Loading and Distribution of Organic Materials in Maninjau Lake

Hafrijal Syandri, Azrita and Junaidi[1]

[1)]Faculty of Fisheries and Marine Sciences University of Bung Hatta
email: hsyandri_bilih@yahoo.co.id

ABSTRACT

Maninjau Lake utilization for the development of fish farming system floating net (KJA) already exceeded the carrying capacity of the number KJA waters in 2012 as many as 15 860 plots are used to maintain tilapia and carp, so the impact of organic matter pollution load is high enough. Water quality research and loading of organic matter and its distribution has been carried out in Maninjau Lake in July 2013. Quality of the surface water dissolved oxygen at each station showed almost the same conditions ranged from 5.70 to 6.77 mg/L, except for dissolved oxygen at a depth of 15 meters ranged from 3.26 to 4.12 mg/L, pH ranged between 8-10, low brightness range between 1.2-2.0 meters and electrical conductivity ranges quite high ranging from 33.66 to 45.32 ms/cm. Total organic content (TOM) on Koto Malintang station at 19.94 mg/L, Koto Kaciek station at 16.69 mg/L, Bayur 9.32 mg/L, the station on the lake outlets Hydropower Intake of 9.35 mg/L and Sigiran station at 14.10 mg/L. TOM accumulation in Maninjau Lake was 10.59 mg /L or 53.10% of the incoming load of KJA. KJA organic load of waste since 2001-2012 in Maninjau Lake have accumulated as much as 167,790.91 tons per year as the average load 13982.57 tons.

Keywords: Maninjau Lake, floating net cages, organic matter, sediments.

INTRODUCTION

Maninjau lake with an area of 9737.5 ha, length of 16,460 m, 7,500 m maximum width, the volume of water 10,266,001,629 m3, maximum depth of 165 m and an average mean depth of 105 m (Fakhrudin et al, 2001) plays an important role in tourism development, hydropower and fisheries (Ardika, 1999). In the fisheries sector is the development of aquaculture carp and tilapia in floating net cages (KJA) to meet the needs of the market, especially for the region of West Sumatra, Riau and Jambi. Potential as a medium for the cultivation of this lake has been used since 1992 to number as many as 16 plots KJA (Syandri, 2004) and based on the results of the survey in 2012 have amounted to as much as 15 860 plots and used to maintain as many as 12,800 plots tilapia with an average production of each plot about 1.5 tons so that the total production in year 1 (two times the maintenance period) equal to the amount of 38,400 tons of feed for 61 440 tonnes with a value of feed conversion 1:1,6 (Syandri et al, 2012.)

Maninjau Lake water conditions in 2012 in a heavily eutrophic status, the value of trophic status index (TSI) by an average of 78.62 ± 1.15 (Syandri et al, 2013). According to Carlson (1977) if the TSI values ranged from 70-80 then the trophic status of eutrophic waters is heavy. Trophic status Maninjau Lake the result of contamination of organic material derived from fish farming system KJA. Estimated supply of organic matter derived from a P tilapia per year amounted to 1,388,544 kg and 2,998,272 kg of N per year. According to Lukman and Hidayat (2001) recast the organic material in the water system does not take place immediately and perfectly, which is the first process that occurs is the accumulation of organic matter in bottom waters. The solid waste in general penetrate and accumulate in sediment nets underneath (Liam and Kelly, 1992).

At this stage in the bottom waters reshuffle will take place and immediately utilize oxygen in the intensive lake hipolimniom layer and allow anaerob conditions and produce high remainder metabolism. Research has been carried out and the loading of organic matter distribution in the waters of Maninjau Lake in order to find out the source of organic load and the load on the ecosystem components.

MATERIALS AND METHODS

Sediment sampling conducted in three regions, namely regions I (Koto Kaciek, 3 points), region II (Koto Malintang, 3 points), region III (Bayur, 3 points). The points of sampling are set crosswise lake waters with a depth proportional to the number of shots (Figure 1). Used for sediment sampling Ekman grab with 15x15 cm2 openings. Organic content determined by the method of incineration in muffle furnace (temperature 600oC) previously treated with a strong acid to remove carbonate (Buchman and Cain, 1984 in Lukman and Hidayat. 2001).

