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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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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 inorganic high as humic acid, xenobiotic compounds (XOCs), ammonia, and heavy metals (Ibrahimpasjae, *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 pungent or characteristic (called ammonia smell). Ammonia can be converted to ammonium by reaction amination.

Each of ammonia released a little market environment will form an action equilibrium with ammonium ion (NH_4^+). 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 amination 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 will 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 it. According Tchobanoglous *et al.*, (1993), leachate COD concentration of less than 2 years of its content is in the range 3000-6000 mg/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 >10 years tend to produce leachate with ammonium content above 500 mg/L (Mangimbulude *et al.*, 2012). In high concentrations of ammonium be toxic to aquatic organisms and also in humans. Exposure to concentrations of 50 ppm ammonium cause nose and eye irritation in humans for 30-60 minutes, whereas at a concentration of 5000 ppm lead 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 O_2 between algae and microbes (Bellinda *et al.*, 2012). Symbiotic mutualism occurs in this process, when the algae use the CO_2 released by microorganisms in the process of photosynthesis (Grobelaar *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 CO_2 (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 kultur 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 been diluted 100 times for 3 months before 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 15 liters 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 algal culture (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 for 1 week, 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 50 spectrophotometer 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 table 1). 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).

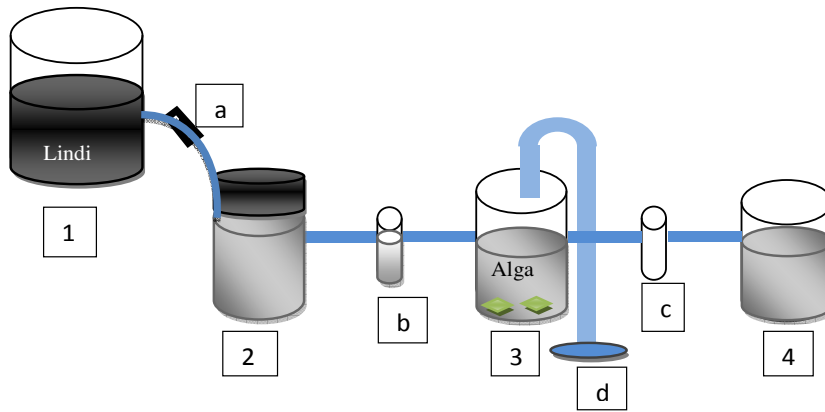
Likewise, the COD, the reductions already seemingly after 24 hours of contact time, then continued to decline until the hour to 148 (day 7) (see figure 3). Overall reduction of COD concentration for 7 days up to 98%, without put COD concentration of 48.8mg/L, and this in accordance with the wastewater 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 of 6.0 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.*, 2005 showed that 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, and anaerobics.

In this study indicate that the content of organic and ammonium in land fill leachate exceeds Ngronggo Salatiga, Central Java Provincial Regulation No. 5 of 2012 on the wastewater quality standards (Table 1). 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 pemerintahan 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)

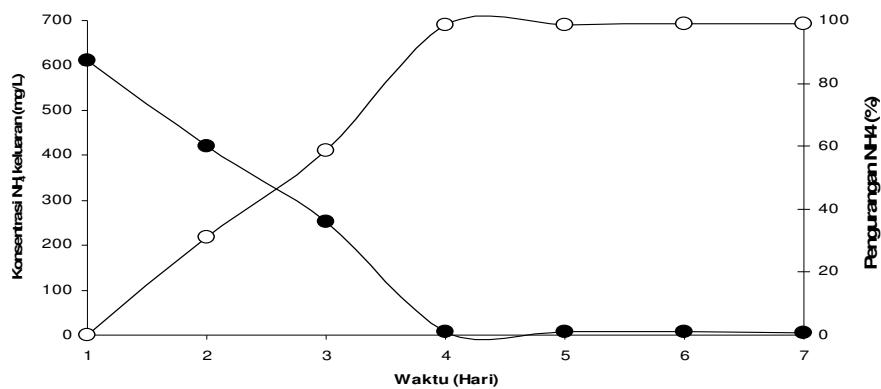
Keterangan (Information) :

