ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 6, December 2012

Removal of Municipal Wastewater BOD, COD, and TSS by Phyto-Reduction: A Laboratory–Scale Comparison of Aquatic Plants at Different Species Typha Latifolia and Saccharum Spontaneum

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Abstract*— Application of phyto-reduction by aquatic plants Typha latifolia and Saccharum spontaneum to treat municipal wastewater was conducted to know the effectiveness in reducing concentrations of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and Total Suspended Solid (TSS) from the municipal wastewater. The research conducted in a laboratory–scale of sand gravel filter by flowing wastewater in the sand gravel filter polybags planted with aquatic plants, Typha latifolia and Saccharum spontaneum continuously at HRT 24 hours. After aquatic plants were exposed to the wastewater, growths of aquatic plants were observed by measuring the increase of shoots at specified interval times and the reductions of COD, BOD, and TSS in water phase were determined. Results showed that municipal wastewater inhibits the growth of aquatic plants, Typha latifolia more resistance compared to Saccharum spontaneum. Application of phyto-reduction by Typha latifolia to treat municipal wastewater may decrease the concentration of COD, BOD, and TSS in the percentage of 50.15%, 56.72%, and 88.83%, respectively. The application of phyto-reduction by Saccharum spontaneum to treat municipal wastewater also may decrease the concentration of COD, BOD, and TSS in the percentage of 56.41%, 37.31, and 97.96%, respectively. These results lead a conclusion that although municipal wastewater inhibit the growth of aquatic plants (Typha latifolia and Saccharum spontaneum), these plants potentially and effectively be used to phyto-reduction process of COD, BOD, and TSS from municipal wastewater.

***Index Terms*— Municipal Wastewater, Organic Matter, Aquatic Plant.**

I. INTRODUCTION

Phyto-reduction of pollutants is well known from wastewater treatment process and other water treatment systems. Natural systems such as constructed wetlands, aquatic systems, and overland flow systems have been studied and used for treatment of municipal wastewater since the early 1950s [1]. They were initially utilized for nutrient removal in domiciliary and municipal sewage, storm water and agricultural runoff displaying a wide range of removal efficiencies [2, 3, 4, 5, 6]. Biological treatment of wastewater is known to have a low efficiency of removing organic compounds with high molecular weights [1]. At present, the application of Phyto-reduction for municipal wastewater treatment represents a promising alternative. Municipal wastewater is one of the main issues that arise in many big cities. The problem is mainly faced in providing urban infrastructure and the treatment of wastewater constitutes a considerable problem in municipal waste management. Phyto-reduction is a part of Phytoremediation process that use of plants to remove, metabolize or degrade pollutants environmental materials. This technique has applications in both the outdoor and indoor environments. As a process of phyotremediation, Phyto-reduction is really a description of what plants do naturally as part of their metabolism: the uptake of moisture and dissolved elements, minerals and compounds from the soil, and the removal of air-borne pollutants under the right conditions. Phyto-reduction of pollutants from the environment serves as an excellent example of the process of plant-facilitated phytoremediation and its role in removing environmental stress. Research related to contaminants biosorbsi process in the reduction of pollutants by aquatic plants has been a subject involving current interest [7, 8,9]. In line with that, research to find new methods to reduce pollutants being continuously conducted. One of them is looking for any species of aquatic plant that has a high ability to absorb and has resistance to pollutants that could be applied in the bioremoval process. There is a wealthy of evidence to show that *Typha latifolia* is highly tolerant to the hostile soil and water conditions and widely used as a natural, effective, and low-cost alternative mean to vegetate the wastewater [10]. *Typha latifolia* has colonized a wide range of wetland habitats, including heavy metal polluted areas [11,12,13]. *Typha latifolia* plant is a Cattail Family (Typhaceae). Cattails are herbaceous, rhizomatous perennial plants with long, slender green stalks topped with brown, fluffy, sausage-shaped flowering heads. These plants