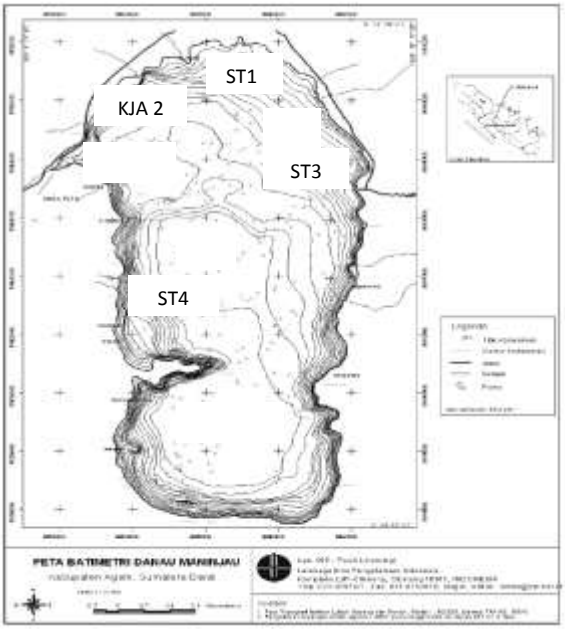


Figure 1. Sampling stations in the Maninjau Lake water and sediment.

Organic parameters determined from levels of TOM (Total Arganic Matter), DOM (Dissolved Organic Matter) and POM (Particulate Organic Matter) on a layer of water below the euphotic region KJA three stations in the region and in the area of the lake outlet. For analysis and DOM TOM KMnO4 used titrimetric methods. conducted in Basic Chemistry Laboratory University of Bung Hatta. POM values obtained from the difference between the values and the DOM TOM.

To determine the level of loading of organic matter derived from KJA, traced from fish production data between the years 2000-2012 were sourced from the Department of Marine and Fisheries Agam and the number of field surveys for tilapia feeding on feed conversion ratio of 1.6.

Supporting water quality is measured and taken at four stations along the sampling stations and DOM TOM. Water quality parameters taken are temperature, pH, brightness,, TSS, TDS, O2, BOD5, COD, total P, orthophosphate and total N, electrical conductivity, and analyzed insitu and eksitu. The timing of the sampling was conducted in March and July 2013.