- | | |
|---|---|
| (1) Bioreaktor(Bioreactor) | a = Pengatur kecepatan alir(Control Of Flow Rate) |
| (2) Reaktor Anaerobik(Anaerobic Reactor) | b = Setling pertama(First Settling) |
| (3) Reaktor Kultur Alga (Algae Culture Reactor) | c = Setling kedua(Second Settling) |
| (4) Bak Penampung Hasil Sampling (Tank The Result Sampling) | d = Aerator(Aerator) |

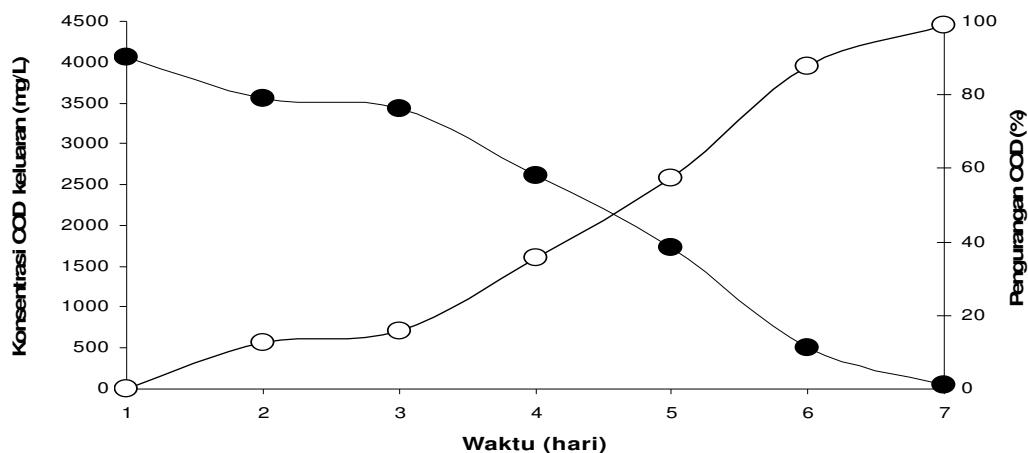
(Table 1. First Characteristics of Landfill Leachate in Ngronggo)

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 akseptor 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 Krustoci 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 *Chlamydomonas nivalis* isolated from landfill leachate in Guang Zhou China is able to grow and reduce the concentration of ammonium 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 memenuhi 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 of 24 for 7 days giving both parameters reduction efficiency reaches above 95%, 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.

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BIBLIOGRAPHY

- Agency of Toxic Substances and Disease Registry. (2004). Toxicological Profile for Ammonia. <http://www.atsdr.cdc.gov/ToxProfiles/tp126.pdf>. (Diunduh 13 Maret 2014)
- ANZECC (Australian and New Zealand Environment and Conservation Council), and ARM CANZ (Agriculture and Resource Management Council of Australia and New Zealand). (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000*. Canberra, Australia.