ISSN: 2277-3754
ISO 9001:2008 Certified
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are 15-30 dm tall. The spike-like, terminal, cylindrical inflorescence has staminate flowers above and pistillate flowers below with a naked axis between the staminate and pistillate flowers. These plants are rhizomatous and colonial. The ability of Typha latifolia to absorb pollutants makes this plant have been used in wastewater treatment process [13]. Saccharum spontaneum (Family-Gramineae) is one type of, sugar cane grass with a tall erect reed-like perennial grass with plume like inflorescence, grows in marshes areas. Leaves and stalks contain lignin, carbohydrates, proteins and amino acids [14]. Root-stocks and roots contain starch and polyphenolic compounds. Aerial parts possess laxative and aphrodisiac properties and are useful in burning sensations, strangury, phthisis, vesicles calculi, blood diseases, biliousness and haemorrhagic diathesis [15]. Roots are used as galactagogue and diuretic [14]. It grows as waste land weed. The ability of Saccharum spontaneum to absorb pollutants makes this plant have been used in wastewater treatment. This paper reports an experimental laboratory scale study on how two different aquatic plant species, Typha latifolia and Saccharum spontaneum reduce COD, BOD, and TSS concentration from municipal wastewater.

II. MATERIAL AND METHODS

A. Preparation of Aquatic Plant

Typha latifolia and *Saccharum spontaneum* collected from the area in Banda Aceh City with 12 – 19 cm length were cultivated in polybag for a couple months to reach the acclimatization phase. The study was conducted at a rain shelter as a quality control step to control the factors of temperature; water supply, pest, and diseases.
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B. Experiment

Aquatic plants (*Typha latifolia* and *Saccharum spontaneum*) from the cultivication ponds were exposed in wastewater taken from anaerobic pond of Municipal Wastewater Treatment Plant (MWTP) of Banda Aceh City for four weeks in sand gravel filter polybag contains soil, sludge, and coral as a filter. Wastewater with a flow rate of 5 ml/sec (HRT 24 hours) for 15 days flowed into each polybag of planted crops and the aquatic plants growth was observed by measuring the increase of shoot at specified interval times. Each polybags contained six stems of aquatic plants. During four weeks of the experiment, the atmospheric air and water temperature (30±2 ^{o}C is optimum) were maintained. Control polybags without waste were also prepared. Water phase from outlet port were analyzed by standard methods to determine the reduction of Chemical Oxygen Demand (COD), Biologycal Oxygen Deman (BOD), and Total Suspended Solids (TSS).

III. RESULTS AND DISCUSSION

The research focuses on the reduction of COD, BOD, and TSS in the municipal wastewater by aquatic plants (*Typha latifolia* and *Saccharum spontaneum*) in a laboratory–scale of sand gravel filter. The study began by flowing wastewater in the sand gravel filter polybag planted with aquatic plants, *Typha latifolia* and *Saccharum spontaneum* continuously at HRT 24 hours.

A. Characteristics of Municipal Wastewater

Wastewater taken from anaerobic pond of MWTP of Banda Aceh City has characteristics as tabulated in Table 1.

Table 1 Characteristics of Wastewater from MWTP of Banda Aceh City

Parameter	Level
COD	591 mg/L
BOD	67 mg/L
TSS	188.4 mg/L
pH	5.7
Dissolved Oxygen	5.5 mg/L
Temperature	27.6 ^{o}C

B. Effect of Municipal Wastewater on the Aquatic Plants Growth

After aquatic plants were exposed to the wastewater, the growths of aquatic plants were observed by measuring the increase of shoots at specified interval times and the results are illustrated in Figure 1 and Figure 2.

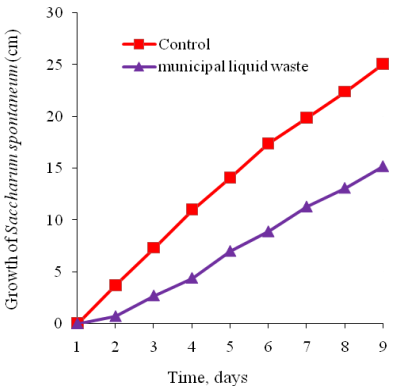

Fig 1 Effect Of Municipal Wastewater On The Aquatic Plants, *Typha Latifolia* (COD: 591 Mg/L; BOD: 67 Mg/L; TSS: 188,4 Mg/L; HRT: 24 Hours and T: 27 ^{O}c)

