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Plant Growth Rate In Evapotranspiration Continuous System Reactors as The 2nd Treatment at Anaerobic-Evapotranspiration System With High Strength Ammonium in Leachate Influent

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Abstract - *Ammonium is one of parameter which responsible to leachate toxicity. Preliminary research was shown that the Fimbristylis globulosa (water plant), Alocasia macrorrhiza (terrestrial plant) and Eleusine indica (terrestrial grass) were potential plants for used as object in evaporation reactor system with high strength ammonium concentration in leachate treatment. This research was integrated of anaerobic system with evapotranspiration system with continuous influent using ammonium concentration in leachate was 2000 mg/l NH_4-N. Plants growth rate was analyzed for 25 days operated. The result shown that average of thallus growth rate of Fimbristylis globulosa was 17,5 cm d^{-1}. The average of leaf and thallus growth rate of Alocasia macrorrhiza was 18,1 cm d^{-1} and 3,2 cm d^{-1} respectively. The average of blade and thallus of Eleusine indica were same that was 4,7 cm d^{-1}.This research conclude that integration system of anaerobic and evpotranspiration was be potential used for high strength ammonium in leachate treatment.*

Keywords *— Ammonium, Continuous system, Evapotranspiration, Leachate*

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I. INTRODUCTION

The leachate contains various pollutants such as organic matter, amonia-nitrogen, heavy metals, chlorinated organic, inorganis salts (Wang *et.al*, 2002) It also may be exposed to organisme in the environment including microorganism and plants. The assessment is confirmed by the large number of studies on leachate toxicity measured by bioassays including aquatic species, plants and bacteria (Thomas *et al*., 2009). The adverse effects of ammonium nitrogen in leachate toxicity have been mentioned by several authors (Clement *et al*., 1997; Castillo and Barcelo, 2001; Marttinen *et al*.,2002). Leachate toxic effect to plants was tested by Bialowiec and Randerson, 2010 using young willow (Salix amygdalina L.) resulted an ability of willow plants to tolerate higher strengths of landfill leachate if they are cultivated in such concentrations from the beginning and the proportion of landfill leachate in the total amount of water supplied to a willow plantation (leachate + precipitation) should not exceed 6% in the initial phase of growth. Marchand *et. al*, 2011 using duckweed (*Lemna minor L.*) resulted negatif affected duckweed growth. The limited factor for leachate toxicity to plants were species and age of plants, toxicant in leachate/dose, toxicant concentration in the cultivated soil. Each plant species has different tolerance levels to the different contaminants and young plant more sensitive to leachate toxicant. Žaltauskaitė and Čypaitė, 2008 has been demonstrated that higher plants can be effectively used to assess toxicity of landfill leachate.

Leachate effect to plant was influence by toxicant in leachate or dose where applied to assay. However, different responses tested organisms make difficult result interpretation, since toxicity results depended on effluent characteristics, which change with the type or treatment degree (Silva *et al*., 2004). The treatment help reducing bio-toxicity of leachate to non-mortality and degree of DNA damage similar to non-exposure level (Theepharaksapan *et al*., 2011). Leachate toxicant in cultivated soil where tested plants can be resulted different respon especially cause by different both toxicant and concentration. Investigated by Bialowiec et al. (2010) resulted the lowest effective concentration (LOEC) willow *Salix amygdalina* was in the range 4.69–5.63% of leachate concentration, where leaf

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length and, especially, fractal dimension are shown to be good indicators of plant response to toxicants in their environment. A toxicant in leachate with high concentration was ammonia (Kjeldsen *et al*. 2002; Price *et al*. 2003, Tengrui *et.al*, 2007), where ammonia can cause various types of injury to plants including necrosis, growth reduction, growth stimulation and increased frost sensitivity. It cause availability of carbohydrates probably plays an important role, where plant can detoxify ammonia as long as it can convert ammonia into amino acids.

