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Assessment of leachate quality by comparing WQI to saprobic index in plankton

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Abstract

Change on landfill function from sanitary landfill to open dumping at District of Mempawah, Western Borneo, Indonesia is deterioration in environmental management. Objective of this research is to assess leachate quality in dry season using a comparison of WQI to SI during tides. Only plankton species survives at specific contamination level in landfill leachate. Utilization of plankton was to evaluate the influence of waste to biotic community through tides that flows to landfill. Concentration exceeds specified limits lead to extinction of native biota. Long dry season indicates a high Pb (0.123 mg/l), Cu (0.065 mg/l), NH_3 (349 mg/l), Fe (17.4 mg/l), as well as high BOD_5, and COD. However, there was low DO in low tide at 2.71 mg/l. Heavy metal such as Pb detected at 0.00 mg/l within safe limits for environment, except NH_3 at 5.20 mg/l and 23.00 mg/l. SI indicated leachate on high tide in level of lightly contaminated (Oligosaprobic), low tide (Oligosaprobic) and (β-Mesosaprobic). WQI of landfill leachate was 0 – 25 in extremely poor category, 25 – 50 in poor category for high tide and 0 - 25 in extremely poor category in low tide. Samples was tested using Gravimetric, Winkler Azide, Closed Refluc, Spectrophotometer. Research result showed that the most source of waste was from domestic. Leachate SI was indicated in extremely poor, which were responded by *Skeletonema* as a tolerant plankton to organic matter, *Nitzchia vermicularis*with groups tendency and *Synedra acu*. Wastewater Treatment Plant is an alternative to minimize contamination to prevent extinction of plankton.

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Introduction

The sanitary landfill was the first concept in Wastewater Treatment Plant (WWTP) construction at Mempawah District, West Borneo, Indonesia. However, due to unsupported factor, the status changed to an open dumping landfill. This condition is a reduction in environmental management because it is not equipped by WWTP and it can be regarded as an uncontrolled landfill (Abu – Daabes, 2013.). Leachate is a chemical substances reaction with infiltration forms liquid (Abbas *et al.*, 2000, Al Sabahi *et al.*, 2009.). Biodegradation processes such as aerobic, asetogenic and anaerobic are occurred during the formation of the leachate. The waste aerobic process is biodegraded by bacteria producing carbon dioxide. It causes waste fully degraded in this process (Tammemagi, 1999., Zanetti, 2008.).

The waste leachateproduces extremely in high concentration in years and directly dumped to the river. It has potency to cause contamination to soil (EL-salam, 2015, Mahvi and Roodbari, 2011.), to surface water (Christensen *et al.*,1992, Hossain *et al.*, 2014), and to groundwater (Fatta *et al.*,1999.). Besides that, It degrades surround environments (Kjeldsen & Christophersen, 2001.), and increases health risk (Ernes AS *et al*, 2005.). Species abundant and plankton growth are also disturbed when the leachate enter the water due to tides in landfill (Wice and Dave, 2006.).

Based on WQI, leachate in poor to extremely poor category has an increase along with increases of landfill, organic matter, and heavy metal, as well as due to season (Kulikowska D, Klimiuk E, 2008., Bhalla, 2013.). The leachate has influences to plankton growth because of high Cd, Pb, Fe, Cu, Phosphate, Ammonia, BOD, COD, TDS, and TSS contents. Plankton responses to contamination are influenced by single daily tides and it causes migration, distribution, and saprobic (Suryanti,2008). Plankton growth is controlled by nutrients and an optimum tolerance and the growth will be disturbed under minimum condition.

It is categorized as lightly contaminated when there are found *Skeletonema sp*, *Synedra acus, Raphidium polymorphum*and*Nitzchia palaea*in the larger quantities than *Oocystus naegeliii*, *Cylops strenus*and *Asterionella gracillina* at high water tides.

The objective of assessment to leachate quality using WQI and Saprobic index were to evaluate leachate concentration to plankton resistance in leachate, to explain index equation, saprobic utilization in leachate. This finding are expected to be a fundamental for water plankton sustainability.

