International Scholars Journals

International Journal of Virology and Parasitology, Vol. 8 (2), pp. 001-006, February, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Removal of Ammonium (NH_4) and Organic Matter (COD) In Landfill Leachate Under Anaerobic and Aerobic Algae Culture In Continuous Systems

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Accepted 11 May, 2018

Final Disposal (Landfill) generally produce pollutants such as leachate and can have a negative impact on the environment. In general, landfill leachate containing high of organic matter and high of nitrogen, as well as Ngronggo landfill leachate in Salatiga, far exceeded the applicable waste water. To reduce the organic matter and ammonium contens, Ngronggo landfill leachate was processed under anaerobic-aerobic process (algae-culture) in continuous system, with residence time of 24-hour for one week. The results showed that anaerobic-aerobic (algae culture) in continuous system were conducted in a laboratory scale give a significant results to removing over 90% of COD and ammonium, and produce water quality that meets with the quality standards of waste water.

Keywords: *landfill leachate, algae culture, continuous, anaerobic, aerobic.*

INTRODUCTION

Leachate is blackish brown liquid that comes from rain water mixture with water produced from the decomposition of litter material(Christensen 2001; Maramis *et. al.,* 2006). Leachate is water degradation results from the trash and can cause pollution if not treated before it is dumped into the environment. Many factors affect the quality of the leachate, such as rainfall and the age of the landfill. Pollution levels in the leachate varies greatly due to rainfall and seasonal changes (ANZECC, 2000). In the rainy season the leachate production is higher than the dry season. Leachate from the final disposal(TPA) has the potential to harm the environment, because it contains a very organic and in organic high as humicacid, xenobiotic compounds(XOCs), ammonia, and heavy metals (Ibrahimpašiæ., *et. al*., 2010). In general, the leachate is toxic because they contain heavy metals that are harmful if exposed to the environment and can contaminate groundwater, surface water and ground, then go through the layers of soil base. Inorganic contaminants such as ammonia is the main product of the decomposition (decay). On dissociated ammonia in the state would be more harmful to the fish than in the form of ammonium

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(Pescod, 1973). Ammonia in water produced by the decomposition process, reduction of nitrate by bacteria, fertilization, and excretion of organisms in it (Boyd, 1982).Ammonia is also called ammonia nitrogen produced from the decay of organic matter by bacteria. These compounds are usually found in the form of a gas with apungentod or characteristic (called ammonia smell). Ammonia can be converted to ammonium by reaction amonifikasi.

Each of ammonia released a little market environment will form are action equilibrium with ammonium ion ($NH4^+$). Ammonium can cause human poisoning, minimal irritation. This Ammonium which then undergoes nitrification nitrite and nitrate form. The content of ammonia (NH_3) is present as a result of decomposition waste that occurs in the leachate, resulting in a process amonifikasi amino acid that has been formed is converted into ammonium with the help of bacterial and fungal micro organisms.

The main components of the garbage is organic and inorganic materials, because the process of an aerobic degradation of organic material (Damanhuri, 1990). Organic waste(bio waste) containing carbon material. Carbon in the waste willed compose and form a soluble material which is measured as COD(Chemical Oxygen Demand). The parameter indicates the total oxygen required to oxidize organic compounds in imbah. According Tchobanoglous *el. al*., (1993), leachate COD concentrationoflessthan2years of its content is in the range3000-6000mg/l. Landfill leachate in a womb have a very complex due to the complexity of the composition of the waste that goes into landfill.

The results of the study reported that ammonium and organic matter are the main pollutants in landfill leachate (Mangimbulude *et. al*., 2009). Ammonium in the leachate generated from the decomposition of protein/amino acids contained in the waste. Ammonium concentrations in the leachate tends to increase over time. That's why in the future landfill operations>10years tend to produce leachate with ammonium content above 500mg/L (Mangimbulude *et. al*., 2012). In high concentrations of ammonium be toxic to aquatic organisms and also in humans. Exposure to concentrations of 50ppm ammonium cause nose and eye irritation in humans for 30-60minutes, whereas at a concentration of 5000ppmlead to death (Agency of Toxic Substances and Disease Registry, 2004). High levels of COD and ammonia in the leachate can reach thousands of mg/L, so the leachate treatment should not be done haphazardly (Machdar, 2008). That is why the concentration of ammonium in the leachate must be reduced to a level that can be accepted by the body of water so as not to disturb the life of aquatic organisms.

