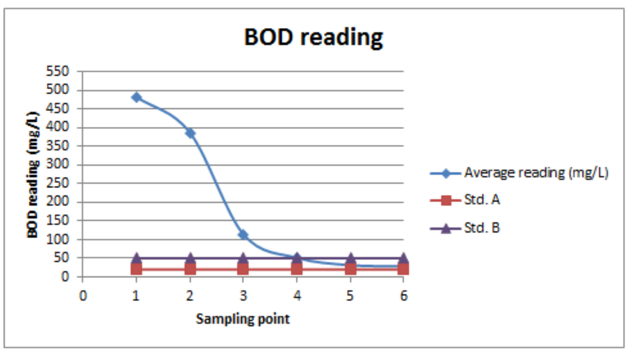

Fig. 1.4: BOD Reading

Based on the standard A in the Figure 1.1, the BOD level must be around 20 mg/L while for the standard B, the BOD level must be around 50 mg/L. From the graph, the amount of the BOD has decrease from the influent of the wastewater (482.48 mg/L) until the last point of phytogreen zone (28.08 mg/L). This is because the wastewater from the influent is still untreated and the amount of organic matter and dead plant is higher compared to effluent. This situation will cause the breaking down process as the bacteria begin to eat the food from the wastewater. This process will make the level of the BOD higher as the process is to consume the dissolved oxygen in the wastewater.

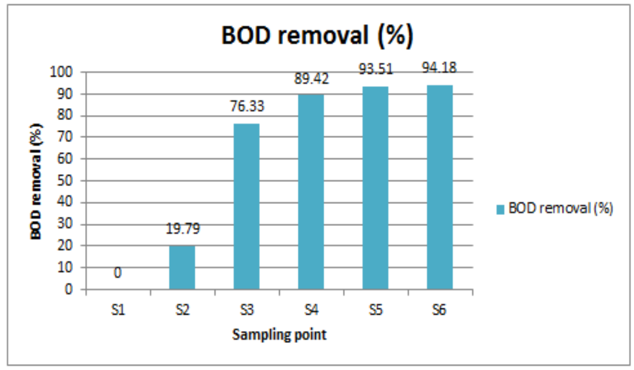

Fig. 1.5: BOD removal

Figure 1.2 shows that the percentage removal of BOD reached to 94.18% at S6 after going through the first phase of phytogreen zone. Thus, the effectiveness of the aquatic plants used has been proven.

3.2 Chemical Oxygen Demand (COD)

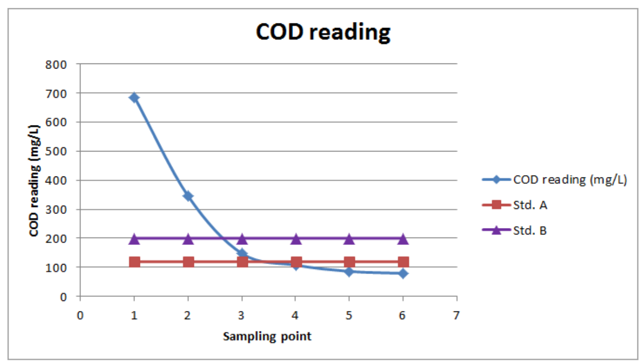

Fig. 1.6: COD reading

Based on the Figure 1.3 shown, the level of COD has decrease due to the different phase. The highest level of COD is when the wastewater first enters the treatment which is at influent part. As the standard A stated that the level of COD must be at range of 120 mg/L and for the standard B the level of COD must be at range of 200 mg/L. The rapid decreased from point 1 to point 2 is due to microorganisms process in the wastewater.