Material and methods

Study area

The landfill at District of Mempawah, Province of West Borneo, Indonesia was built on 1996. The earlier concept for this landfill was a sanitary landfill but later it changed to an open dumping landfill on 2000. It is laid in 4 ha low land in slope of <8% and it is flooded. Geographically the landfill is located in 0,302764/0°,18´9,95"N, 109,041622/109° 2´29,84"E and in 0,302858/0°,18´10,29"N, 109,041637/109°2´29,89"E.

Water analysis

Physical, chemical and biology samples was taken from landfill leachate. Samples analysis was conducted in three laboratories, i.e. Laboratory of , Laboratory of soil quality and land health, Agricultural Faculty, Tanjungpura University, Indonesia. Meanwhile, plankton was analyzed in Testing Laboratory of Agency for Industrial Policy, Quality, Climate and Quality Assessment; Laboratory of Center of research and Industrial Standardization; and Laboratory of Water Resources Management, Fisheries and Marine Science Faculty, Diponegoro University, Indonesia..

WQIanalysis

WQI analysis was conducted to analyze physical and chemical parameters, simplify data into single value from extremely good to extremely poor levels (Ferreira *et al,* 2011). It was done by selecting represented parameter from whole parameter, scoring, simplify difference on unit in an ordinary scale,. The equation for WQI is

$$WQI = \frac{\sum_{i=1}^{n} PiCi}{\sum_{i=1}^{n} Pi}$$

Noted:

Level in WQI

0 – 25 = extremely poor

50 – 70 = poor

70 – 90 = pair

90 – 100 = extremely good

Saprobic Index Analysis

SI is indicated from the equation of formula Persoone and De Pauw:

$$SI = \frac{1C + 3D + 1B - 3A}{1A + 1B + 1C + 1D}$$

Noteed:

SI = Saprobic Index

A = Total species of Polysaprobic organism

B = Total species of α- Mesosaprobik organism

C = Total species of β- Mesosaprobik organism

D = Total species of Oligosaprobik organism

Methods

The leachates were taken in depth of 3 mduring water tides in the dry season . 100 l samples was filtrated into 50 ml using 0.054 planktonet. Meanwhile, plankton samples were preserved using 0.5% lugol and 1 ml preservation reagent was added into Sedwich Rafter. Then, it was observed under microscope and name of plankton species was identified (Yamaji,1979; Haste O.R). Physical and chemical sample was stored at 4°C and was analyzed using method of Gravimetric, Winkler Azide, Closed Reflux, Spectrophotometer, and AAS flame.

Result and discussion

The landfill sanitary was the first concept for landfill in Mempawah District. However, it changed into open dumping landfill because factor did not support the operational system. Analysis results for both samples was found high content of TDS, TSS, BOD_5, COD, NH_3, Fe, Phosphate, and Ammonia (Aluko *et al.*, 2003.) as well as Cu and Cd exceeded allowable standard. This results are seen in Table 1, 2, and 3. TDS in high tides was 2770 mg/l, TSS 75 mg/l, BOD_5 16.27 mg/l, COD 143.8 mg/l, DO 2.71 mg/l, NH_3 5.20 mg/l, Fe 0.19 mg/l. The same result was obtained in low water tides but Pb concentration was in allowable concentration. Fig. 1. and 2. show that TSS concentrations were 428 mg/l, 75 mg/l, 170 mg/l and TDS concentrations were 7,926 mg/l, 2770 mg/l, and 4990 mg/l. A decrease on DO at 2.71 mg/l and 0 mg/l (Nwabueze, 2011.) caused death on anaerobic organism. It affected increasing on ammoniac toxicity at 349 mg/l (Bernard *et al.*,1996.). Concentration of Pb at 0.123 mg/l, Cd at < 0.001 mg/l, Cu at 0.065 mg/l exceeded allowable concentration for those metals in the leachate. These concentrations are dangerous for aquatic organism (Wice and Dave, 2006). Concentration of Pb at tides is under allowable standard. Factor of water, wind and rain influence Pb concentration in leachate. Pb is not evaporate and it is an organic element found in the air as particles, element in rocks, soil, plants and animals (Wardayani, 2006.).