The results showed that both control plants grew very fast in the log phase where control plants of Typha latifolia grew as high as 9 cm, while Saccharum spontaneum grow as high as 13.7 cm. In contrast to the control plants, the growths of the two treatment plants were slower. Typha latifolia increases only by 1.6 cm in high and Saccharum spontaneum grew by 0.7 cm in high. After 1 day culturization, the increased plant height fluctuated. This result indicates that wastewater inhibits the growth of both aquatic plants because the nutrients needed for plant growth depleting as the number of microorganisms on the roots. Microorganisms need nutrients that exist in the waste to decompose organic material in wastewater, so the competition between plants and microorganisms occurred on plant roots [16]. These results also showed that overall growth of Typha latifolia faster than Saccharum spontaneum in water, which means that Typha

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ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 6, December 2012

latifolia more resistance to municipal wastewater compared to Saccharum spontaneum.

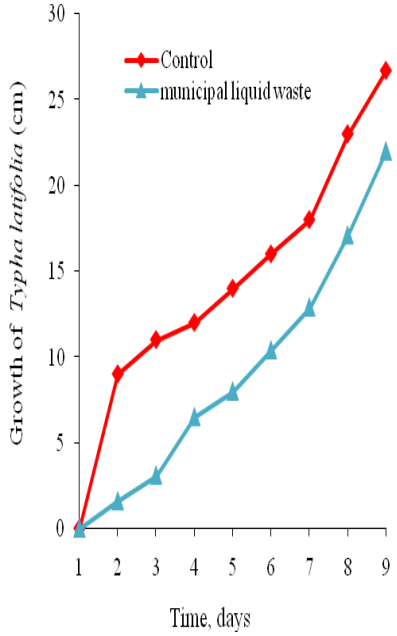

Fig 2 Effect Of Municipal Wastewater On The Aquatic Plants, *Saccharum Spontaneum* (COD: 591 Mg/L; BOD: 67 Mg/L; TSS: 188,4 Mg/L; HRT: 24 Hours and T: 27 ^{O}c)

C. COD Reduction from Municipal Wastewater

COD decreasing in wastewater by *Typha latifolia* and *Saccharum spontaneum* measured daily for 9 days. Figure 3 shows that the decrease in COD concentration for several time by *Typha latifolia* and *Saccharum spontaneum* with initial concentration of 591 mg/L. Reduction of COD concentration from water phase by Typha latifolia at a certain time were 354 mg/L; 340 mg/L; 325 mg/L; 260 mg/L, and 194 mg/L, respectively. The COD decreasing in wastewater by *Typha latifolia* was lower when compared to *Saccharum spontaneum*. Reduction of COD concentration from water phase by *Saccharum spontaneum* at a certain time were 280 mg/L; 270 mg/L; 260 mg/L; 246 mg/L; and 232 mg/L, respectively. Reduction of COD concentrations from water phase by *Typha latifolia* reached 67.17% on day 9 with initial COD concentration of 591 mg/L, whereas *Saccharum spontaneum* highest decline reached 60.74% as shown in Figure 3. These results suggest that *Typha latifolia* and *Saccharum spontaneum* able to reduce COD to 67.17% and 60.74%, respectively with HRT 24 hours for 9 days. In line with the other result research of *Degra simba* [17], longer operating time can lead to a large reduction of COD concentration and greater concentrations of *Degra simba* to treat waste causing greater reduction in concentrations of COD. Similar results were also reported by other researcher [18] showed that the reduction of COD concentration of pulp mill wastewater by aquatic plants *Typha latifolia* and *Cyperus pangorei* were 62.55% and 49%, respectively.

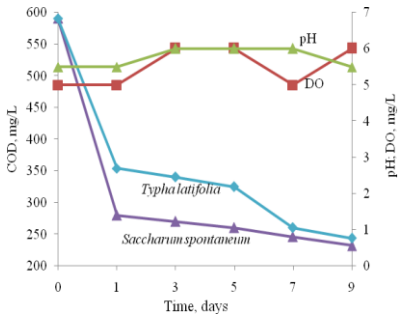

Fig 3 COD Reduction from Municipal Wastewater By Aquatic Plants *Typha Latifolia* and *Saccharum Spontaneum* (COD: 591 Mg/L; and HRT: 24 Hours)