Ammonium nitrogen can be removed by biological methods as an effective conventional alternative treatment but unexpensive cost (Baquerizo *et.al*, 2005). Some researcher using anaerobic system as biological denitrification process to degradation ammonia nitrogen with many reactors design (Barber and stuckey, 2000, Shivaraman *et.al*, 2001, Qin and Liu, 2006, Thabet, *et.al,* 2009, Tang *et.al,* 2009). Biological denitrification is the reduction of nitrate to nitrogen gas by facultative heterotrophic organisms taht require carbon as a source of food. A sufficient carbon : nitrogen ratio at least 2:1 is necessary to complete denitrification reaction in natural systems (Metcalf and Eddy, 1991).

Anaerobic system in the first stage commonly have function to lighten aerobic system in the second stage, where ammonia removal was occur. Some researcher reveal the limiting factors for an aerobic process were as follows: bacterial present, oxygen concentration, electron acceptor, chemical concentration as carbon sources, and detention time. Anaerobic process as denitrification process was performed by various chemoorganotrophic, lithoautotrophic and phototrophic bacteria and some fungi (Zart *et al.*, 1999).

Amonium removal used natural process also was potential system to applied in the leachate treatment system facilities. Aerobic process with based on plants used commonly know as evapotranspiration bed reactor (ETBR). Evapotranspiration is the net water loss caused by the evaporation of moisture from the soil surface and transpiration by vegetation. For continuous evaporation, three conditions must be met. First, there is a latent heat requirement of approximately 590 cal/g of water evaporated at 15 ^{0}C. Second, a vapor pressure gradient is needed between the evaporative surface and the atmosphere to remove vapor by diffusion, convection, or a combination of the two. Third, there must be a continuous supply of water to the evaporative surface (Solomon *et.al*, 1998). Higher plant have potential to used for ETBR. Green plants used to treat and control contaminant from waste known as Phytoremediation.

Fact showed vegetated landfill cover contributed to an additional removal of excess leachate volume and leachate components from the system (Justin dan Zupancic, 2009). Phytoremediation in engineered wetland has been successfully tested in many locations worldwide and apply were of wetlands, grass lands, crops, and tree plantations.The rate of biodegradation and mineralisation during phytoremediation was affected by the nature and concentrations of contaminants present, as well as surrounding soil/air moisture, pH, temperature, soil elemental contents and their bioavailability, and the supporting microbial media. Usually present in low concentrations that not acutely phytotoxic (Mccutcheon and Jorgensen, 2008). However, some researcher resulted not acutely phytotoxic at high concentration. Willow plants apllication did not react negatively, despite very high annual loads of nitrogen (≤ 2160 kg N ha^{-1}), chloride (≤ 8600 kg Cl ha^{-1}) and other elements. Irrigation resulted in elevated groundwater concentrations of all elements applied. Treatment efficiency varied considerably for different elements, but was adequate when moderate loads were applied (Aronsson, et.al, 2010). Landfill leachate positively affected growth of *Salix* and *Populus* and increased biomass production due to the fertilization/irrigation properties of wastewater with up to 2144 kg N ha^{-1}, 144 kg P ha^{-1}, 709 kg K ha^{-1}, 1010 kg Cl ha^{-1}, and 1678 kg Na ha^{-1} average mass load in the experiment (Justin, et.al, 2010) Vetiver grass was applied in the landfill and used leachate as water source and nutrient shows excellent establishment (Percy dan Truong, 2003). Resulted both flow rate and recirculation ratio should be taken into account for proper design of reactor. (Lavrova and Koumanova, 2010). *C. Haspan* was reliable used plant in treating leachate with sub-surface flow wetland constructed and efficient in removing of some parameters in leachate. Sand and gravel as media were suitable for plant growth (Akinbile, et.al, 2012). *Populus* used at laboratorium and field scale resulted both good growth and genotip respond when irrigated and fertilized with landfill leachate (Zalesny, et.al, 2007; Zalesny Jr, et.al, 2009). *Typha angustifolia* L. and *Cyperus involucratus* was used for treat high-strength (*ca.*300 mgL^{-1} of COD and *ca.* 300 mgL^{-1} total-nitrogen) under tropical condition showed the number of *Nitrosomonas* was two to three orders of magnitude higher in the planted systems compared to the unplanted systems (Kantawanichku, *et.al*, 2009).