Table 1. Value of WQI in the Leachate in Dry Season.

No	Parameter	Unit	Test result	Ci	Pi	Ci*Pi
1	TDS	mg/L	7.926	25	2	50
2	TSS	mg/L	428	-	4	-
3	COD	mg/L	2.398	-	3	-
4	pH		7,21	90	1	90
5	DO	mg/L	-	-	4	-
6	BOD	mg/L	1.113	90	3	270
7	Phosfat	mg/L	0,308	50	1	50
8	Ammonia	mg/L	349	-	3	-
	Total				21	460
	Value index					21,9
	Category	Value between 0 - 25 = extremely poor				

Leachate taken in the dry season contain heavy metal, organic and anorganic matter (Abas *et al.*, 2009, Bhalla, 2013, Daabes, 2013; Fatta *et al.*, 1999, Li, 2010.). Sample taken in high temperature cause a decrease on gas solubility in the water so that decomposition process occurs along with an increase in temperature. Anaerob organism would be death due to lack of dissolved oxygen and it produces hydrogen sulfide that cause unpleasant smell (Arbain *et al.*, 2008; Renoua *et al.*, 2005.). It increase free ammonia toxicity that cause death to aquatic organism (Effendi, 2003.).

Table 2. Value of WQI in the Leachate at High Water Tidein Dry Season.

No	Parameter	Unit	Pi	Result	Ci	Ci*Pi
1	TDS	mg/l	2	2770	25	50
2	TSS	mg/l	4	75	70	280
3	BOD5	mg/l	3	16,27	0	0
4	COD	mg/l	3	143,8	25	75
5	DO	mg/l	4	2,71	25	100
6	Ammonia	mg/l	3	5,20	0	0
7	pH	-	1	7,8	90	90
	Total		20			595
	Value index					29,75
	Category			Value between 25 -50 = Poor		

COD and BOD in the leachate have chemical composition that is constantly changing for long term, and highly dependent on the characteristics of waste composition, landfill top soil, season, pH, humidity and landfill age. BOD and COD have a multiple number of times higher than specified limit (Deng and Englehard, 2006). COD was found higher than BOD because bacteria oxidizes organic substance to become CO_2 and H_2o. Potassium dichromate oxidize more organic substance producing a high COD. COD in the day shows a high increase due to temperature fluctuation (Khattabi, 2002.).

Table 3. Value of WQI in Leachate at Low Water Tides in Dry Season.

No	Parameter	Unit	Pi	Result	Ci	Ci*Pi
1	TDS	mg/l	2	4990	25	50
2	TSS	mg/l	4	170	25	100
3	BOD5	mg/l	3	135,59	0	0
4	COD	mg/l	3	2047,6	0	0
5	DO	mg/l	4	0	0	0
6	Ammonia	mg/l	3	23,00	0	0
7	pH	-	1	7,8	90	90
	Total		20			240
	Value index					12
	Category			Value between 0 -25 = Extremely Poor		

Long dry season affects characteristic and quantity of leachate, increament on waste quantity, and landfill age (Tengrui *et al.*, 2005; Kjeldsen *et al.*, 2002;Kargi and Pamukoglu, 2003 a,b.). Regarded to water percolation as a main source, leachate depends on rainfall to seep into the trash pile, the water out of the landfill base, and percolate through the layers of waste. But the result is inversely proportional to the age of the landfill in the Mempawah District.

Plankton selection was to assess leachate quality by comparing WQI to Saprobic index. Physical, chemical and biological analysis were conducted to evaluate the whole description of studied object. It becomes important when plankton species is used as a comparison in leachate. When water tide enters to landfill, mixture of leachate with water beyond landfill begins. Changes begin from contamination to water reaction in which organic matter have an increase and become useful for plankton. Moreover, animals or plants will be death because of suspended material disturbance factor.

Table 4. Saprobitas Index (SI) in the Dry Season.