RESULTS AND DISCUSSION

Water quality conditions

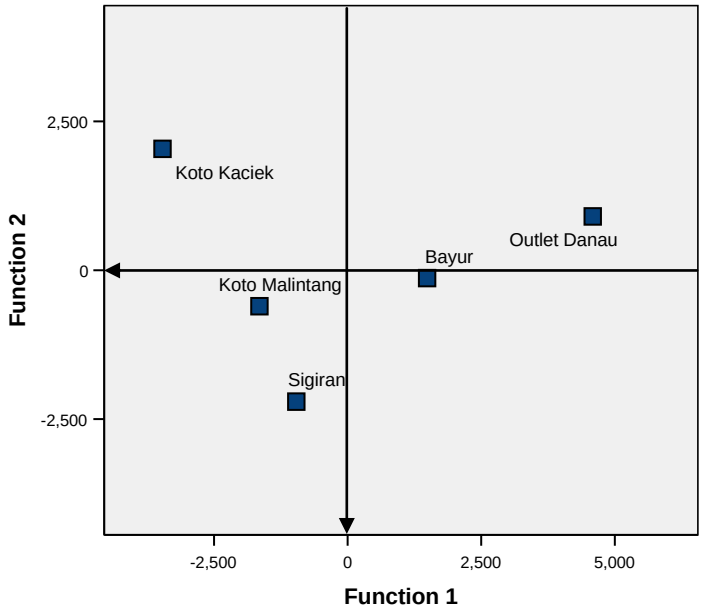
Quality of the surface water dissolved oxygen at each station showed almost the same conditions ranged from 5.70 to 6.77 mg / l, except for dissolved oxygen at a depth of 15 meters ranged from 3.26 to 4.12 mg / l. And Hidayat Lukman (2001) have reported in Maninjau Lake in December 2008 and in January 2009 dissolved oxygen ranged from 0.8 to 7.84 mg / L. According to Wetzel (2001) fluctuations of oxygen in the water affect the reduction and oxidation processes that are directly related to the formation of ammonia, nitrite and nitrate. Dissolved oxygen levels were measured in this study is still fairly high in the surface of the water, it is supported by the condition of the waters of Maninjau Lake fairly broad and open in supporting the process of autotrophic growth. Temperatures in the range of 27-28^{o}C, pH ranged between 8-10 waters that characterize wet. Maninjau waters pH value at December 2009 ranged from 7.01 to 10.29 (Sulawesty et al, 2011), electrical conductivity ranges from quite high ranging from 33.66 to 45.32 ms / cm. This lake productivity is high, as indicated by Secchi depth is in the range of 1.2-2.0 meters. In contrast to Toba Lake with relatively low levels of productivity with Secchi depths in the range of 7-15 m (Lukman, 2011).

TP concentration in surface waters in July 2013 ranged from 0.49 ± 0.03 mg/L-0, 63 ± 0.03 mg / L and TN levels ranged from 1.076 ± 0.02 to 1.563 ± 0.03 mg / L. TP and TN levels higher detected in the dense waters in the waters of the KJA in Koto Kaciek and Sigiran, including the waters of the lake outlet in Maninjau hydropower intakes. Nomosatryo and Lukman (2011) states in Toba Lake fish feeding activity at KJA thought to be a source of nutrient elements input TN and TP.

Table 1. Water quality data Maninjau Lake in July 2013

Parameters	Station				
	I. Koto Malintang	II. Koto Kaciek	III. Bayur	IV. Outlet Danau	V. Sigiran
Temperature (°C)	27,66±0,57[a]	27,33±0,57[a]	28,00±0,00[a]	26,66±0,57[b]	26,66±0,57[b]
pH	10,00±0,00[a]	10,00±0,00[a]	9,00±0,00[b]	9,3±0,28[c]	9,00±0,00[b]
TSS (mg/l)	14,35±0,40[a]	16,44±0,04[b]	17,03±0,07[c]	4,19±0,03[d]	20,45±0,02[e]
TDS (mg/l)	33,08±0,11[a]	26,73±0,03[b]	20,25±0,02[c]	9,77±0,03[d]	39,69±0,02[e]
Brightness (m)	2,00±0,00[a]	1,19±0,17[b]	1,93±0,11[a]	2,00±0,00[a]	1,29±0,03[c]
O_2 (mg/L) water level	6,10±0,04[a]	6,24±0,02[b]	6,77±0,02[c]	6,36±0,03[d]	5,73±0,03[e]
O_2 (mg/L) depth 15 m	3,69±0,04[a]	3,24±0,04[b]	4,12±0,02[c]	4,89±0,03[d]	3,96±0,01[e]
BOD_5 (mg/l)	2,03±0,02[a]	2,74±0,01[b]	2,13±0,03[c]	2,60±0,03[d]	2,98±0,03[e]
COD (mg/l)	30,50±0,02[a]	47,79±0,02[b]	16,11±0,05[c]	8,91±0,02[d]	24,05±0,04[e]
Total P (mg/l)	0,49±0,03[a]	0,63±0,03[b]	0,57±0,02[a]	0,54±0,04[a]	0,62±0,02[b]
Total N (mg/l)	1,076±0,02[a]	1,111±0,00[a]	1,373±0,35[a]	1,563±0,03[b]	1,189±0,10[a]
DHL (ms/cm^{-1})	47,47±0,03[a]	39,86±0,03[b]	33,66±0,03[c]	23,18±0,01[d]	45,33±0,03[e]