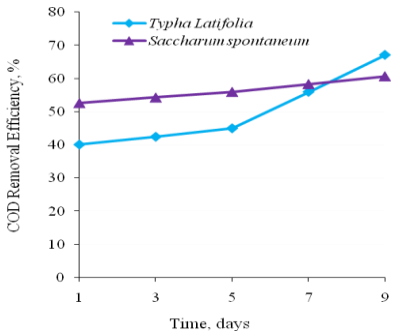

Fig 4 COD Removal Efficiency of Aquatic Plants *Typha Latifolia* and *Saccharum Spontaneum* to Municipal Wastewater (COD: 591 Mg/L; and HRT: 24 Hours)

D. BOD Reduction from Municipal Wastewater

BOD decreasing in wastewater by *Typha latifolia* and *Saccharum spontaneum* measured daily for 9 days and the results are illustrated in Figure 5 and Figure 6.

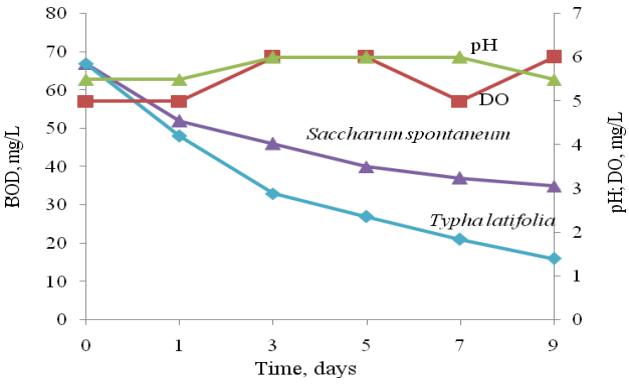

Fig 5 BOD Reduction from Municipal Wastewater By Aquatic Plants *Typha Latifolia* and *Saccharum Spontaneum* (BOD: 67 Mg/L, and HRT: 24 Hours)

Figure 5 shows that the decrease in BOD concentration for several time by Typha latifolia and Saccharum spontaneum with initial concentration of 67 mg/L. After 3 days exposing to the wastewater, BOD concentration decreased to 46 mg/L due to the absorption of organic compound in wastewater by the roots of Typha latifolia, whereas absorption by Saccharum spontaneum lead BOD concentration decreased to 33 mg/L. This value shows the difference BOD concentration reduction in with the use of two different aquatic plants. BOD

ISSN: 2277-3754
ISO 9001:2008 Certified
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Volume 2, Issue 6, December 2012

decreasing in wastewater by *Typha latifolia* was higher when compared to *Saccharum spontaneum*. The highest reduction of BOD concentrations from water phase by *Typha latifolia* reached 76.12% on day 9 with initial BOD concentration of 67 mg/L, whereas *Saccharum spontaneum* highest decline reached 47.76% as shown in Figure 5. These results indicate that the reductions of BOD concentrations of were also affected by aquatic plant activities involving microorganisms that can break down the organic compounds in the process Phytoremediation. Phytoremediation process that occurs at this phase was phyto-reduction/rhizodegradation that use of plant roots to absorb pollutants from wastewater [19]. Other researcher [18] also confirmed that the reduction of BOD could be caused by oxidation of organic matter in wetlands system that provides energy for microbial metabolism. The organic matter contained in the wastewater provides a substrate for aerobic microbial metabolism and the length of culturization time could lead to a decrease of BOD concentration in water phase. In addition, the reduction of BOD was also influenced by the length of phytoremediation time [20].

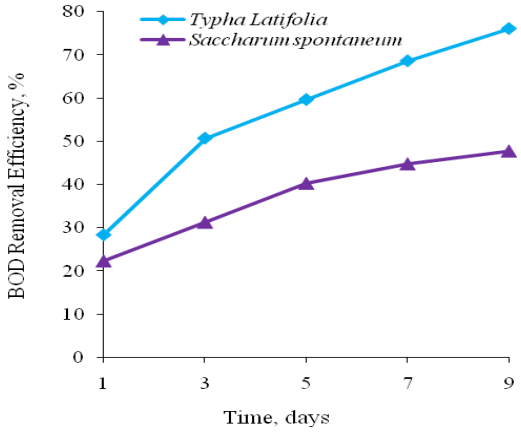

Fig 6 BOD Removal Efficiency of Aquatic Plants *Typha Latifolia* and *Saccharum Spontaneum* to Municipal Wastewater (BOD: 67 Mg/L, and HRT: 24 Hours)