SI	Tide	Category	Receding	Category
a	1,667	Oligosaprobik	2,00	Oligosaprobik
b	1,8	Oligosaprobik	1,2	Oligosaprobik
c	1,8	Oligosaprobik	1,14	β - Mesosaprobik

A comparation of WQI to leachate was categorized into extremely poor (0 – 25) to poor (25 - 50). Physical and chemical values have similar category to WQI. These values affect to development of plankton that depend on resistance to water quality. Water quality analysis has different effects as well as WQI scoring is conditioned by the parameter role to biota life such as limiting factor. DO is limiting factor for organism in the water. Meanwhile, controlling factors were related to temperature and affected water biochemistry, biota life, organic matter decomposition by microbe as well as gas solubility in the water. Value categories for this factors are seen in Table 1, 2, and 3.

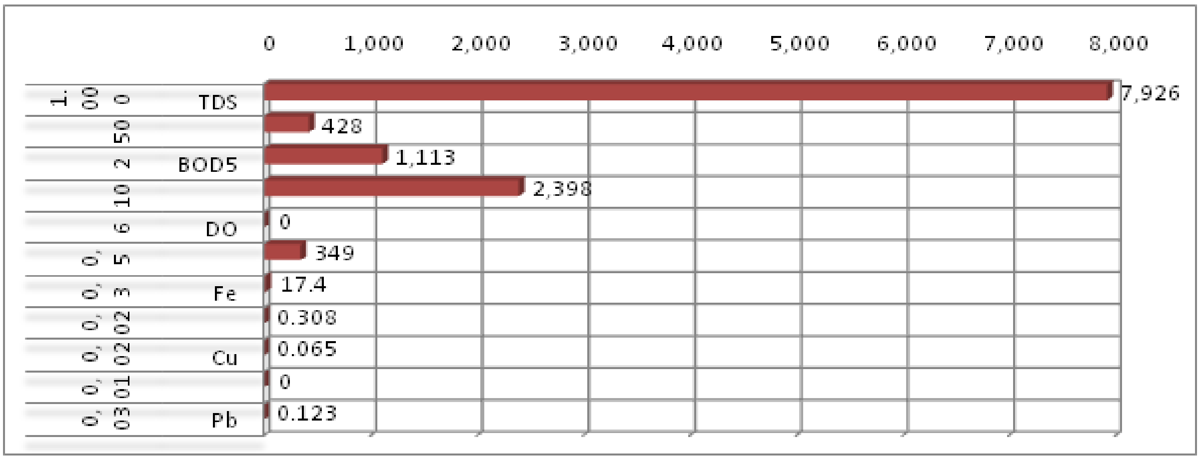

Fig. 1. Leachate Concentration in the Landfill in the Dry Season.

Saprobic indexes of high tide leachate was categorized as light to pair contaminated. 12 plankton species were found at (Fig. 3), 73 plankton species were found in the evening high water tides, 46 plankton species in the afternoon high water tides and 58 plankton species in the morning high water tides. Whereas, 29 plankton species were found in the evening low water tides. 23 plankton species in the afternoon low water tides and 18 plankton species in the morning low water tides (Fig. 4 and 5).

Groups of saprobic leachate in the dry season (Fig. 3) from α – mesosaprobik group (lightly contaminated) are *Nitzchia palaea, Clostridium acresum,* and *Oscillatoria sp*; from β- mesosaprobik group are *Asterinolla formosa, Diatoma vulgare,* and *Gyrosgyma acuminata*; from Oligosaprobicgroup are *Skeletonema coastum,* and *Synedra acus,*and from Non saprobic group were*Raphidium polymorphum, Oocystus naegelii,*and *Hairotina reticulata*.