Description: Mean ± SD (n = 3) with different superscript letters indicate significantly different (p <0.05) and showed the same superscript letters are not significantly different (p> 0.05)



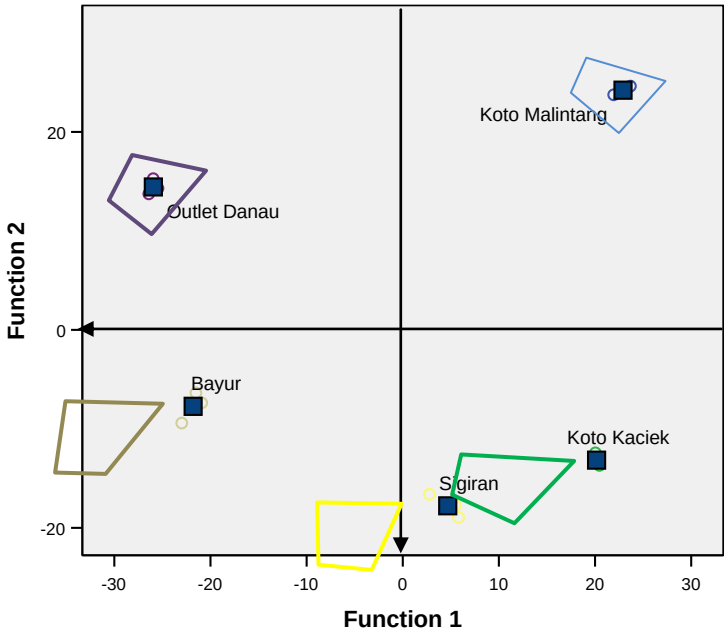
Organic Loading

Dissolved organic content (DOM) seems more dominant than the organic content of particulate matter (POM) in the total organic construct (TOM), and the levels of DOM fractions showed a decrease from the inlet to the outlet (Table 2). According to Saunders (1972) in Wetzel (1983) on the proportion of lake water soluble organic fraction is much higher than particulate. Sedimentation and mineralization processes are thought to contribute to the reduction organic content in the Maninjau Lake. Stagnant water conditions of the lake waters over giving a second chance process. Dissolved organic components easier to undergo mineralization, while the particulate components will undergo sedimentation.

Table 2. Levels of TOM, DOM and POM in water samples Maninjau Lake

Parameters	Station				
	I. Koto Malintang	II. Koto Kaciek	III. Bayur	IV. Outlet Danau	V. Sigiran
TOM (mg/L)	19,01±0,80[a]	16,33±0,30[b]	9,12±0,24[c]	9,31±0,10[d]	13,59±0,44[e]
DOM (mg/L)	14,20±0,13[a]	10,14±0,05[b]	6,58±0,24[c]	8,41±0,10[d]	8,17±0,08[e]
POM (mg/L)	4,55±0,05[a]	6,50±0,05[b]	2,55±0,05[c]	0,90±0,05[d]	5,43±0,20[e]

Description: Mean ± SD (n = 3) with different superscript letters indicate significantly different (p <0.05) and showed the same superscript letters are not significantly different (p> 0.05)