Ammonium reduction in leachate or wastewater today generally use biological processes. This process is a wastewater treatment process by utilizing microorganisms in contact with waste water. In the contact, microorganisms use organic material as a substrate pollutants under certain environmental conditions and stabilize into a simpler form (Metcalf & Eddy, 2004). To get a better process, some researchers have conducted research on the reduction of organic matter and ammonium in landfill leachate by using a combination of anaerobic and aerobic continuously. In this study, the use of algae culture in the aerobic process. Algae has several advantages, namely, generating dissolved oxygen content at the time of algae perform photosynthesis. It is known that bacteria in symbiosis with algae in wastewater treatment, algae will photosynthesize and produce oxygen, where oxygen is used by bacteria to degrade organic pollutants. Algae produce oxygen in need of light, then the oxygen content in the evening will decrease and will lead to competition for O2 between algae and microbes (Bellinda et al., 2012). Symbiotic mutualism occurs in this process, when the algae use the CO2 released by microorganisms in the process of photosynthesis (Grobbelaar et al., 1988). Algae can also tolerate a ratio of N: P is low and will continue to grow despite the N dwindling, high pH values and low CO2 (Bellinger & Sigee, 2010). Research relating to the use of algae has been done both to manage wastewater treatment plants as well as domestic Limba.

Wastewater treatment systems can be done using the maximum algae (Suriawiria, 1986). According Syahputra (2002), algae can be used in lowering copper (Cu) in the metal plating industry, because this algae has the ability to absorb heavy metals including Cu. In addition, algae as a means of handling liquid waste because these algae can grow and thrive in dirty water. Factors affecting the growth of algae, which are: light, temperature, nutrients and organic, carbon dioxide, oxygen, flotation, and drowning. Algae growth is stimulated by nitrate and phosphate, mostly algae using NO^3 as a source of nitrogen (Mara, 1976).

This study focuses on the reduction of COD and ammonium Ngronggo Salatiga landfill leachate using continuous culture system algae and take place simultaneously in a single reactor that given two different zones(zone anaerobic and aerobic zone). Anaerobic wastewater treatment is an effective way of aspects of the use of energy to treat wastewater. Management of a multistage process involves an aerobic degradation of organic compounds to methane and carbon dioxide by the action of anaerobic micro-flora (Kalyuzhnyi et al., 2007). According to Khanal (2008), anaerobic processes as biological processes which organic matter is metabolized in dissolved oxygen free environment. Anaerobic treatment is a biological method for the decomposition of organic or inorganic material without the presence of oxygen (Milasari & Ariyani, 2010). In anaerobic processes, a reduction in the concentration of organic matter, and if it continues to aerobic process allows for the growth of algae. The purpose of this study was to determine the ammonium and COD reduction using kulturan aerobic microbes and algae culture simultaneously in a continuous system.

MATERIALS AND METHODS

1. Leachate

Samples obtained from landfill leachate Ngronggo Salatiga. This landfill has been operated since 1994. Leachate generated from the landfill is not processed, only accommodated in the tank, then flows to the river.

2. Algae Culture

Obtained from algae ponds in landfill leachate Jatibarang, Semarang, which then cultured in the laboratory Master Biology, Christian University Satya Discourse, Salatiga. Acclimatization process is done by culturing algae in a natural medium in the form of leachate that has beendiluted100 times for 3monthsbefore being used as inoculums in the experiment.

1. Experimental Procedure

Experiments reduction of organic matter and ammonium continuously in the design follows the scheme 1. Approximately 15liters of leachate (pH adjusted neutral) were taken from the landfill Ngronggo Salatiga, put in a container 1, drained (flow rate of 0.21L/h) to the container 2 (as the an aerobic reactor, DO=0mg/L) which has filled 10 liters of leachate (pH neutral), then over flow from the an aerobic reactor housed in a container for separating solids then it over flow into the reactor 3 containing a volume of 10 liters algalculture (pH neutral). Reactor 3 in aeration, over flow of reactor 2 is passed into the container C and subsequently stored in a container over flow reservoir 4. The process lasts for1week, the addition of fresh leachate done, if the volume of leachate in the container 1 has been reduced. Sampling was carried out on the container vessel every 24 hours, to measure COD, ammonium, nitrite and nitrate.

2. Analysis of Samples

Measurement of pH using a pH-indicator strips. Ammonium and COD concentration in the samples was measured using a Varian Cary photometric 50spectrophoto meter at a wave length of 425nm to 600nm ammonium and COD. APHA measurement procedure to follow.(1998).

THE RESULTS

Through anaerobic-aerobic treatment systems continuously using algae culture, there is a change in the character of the leachate. Reduction of ammonium started happening after hours to 24 hours to up to up to 96 hours (day 4), and after it did not happen reduction see Figure 2. In Figure 2 shows that the concentration of ammonium in the processed leachate after 96 hours was 5.5mg/L, this indicates that in this period the reduction of ammonium with continuous system reaches 98.6%. With this efficiency ammonium concentrations in the treated leachate quality standard approach (see table1). In addition to ammonium, nitrate and nitrite were also analyzed and the results were negative. While the concentration of ammonium in the container 1 (fresh leachate) was not changed during the process (7 days).