Plankton growth is related to tides (Fig. 4). Plankton species found at the High water tide in the morning were *Skeletonema, Nitzchia vermicularis,Udinula vulgaris,Skeletonema, Nitzchia vermicularis, Synedra ulna, Nitzchia seriata,* and*Dactylocococopsis sp*were found in the evening high water tide, as well as *Skeletonema sp, Nitzchia vermicularis, Synedra ulna, Synedra acus,* and *Dactylocococopsis sp*in the afternoon high water tide.*Polyedrium trigonum,Coelosphaerium, Nitzchia seriata, Synedra acus, Nitzchia vermicularis,* *Skeletonema sp*(Fig.5) were found in the low water tide in dry season. Drought recede found (Fig.5)*Polyedrium trigonum,Coelosphaerium, Nitzchia seriata, Synedra acus, Nitzchia vermicularis, Skeletonema sp*. More plankton species were found in the high water tides in the dry season due to the influx of sea water. Sea plankton species found the most were *Nitzchia*, which tolerance to an extreme life and salinity (Hogan, 2008.).

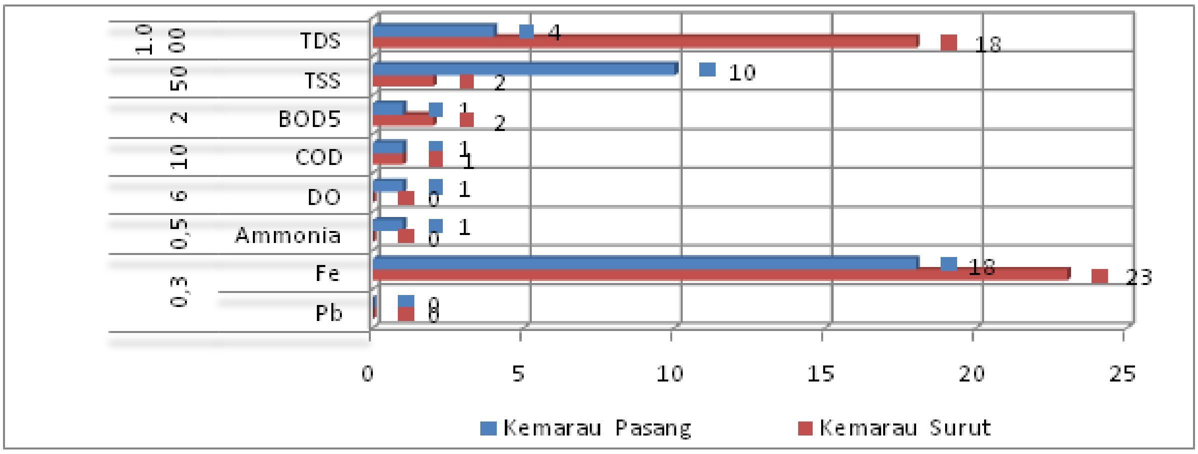

Fig. 2. Leachate Concentration at High Water Tides in the Dry Season.

Hynes (1960) mentioned that *Nitzchia,* and *Skeletonema sp* resistant to waters with abundant organic matter and live in groups (Munda,2005.). The similarity from both species were found because of adjacent sample location so that resulted in similar physical and chemical condition. Factors of food competition and environment affect to plankton growth indicated by total of plankton species.