Dissolved organic content (DOM) is more dominant than the organic particulate matter (POM) in the total organic construct (TOM) and higher levels of DOM fraction in waters more KJA (waters Koto Malintang, Koto Kaciek and Sigiran) than waters that are rarely KJA (Bayur and hydropower Intake). DOM fractions showed reduced levels of many waters KJA towards the outlet at the hydropower intake Maninjau.Of the data shows the Maninjau Lake organic load allochtonus sourced from fisheries activities floating net (KJA). KJA on solid location in waters Koto Malintang based census in 2012 with as many as 3,768 plots number KJA TOM levels amounted to 19.94 mg / l (0.01994 kg.m-3), waters Koto Kaciek KJA 1,060 plots the number of levels of TOM amounted to 16.69 mg / L (0.01669 kg.m-3), while at the outlet waters of hydropower in Muko-Muko released TOM levels of 9.35 mg.l-1 (0.0935 kg.m-3) . Based on the difference between the organic load in locations such KJA Koto Malintang waters and were released in the outlets, then accumulated in the Maninjau Lake TOM was 10.59 mg / L (0.1059 kg.m-3), or 53.10% of the incoming load of KJA. In Cirata TOM accumulation amounted to 29.4% of the incoming load (and Hidayat Lukman, 2002). Such differences may be caused by differences in topography lakes maninjau and Cirata reservoirs and water residence time. According Saunderss (1972) in Wetzel (1983) on the proportion of lake water soluble organic fraction is much higher than particulated. Condition of the lake water is more stagnant allow both processes take place. Dissolved organic components easier to undergo mineralization, while the particulate components will undergo sedimentation.

Loading of organic matter in Maninjau Lake greater sourced from autochtonus, especially from fish waste in the production process when compared with the KJA system loading allochtonus organic materials sourced from other inlet. To determine the level of loading of organic matter in Maninjau Lake KJA then traced back based on the data generated from the fish production system KJA (Table 3 and Figure 2).

Table 3. Fish production data, the amount of feed given and estimates of organic wastes from fish farming system in Maninjau KJA

Year	KJA Total	KJA Total Productive	Tilapia Fish Production (ton)		Feed (ton)		Organic Waste (ton)	
			BB[1]	BK[2]	BB[3]	BK[4]	Per tahun[5]	per hari
2001	3.500	2.800	10.500,00	2.625,00	16.800,00	8.400,0	5.775,00	16,04
2002	3.608	2.886	10.822,50	2.705, 62	17.613,00	8.806,6	6.100,98	16,94
2003	3.960	3.168	11.880,00	2.970,00	19.008,00	9.504,0	6.534,00	18,15
2004	4.316	3.452	12.945,00	3.236,25	20.712,00	10.356,0	7.120,00	19,78
2005	4.920	3.936	14.760,00	3.690,00	23.616,00	11.808,0	8.118,00	22,55
2006	8.955	7.164	26.865,00	6.716,25	42.984,00	21.492,0	14.775,75	41,05
2007	9.100	7.280	27.255,00	6.806,25	43.560,00	21.780,00	14.973,75	41,59
2008	9.450	7.560	28.350,00	7.087,50	45.360,00	22.680,00	15.592,50	43,31
2009	9.830	7.864	29.490,00	7.372,50	47.184,00	23.592,00	16.219,50	45,04
					63.018,00	31.509,00	21.662,43	60,17
					72.000,00	36.000,00	24.750,00	68,75
					76.128,00	38.064,00	26.169,00	72,69

Description : BB: Wet Weight BK: Dry Weight	Accumulation of Waste Waste flats/year Waste flats/day	167.790,91 13.982,57 38,84

Description : Feed 3 ton/plot, harvest 2 time/year; KJA total productive 80% of the total KJA (census results)
(2) 25% BB[1] (Garno dan Adibroto, 1999), (3) Feed conversion ratio 1,6, (4) 50% BB[3] (Garno dan Adibrota, 1991), (5) BK Feed-BK Fish