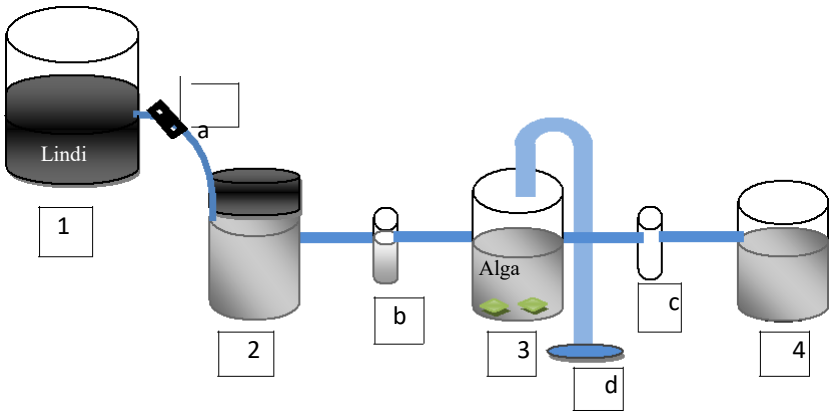
Likewise, the COD, the reductions already seemingly after 24hours of contact time, then continued to decline until the hour to 148 (day 7) (see figure 3). Overall reduction of COD concentration for 7daysup to 98%, without put COD concentration of 48.8mg/L, and this in accordance with the wastewater quality standards. During the process is relatively stable H in the range of 7-7.8.

DISCUSSION

Landfill leachate Ngronggo Salatiga has an average pH of6.0 to 9.0 COD 6650mg/L and ammonium 602mg/L. Nitrates and nitrites are below the limit of detection that can be said to be zero, while the dissolved oxygen content is 0mg/L. Leachate pH is neutral, indicating the status of leachate are not in phase as idofil. The study of the characteristics of the leachate has been reported by many researchers at home and abroad, which showed that the leachate has the potential to pollute the environment mainly surface water and groundwater (Christensen *et. al*., 2001, Kjeldsen *et. al*.,2002, Mangimbulude *et. al*., 2009). Organic matter in the leachate derived from degarasi process waste in the landfill, as well as ammonium, derived from the decomposition of proteins in the trash. Studies reported by Berge et al., 2005showedthat the content of ammonium in the leachate from the conversion of the protein in the trash by microbe shetrotrofik that' just happen in two steps: first the conversion of the protein into amino acids, and secondly through the domination of amino acids so that the release of ammonium. This process takes place under anaerobic conditions, andaerobics.

In this study indicate that the content of organic and ammonium in land fill leachate exceeds Ngronggo Salatiga, Central Java Provincial RegulationNo.5of 2012 on the wastewater quality standards (Table1). In addition, landfill leachate Ngronggo Salatiga is an aerobic. Thus Ngronggo land fill leachate has the potential environmental contaminants that need to be processed before being released into the environment. So that should be considered by pemeiritah agencies who own a landfill leachate authority to process Ngronggo precisely in order to reduce the concentration of COD and ammonium.

Overall the results of this study indicate that the reduction of ammonium through an aerobic-aerobic system continuously deliver high performance, the concentration of ammonium in the output approaching waste water quality standards applicable. Ammonium reduction is thought to occur when it is in the aerobic phase, where the presence of algae participate in the process. During aerobic process, the concentration of



(Figure 1. Scheme of Research Design)

Keterangan (*Information*) :

(1)Bioreaktor*(Bioreactor)* a = Pengatur kecepatan alir*(Control Of Flow Rate)*

(2) Reaktor Anaerobik*(Anaerobic Reactor)* b = Setling pertama*(First Setling)*

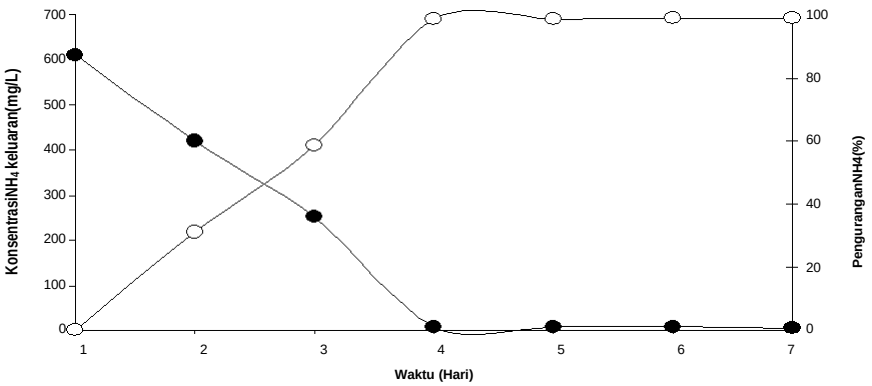
(3) Reaktor Kultur Alga *(Algae Culture Reactor)* c = Setling kedua*(Second Setling)*