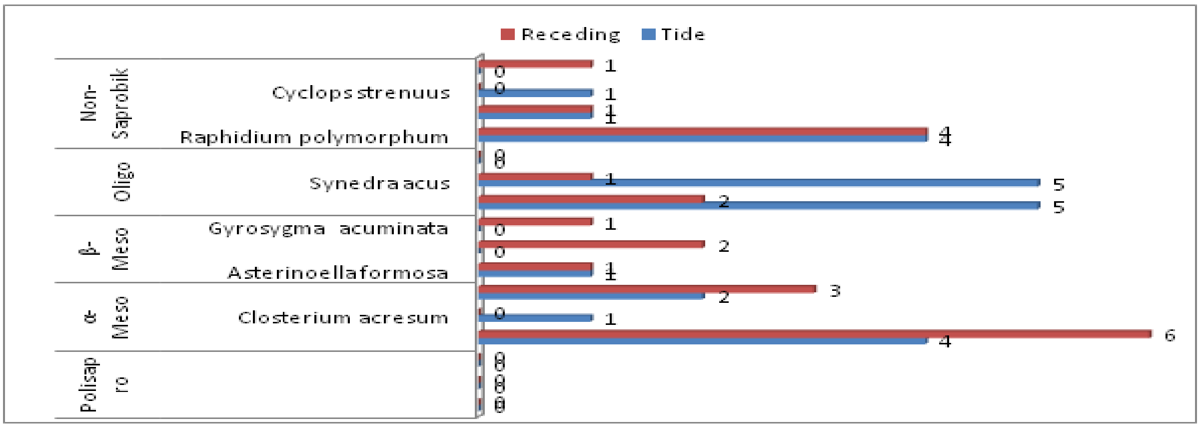

Fig. 4. Saprobic Group in the Dry Season.

A high organic matter cause drastically increases on number of microorganism and bacteria. Explanation for this condition is more dissolved oxygen used for respiration and cause a decrease on DO until it dropped under minimum to undetected drastically. However, there were found deaths on non-tolerant species followed by a decrease in number of plankton species. In the contrary to pollution tolerant organism that have more species. Changes of some parameters were caused by dense plankton and low nutrients so plankton species were decline. According to a lot of total plankton, the possibility for nutritional needs are met for plankton because plankton stores energy source (Basmi, 2000), absorbs ammoniac waste in leachate when enters ammoniac water and non-toxic to waste exposed animal.

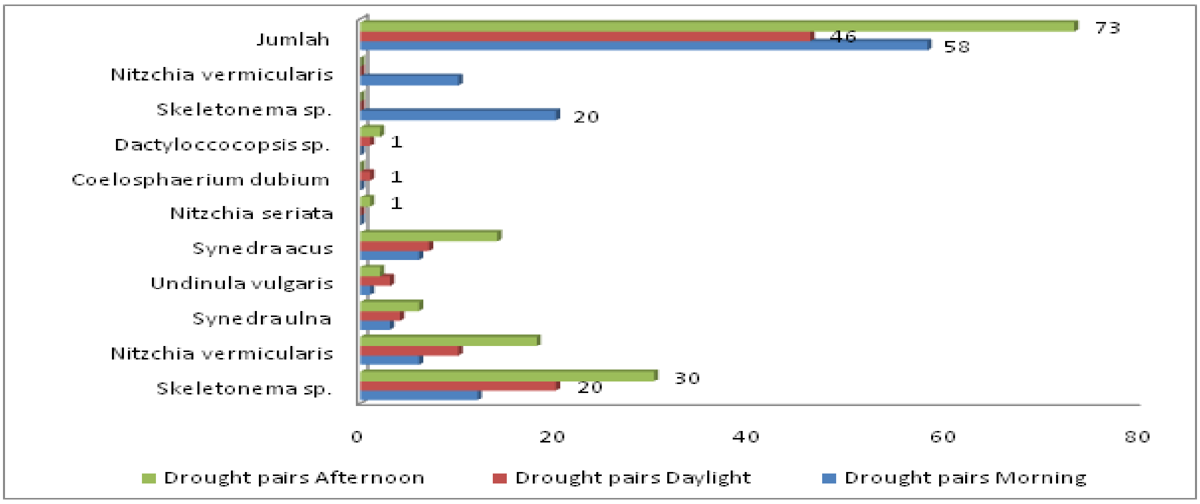

Fig. 5. Dry plankton species pairs.