- APHA (1998). *Standard Methods for Examination of Water and Wastewater, 2nd ed.* American Public Health Association. Washington DC.
- Bellinda IA, Agus S, dan H Joni (2012). Efek Aerasi Terhadap Dominansi Mikroba Dalam Sistem *High Rate Algae Pond* (HRAP) Untuk Pengolahan Air Boenzem Morokrengan. ITS Sukolilo, Surabaya. [Paper]
- Berge ND, Reinhart DR, TG Townsend (2005). *The fate of nitrogen in bioreactor landfills.* Critical Reviews in Environmental Science and Technology 35, 365–399
- Boyd CE (1982). *Water Quality Management for Pond Fish Culture.* Elsevier Scientific Publishing Co., New York.
- Christensen TH, Kjeldsen P, Bjerg PL, Jensen DL, Christensen JB, Baun A, Albrechtsen HJ, Heron G (2001). Review : Biogeochemistry of Landfill Leachate Plumes. *App Geochem* 16:660-718.
- Damanhuri E (1990). Peranan Biodegradasi Sampah dalam Memepercepat Satabilitas Lahan Urug Saniter. *Jurnal Ilmiah dalam Seminar PAU Bioteknologi ITB – 11 Januari 1990.* Jurusan Teknik Lingkungan ITB. Bandung.
- Grobbelaar JJ, Soeder CJ, Groeneweg J, Stengel E, Hartig P (1988). Rates of Biogenic Oxygen Production in Mass Cultures of Microalgae. Rates of Biogenic Oxygen Production in Mass Cultures of Microalgae. Absorption of Atmospheric Oxygen and Oxygen Availability for Wastewater Treatment. *Water Research* 22, 1459-1464.
- Ibrahimpašić JT, Dragičević L, Zanoški MH, Bačun VD, Ćurlin M, Vrèek IV (2010). *Nitrogen Removal from Landfill Leachate Municipal.* Biotechnical Faculty. University of Bihać.
- Kalyuzhnyi S, Veeken A, Hamelers B (2007). Two-particle model of anaerobic solid state fermentation. *Water Science and Technology.* vol. 41. no. 3. pp: 43-50.
- Khanal SK (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. [http://www. online library.wiley.com/doi/10.1002/9780813804545.fmatter/summary.](http://www.online.library.wiley.com/doi/10.1002/9780813804545.fmatter/summary) (Diunduh 10 Juni 2014.)
- Kjeldsen PI, Barlaz MA, Rooker AP, Baun A, Ledin A, and Christensen TH (2002). Present and Long-Term Composition of MSW Landfill Leachate: A Review. *Critical Reviews in Environmental Science and Technology,* 32(4):297-336.
- Krustocl I, Guillermo DJ, Shabiimam MA (2014). Algae biomass cultivation with ammonium rich wastewaters as substrate: The potential for simultaneous wastewater treatment and energy recovery. *5th International Symposium on Energy from Biomass and Waste, Venice, Italy, 17-20 Nov.*
- Lin L, Chan GY, Jiang BL, Lan CY (2007). Use of ammoniacal nitrogen tolerant microalgae in landfill leachate treatment. *Waste Management* 27, 1376-82.
- Machdar I (2008). *Water Science and Technology.* 39 (7) (1999), pp. 23-31.
- Mangimbulude JC, Van Breukelen BM, Krave AS, Van Straalen NM, Röling WFM (2009). Seasonal Dynamics in Leachate Hydrochemistry and Natural Attenuation in Surface Run-off Water From a Tropical Landfill. *Elsevier. Waste Management* 29:829-838.
- Mangimbulude JC, Van Straalen NM, Röling WFM (2012). Microbial nitrogen transformation potential in surface run-off leachate from a tropical landfill. *Elsevier. Waste Management* 32:77-87.
- Mara D (1976). *Sewerage Treatment in Hot Climate.* John Wiley and Sons. New York.
- Maramis AA, Kristijanto AL, dan Notosoedarmo S (2006). Sebaran Logam Berat dan Hubungannya dengan Faktor Fisiko-Kimiawi di Sungai Kreo, Dekat Buangan Air Lindi TPA Jatibarang, Kota Semarang. *Akta Kimindo.* Vol. 1 (2) : 93-98.
- Metcalf, Eddy (2004). *Wastewater Engineering. 4th edition.* Mc Graw Hill International Editions. New York.
- Milasari NI dan SB Ariyani (2010). Pengolahan Limba Cair Kadar COD dan Fenol Tinggi Dengan Proses Anaerob dan Pengaruh Mikronutrient Cu : Kasus Limbah Industri Jamu Tradisional. Semarang. Universitas Diponegoro. [Skripsi]
- Peraturan Daerah Provinsi Jawa Tengah Nomor 5 Tahun (2012). Tentang Perubahan Atas Peraturan Daerah Provinsi Jawa Tengah Nomor 10 Tahun 2004 Tentang Baku Mutu Air Limbah.
- Pescod MB (1973). *Investigation of Rational Effluent and Stream Standard for Tropical Countries.* London: AIT.
- Suriawiria (1986). *Pengantar Mikrobiologi Umum/Unus Suriawiria.* Angkasa. Bandung.
- Syahputra B (2002). *Pemanfaatan Alga Chlorella pyrenoidosa Untuk Menurunkan Tembaga (Cu) Pada Industri Pelapisan Logam.* Fakultas teknik UNISSULA. Semarang.
- Tchobanoglous G (1993). *Integrated Solid Waste Management.* McGraw-Hill Book Co: Singapore.
- Van Loosdrecht, Jetten (1998). Microbiological conversions in nitrogen removal. *Jurnal: Water Science and Technology.* Page 1-7. Delft University of Technology.