E. TSS Reduction from Municipal Wastewater

TSS decreasing in wastewater by *Typha latifolia* and *Saccharum spontaneous* measured daily for 9 days and the results are illustrated in Figure 7. Reduction of TSS concentration from water phase by *Typha latifolia* at a certain time were 58.6 mg/L; 31.1 mg/L; 14.7 mg/L; 13.5 mg/L; 13.0 mg/L; 12.9 mg/L; 12.6 mg/L; and 12.2 mg/L, respectively. TSS concentration decreasing in wastewater by *Typha latifolia* was lower when compared to *Saccharum spontaneum*. Reductions of TSS concentration from water phase by *Saccharum spontaneum* at a certain time were found 8. mg/L; 5.3 mg/L; 3.5 mg/L; 2.9 mg/L; 2.8 mg/L; 2.7 mg/L; 2.7 mg/L; and 2.6 mg/L, respectively with initial concentration of 188.4 mg/L. Highest reduction of TSS concentrations from water phase by *Typha latifolia* reached 93.62% on day 15 with initial TSS concentration of 188.4 mg/L, whereas *Saccharum spontaneum* highest decline reached 98.59% as shown in Figure 8. Reduction of TSS concentrations occurred due to the presence of sand media filters was used as gravel filtration to precipitate the suspended solids materials. The longer of exposed time lead more soluble solid materials that could be deposited. Large particles of solid material dissolved in the wastewater would be settled while the lighter materials would be carried by water and retained by aquatic plants and then settles as sediment [16]. Smaller particles would be absorbed in biofilm layer attached to the surface of media or the roots of aquatic plants in the polybag treatment.

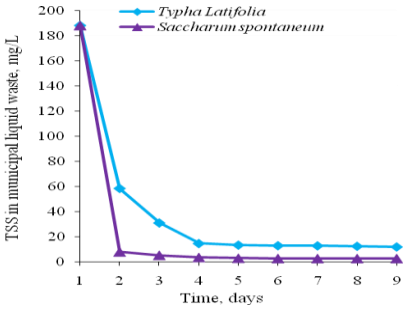

Fig 7 Reduction of TSS from Municipal was water

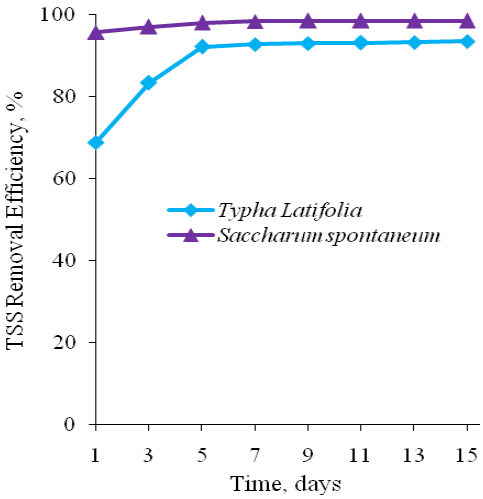

Fig 8 Removal Efficiency of TSS from Municipal Wastewater

IV. CONCLUSION

In this paper, the removal of municipal wastewater BOD, COD, and TSS by phyto-reduction is presented and leads the following conclusions.

1) Wastewater inhibits the growth of aquatic plants, *Typha latifolia* more resistance compared to *Saccharum spontaneum*.
2) Application of phyto-reduction process by *Typha latifolia* to treat municipal wastewater may decrease the concentration of COD, BOD, and TSS in the percentage of 50.15%, 56.72%, and 88.83%, respectively,
3) Application of phyto-reduction process by *Saccharum spontaneum* to treat municipal wastewater also may decrease the concentration of COD, BOD, and TSS in the

ISSN: 2277-3754
ISO 9001:2008 Certified
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percentage of 56.41%, 37.31, and 97.96%, respectively.

4) Generally, results show that although municipal wastewater inhibit the growth of aquatic plants (*Typha latifolia* and *Saccharum spontaneum*), these plants potentially and effectively be used to phyto-reduction process of COD, BOD, and TSS from wastewater water

ACKNOWLEDGMENT

We thank Ministry of Indonesia National Education and Culture for National Priority Research Grant at 2010 fiscal year.

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