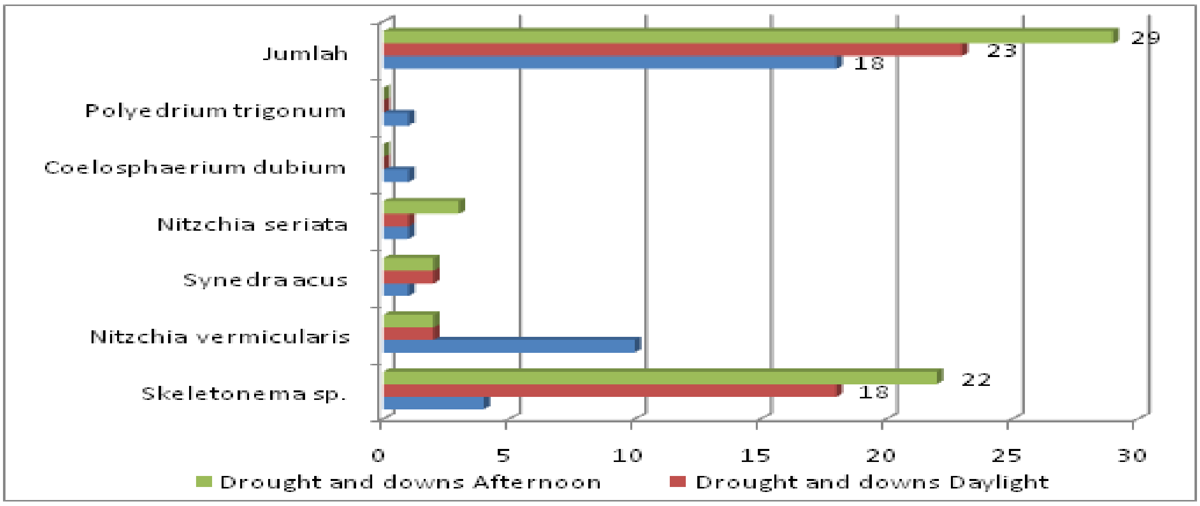

Fig. 5. Plankton species drought recede.

A low minimum DO cause unbalance plankton community, as seen in Fig. 4 and 5. Availability of saprobic organism was as a determinant indicator for water quality. It was influenced by physical and chemical quality so that affected to life of saprobic organism. Microorganism in leachate indicated that pollution parameter (saprobic index) between contaminated materials with saprobic index could be related to pollution (Suwondo*et al*, 2004). Oligosaprobic indicates light pollution level, which decomposition of organic materials completely occurred and community of organism structure is available in abundant number of species (Zahidin, 2008).

Saprobic value is pollution level that measured using nutrient contents and contaminated materials (Suryanti, 2008). Based on calculation of Saprobic Index to leachate indicated that dry season was categorized in light pollution. It was shown by resistant species in high water tide, i.e. *Skeletonema* sp, *Synedraulna,* and *Synedra acus*. *Skeletonema* sp occupied in receding pattern in number of 22, 18 and 4 species. *Nitzchia vermiculariss,Synedra acus*, *Nitzchia seriata* and *Nitzchia sp* growth rapidly in low light and nutrient condition, have capability to high reproduction so that its total dominated other species.

Oligotropic is categorized in non productive environment due to organic and anorganic substances. A high BOD (16.27 mg/l) indicated an unqualified leachate meet supply of oxygen needs for water organism, as well as COD (143.8 mg/l) was oxidized through microbiological so that causes a decrease on DO in leachate. Low DO caused by high respiration activity from photosintesis and water organism as well as biological decomposition. Number of plankton species is related to non supported environmental condition for plankton growth such as low DO at 2.71 mg/l, high BOD, COD, Ammonia, Fe, TSS and TDS. Another factor that tides enter leachate affects migration and distribution. It has potency to affect saprobic level.One of alternative needed is WWTP to minimize pollution when leachate dumps into river so that plankton will not be extinct.