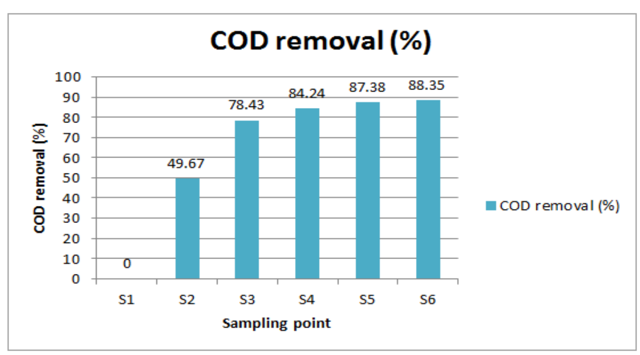

Fig. 1.7: COD removal

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The removal of COD can achieved up to 88.35% from influent point to the phytogreen zone at point 6. From Figure 1.4 shown, the removal of COD is very effective.

Total Suspended Solids (TSS)

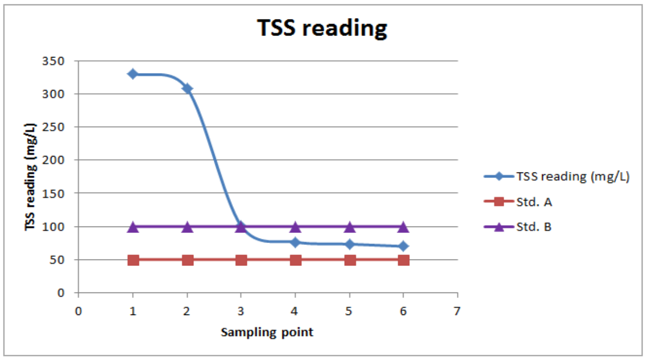

Fig. 1.8: TSS reading

The safe level for suspended solid so that the wastewater can be release into the river according to standard A is 50 mg/L while according to standard B is 100 mg/L. In the Figure 1.5, the level of the suspended solids has reached the standard B.

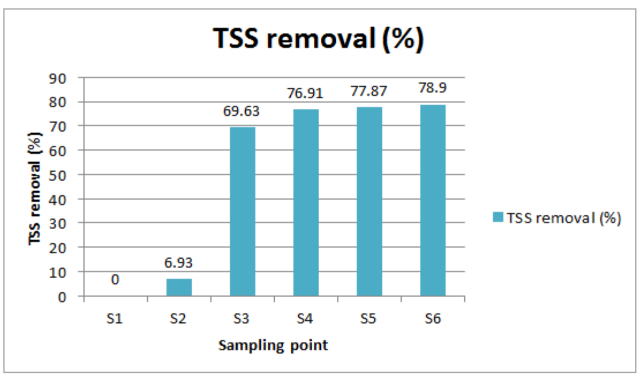

Fig. 1.9: TSS removal

TSS percentage removal in Figure 1.6 shows that the effectiveness of removing TSS reached to 78.9% at S6.

Oil and Grease

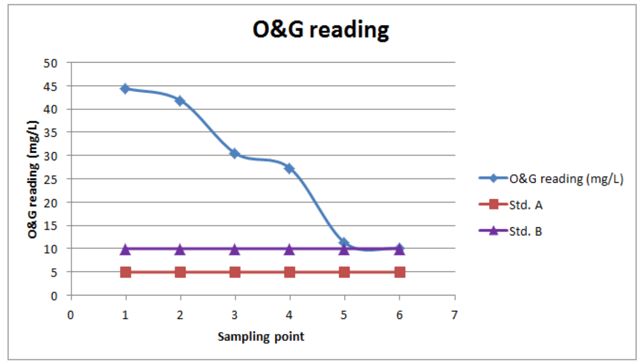

Fig. 1.10: Oil and Grease reading

Based on the Figure 1.7, the value of oil and grease is decreasing thoroughly throughout the graph. At the phytogreen area, the value of oil and grease is decreasing through point S3, S4, S5 and S6 which is 30.47 mg/L, 27.21 mg/L, 11.25 mg/L and 10.07 mg/L respectively. Point S3, S4 and S5 is located between the aquatic plant cages. The root of the aquatic plant traps the suspended sludge that contains oil and grease level is decreasing at the phytogreen area.