With high potential of phytoremediation system for high-strength leachate concentration, biological process with economic cost but high efficient was needed to treat amonium in leachate especially at tropical condition. Plants growth rate and physical condition effect caused by high strength ammonium in leachate to integrated continuous system between anaerobic bacterial and plants of *Fimbristylis globulosa* (water plant), *Alocasia macrorrhiza* (terrestrial plant) *and Eleusine indica* (terrestrial grass) was analyzed in this study as a basic information before applied for ammonium in leachate removal treatment system.

II. METHODS

Reactor Design

Every set reactors was designed by integrated of anaerobic reactor test (ART) with evapotranspiration reactor (ER), where every reactors was added with toxicity indicator (TIR) reactor. Detention time of it's reactors was 3 days. The volume of toxicity indicator reactors was about 80% smaller than test reactors. This research was designed with 9 set reactors,where every plant test species was be triplicated. It's reactors formation was follows:

Reactors Operation

The reactors was operated with continuous influent system. Plants growth rate in evapotranspiration reactors was analyzed for 25 days operated. The Ammonium concentration in leachate as influent was 2000mg L^{-1} NH_4-N

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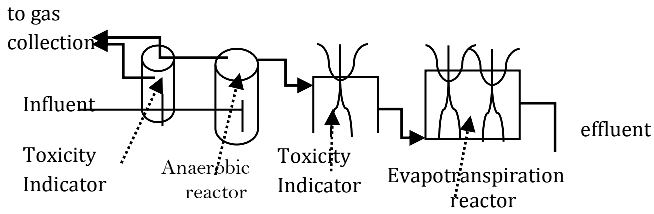


Fig.1. A Set of Continuous Reactor Design

Data Collection

Plants thallus high, plants leaf wide,plants blade wide was measure at the first day reactors operated and then was measure every week and at the end reactors operated used elastic plastic ruler. Spatial plants condition was observed to control the reactors

III. RESULT AND DISCUSSION

The plant of *Fimbristylis globulosa* growth rate for 25 days reactors operated shown that growth rate was unsignificant different between TIR and ER. In TIR 1 and TIR 3 *Fimbristylis globulosa* growth rate was faster than in ER 1 and ER 2, but in TIR 2 it's growth rate was slower than in ER 2. The average of growth rate in TIR and ER 19.5 cm d^{-1} and 17.5 cm d^{-1} respectively. The new thallus shoot rate in TIR and ER was 0.49 thallus d^{-1} and 0.47 thallus d^{-1} or new thallus shoot will growth every 2 days (figure 3). This growth rate was very high (>10 cm d^{-1}), where the fastest thallus growth rate in batch reactor was 1.37 cm d^{-1} [19]. It's growth rate shown that *Fimbristylis globulosa* may use ammonium as one of nutrient for photosynthetic processes and medium volume was unhibit it's growth rate.