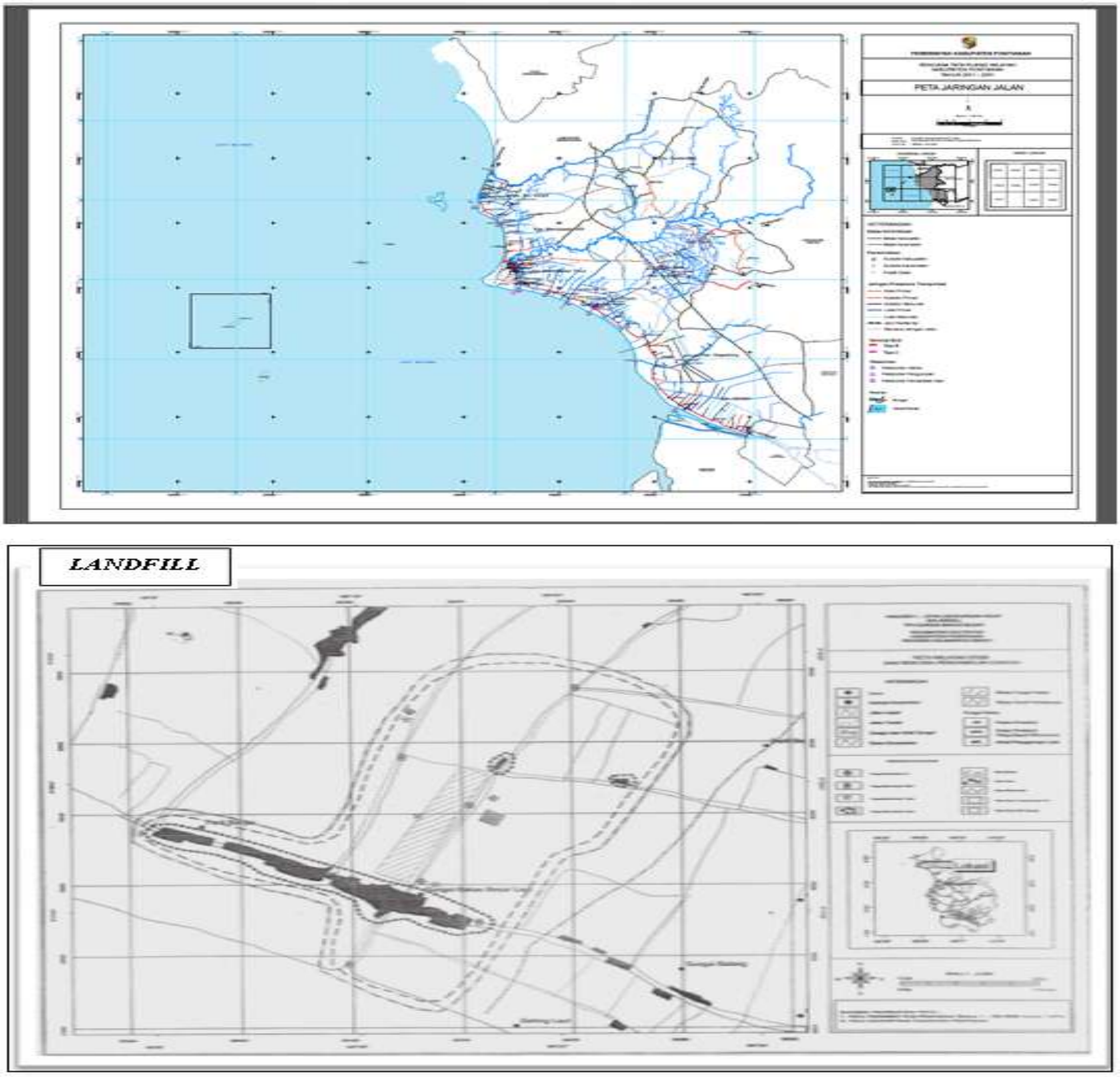

Fig. 6. Location studies.

Conclusion

Leachate at landfill in District of Mempawah has high quality with poor and extremely poor categorizes, as well as similarity in leachate quality values. It is affected by factors of season, number of new wastes, and tides role in plankton distribution. Age of landfill in District of Mempawah is inversely proportional to decrease of leachate quality. The worst leachate quality was responded by resistant plankton to water quality. *Skeletonema sp*, *Nitzchia vermicularis* and

Synedra acus are dominant plankton in leachate. *Skeletonema sp*, and *Nitzchia* are tolerant species to organic matter, live in groups with numerous amount in leachate. Such changes indicated a shift in zone with an indication of light polluted, although index comparison shows poor – extremely poor categorizes. WWTP is needed to reduce polution. Plankton potency as water quality indicator is very useful to evaluate physical condition of environment generally and specifically in landfill area.

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