Oil and grease values ranged by the EQA 1974 for standard A is below 5 mg/L and standard B 5-10 mg/L. Based on the graph, the oil and grease value at the S6 is 10.07 mg/L reached the standard B.

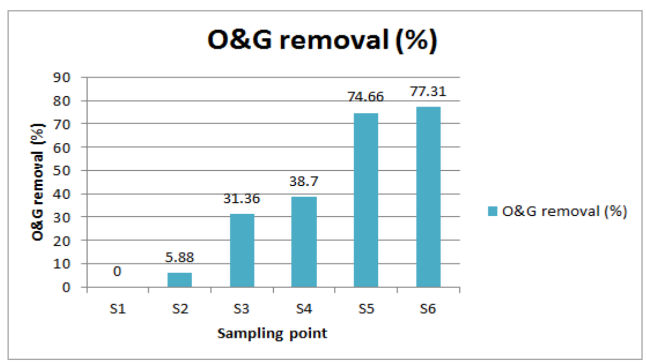

Fig. 1.11: Oil and Grease removal

Meanwhile, the percentage of oil and grease removal reached up to 77.31% at S6 which shows the effectiveness of the aquatic plants to remove oil and grease from the wastewater.

Ammoniacal Nitrogen (AN)

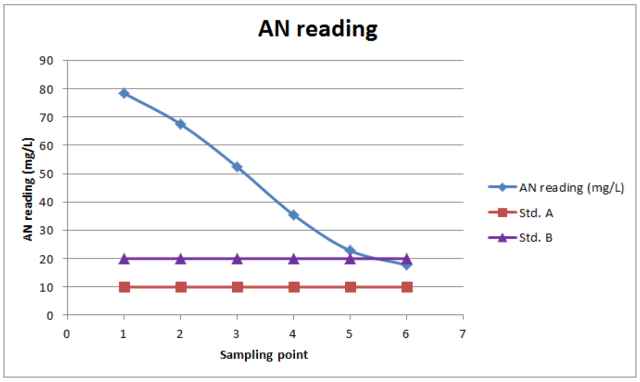

Fig. 1.12: AN reading

Based on the standard A in the Figure 1.9, the ammoniacal nitrogen level must be around 10 mg/L while for the standard B, the ammoniacal nitrogen level must be around 20 mg/L. From the graph, the amount of ammoniacal nitrogen has decrease from the influent of the wastewater until the phytogreen part. This is because the wastewater from the influent is still untreated and when the wastewater flows through the plant, the plant adsorp and absorp the ammoniacal nitrogen as the source of the food. This process will make the level of the ammoniacal nitrogen decrease with time.

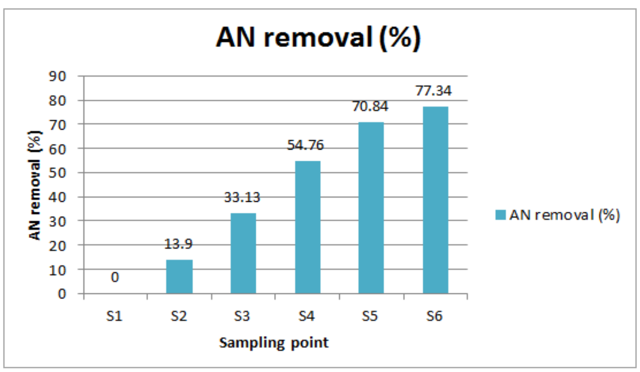

Fig. 1.13: AN removal

The removal of ammoniacal nitrogen occurred at S6 is 77.34%.

4. Conclusions

The plants used in this study have shown up to 95% efficiency based on removing the contaminants from wastewater. Both bioremediation and phytoremediation have a higher potential to treat wastewater inside the oxidation pond based on the analysis shown above. Furthermore, the interactions between aquatic plants and contaminants has 33% of absorption and adsorption process.

Acknowledgments

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