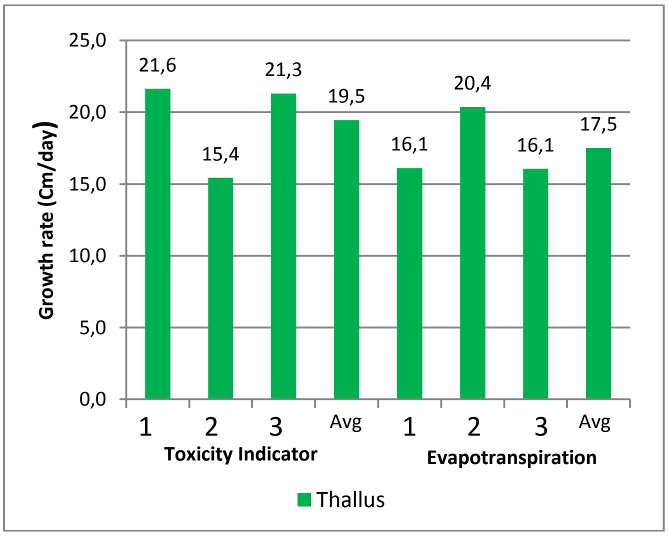


Fig. 2. Growth rate of *Fimbristylis globulosa* plant

The thallus growth rate of *Alocasia macrorrhiza* in TIR and ER was unsignificant different but leaf growth rate was significant different. The thallus growth rate in TIR and ER was similar with range 3.2 to 3.9 cm d^{-1} with new thallus shoot rate in TIR and ER was 0.21 thallus d^{-1} and 0.11 thallus d^{-1} respectively. It's mean in TIR and ER will growth new shoot thallus every 5 days and 10 days respectively. The opposite condition was happened for leaf growth rate, where in TIR and ER leaf growth rate were significant different. Leaf growth rate in TIR was slower then in ER, where average leaf growth rate in TIR and was 11.0 cm d^{-1} and 18.1 cm d^{-1} rspectively. It's mean that leaves in ER was much more wide then in TIR and the medium volume was inhibit to growth of *Alocasia macrorrhiza.* Although, *Alocasia macrorrhiza* showed was capable to used ammonium in high strength condition as nutrient to photosynthetic processes in it's plants and unhibit growth rate.

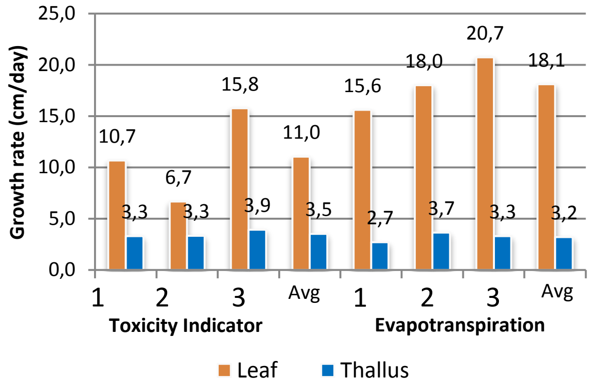
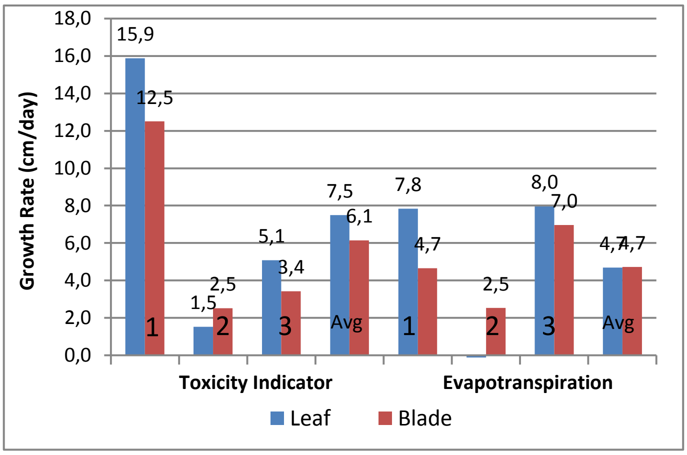


Fig.3. Growth rate of *Alocasia macrorrhiza* plant

Different condition was happened to *Eleusine indica* grass. In the TIR 1 reactor, leaf and blade growth rate was highest and leaf growth rate in ER 2 was minus. It's condition was happened caused by grasshoppers leaves grazing of *Eleusine indica* grass. Although, the average of leaf and blade growth rate was relatively fast, where in TIR was 7.5 cm d^{-1} and 6.1 cm d^{-1} respectively and it's new blade shoot was 0.33 blade d^{-1} that mean every 3 days will appear new blade shoot. In ER, the average of leaf and blade growth rate was 4.7 cm d^{-1} each, with new blade shoot was 0.25 blade d^{-1} or every 4 days will appear new blade shoot (Figure 4).

Fig. 4. Growth rate of *Eleusine indica* grass



This result shown that *Eleusine indica* grass commonly have capabilities to used and treat high strength ammonium in leachate as nutrient by photosynthetic processes

IV. CONCLUSION

[1] *Fimbristylis globulosa, Alocasia macrorrhiza* and *Eleusine indica* can be used to ammonium treatment until concentration was 2000mg $^{L-1}$ NH_4-N with relatively fast growth rate.

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[2] Integrated system was have potential to used as a treatment system with high strength ammonium in leachate.

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