(4) Bak Penampung Hasil Sampling *(Tank The Result Sampling)* d = Aerator*(Aerator)*

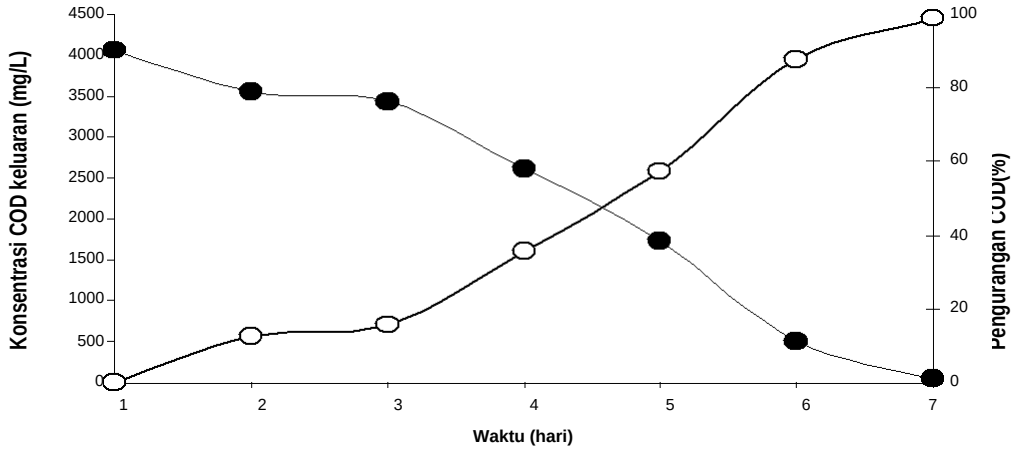
(*Table 1. First Characteristics of Landfill Leachate in Ngronggo*)

Parameter	Unit	initial concentration	Quality Standards*
COD	mg/l	6650	100
Amonia sebagai NH_3-N	mg/l	602	5
pH	mg/l	7,8	6,0-9,0

*Sumber : Peraturan Daerah Provinsi Jawa Tengah Nomor 5 Tahun 2012



(**Figure 2.** The concentration of ammonium in the output of processed products (black dots) of leachate with a residence time of 24 hours during a week and presentation the degradation of ammonium reduction (white dots).



(**Figure 3**. Concentration of COD in the output of processed products (black dots) of leachate with a residence time of 24 hours during a week and the presentation of the degradation of COD (white dots).

ammonium is not reduced. Ammonium reduction in anaerobic conditions can occur through a process ANAMMOX (Anaerobic Ammonium Oxidation), along availability aksteptor electrons as nitrite and nitrate (Van Loosdrecht and Jetten, 1998). In this study, nitrate and nitrite was not found during the an aerobic and aerobic processes, thus it is reasonable to say that the anammox process does not occur in the an aerobic stage. In aerobic conditions, ammonium is reduced through the nitrification process, characterized by reduced ammonium, nitrate and nitrite concentration increased. But it is not found in this research, so it can be said that there reduction of ammonium occurring in the aerobic phase, carried out by the algae culture. Recent research reported by Krustocl et al., (2014) showed that culture algae can be used as an agent to lower the high ammonium concentrations in wastewater. The same thing was also reported by Lin *et al*., (2007) that the micro algae Chlorella pyrenoidosa and Chlamydomonassnowiae isolated from landfill leachate in Guang Zhou China is able to grow and reduce the concentration of amounium significant in landfill leachate.

Reduction of organic matter as measured by the reduction of COD, occurs also in the anaerobic stage, but large reductions lower than the reductions that occur under aerobic conditions. It was reinforced with test data in batch leachate COD reduction in anaerobic and aerobic conditions, indicating that the reduction COD under aerobic conditions for one week, reaching 62% higher almost 4 times with 19% anaerobic conditions.

Overall, anaerobic-aerobic system (culture algae) were conducted in a laboratory scale give significant results on the reduction of COD and ammonium to over 90%, and produce quality processed memenui quality standards. But before applied, needs to be done also in a pilot scale test project to see if there are irregularities and changes in the effectiveness of the system.

CONCLUSION

Ammonium and COD reduction of landfill leachate Ngronggo Salatiga using anaerobic-aerobic system of continuous-culture algae with a contact time of24for 7daysgivingboth parametersreductionefficiencyreachesabove95%, resulting in a quality that is still processed in accordance with the waste water quality standards. Algae very important role reducing the concentration of ammonium under aerobic conditions.

AKNOWLEDGMENT

The author would like to thank District Government Yapen Islands Papua Province, for providing financial supporter of this stu.

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