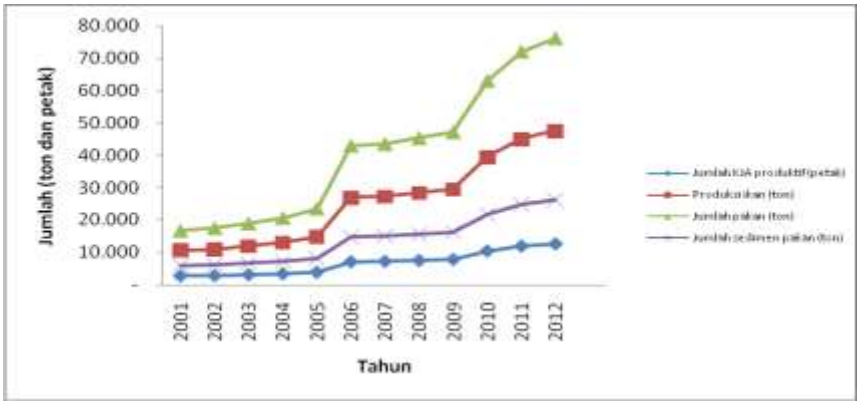


Figure 2. Fish production, the amount of organic waste feed and estimates of KJA in Maninjau Lake.

KJA organic load of waste since 2001 - 2012 in Maninjau Lake have accumulated as much as 167,790.91 tons per year as the average load 13982.57 tonnes and has not since 1993 is estimated at the beginning of fish farming by KJA implemented in Maninjau Lake. Loading of this organic waste starting in 2001 - 2012 according to the linear moving of fish production with a value of R2 = 1. For a clearer picture of the organic waste derived estimates of fish production shown in Figure 3.

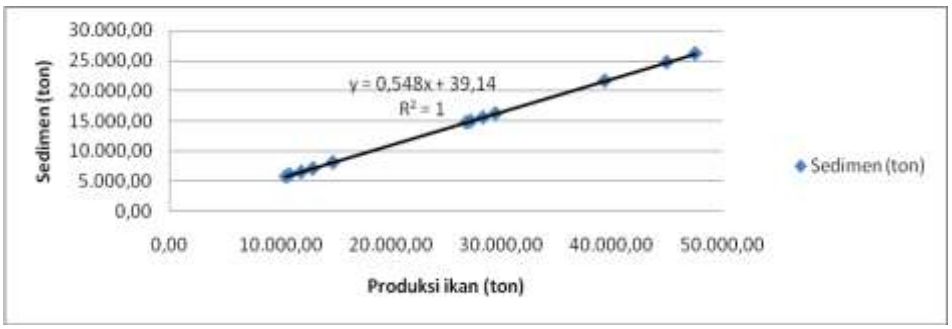


Figure 3. Relationship the fish production with sediments in Maninjau Lake

It should be noted that the Lake Maninjau has an area of 9737 ha, 10.226x106 m3 water volume and water residence time 25.05 years (Fahkrudin et al, 2001). Thus the loading of the organic material will be greater impact on Maninjau Lake, when compared with Cirata reservoir with water area 6,200 ha and the volume of 2.165 x 106 m3 of water with a residence time of water (water retention time) based on the incoming water discharge of 2,534 x 106 m3 per year (Anonymous in Lukman and Hidayat, 2001) just ten months. Hidayat and Lukman (2001) states that the difference of water area, water volume and residence time of water in a water body contained KJA activity will give the same effect, namely the mass death of fish in these waters. As has been reported by Syandri (2000) that the mass death of fish farming with KJA ever occurred in December 1997 as many as 950 tons.

Chemical composition of sediments taken under KJA at each station in the present study in Table 4.

Table 4. KJA chemical composition of sediments in Maninjau Lake

No	Parameters	Unit	I.Koto Malintang	II.Koto Kaciek	III. Bayur	IV. Lake Outlet /Hydropower In-take	IV. Sigiran
1	Total C-Organic	(%)	57,14	62,35	48,81	-	52,25
2	Total Nitrogen	(%)	1,68	2,10	1,10	-	1,34
3	Total Phosphate (P_2O_5)	(%)	0,23	0,32	0,12	-	0,16
4	Total Kalium (K_2O)	(%)	0,21	0,28	0,05	-	0,11
5	Zinc (Zn)	(µg/kg)	296,23	310,50	174,04	-	237,48
6	Lead (Pb)	(µg/kg)	103,56	106,50	56,12	-	61,90

Sources : Primary Data 2012, at the intake no sediment at the bottom.

Dynamics of TP and TN in the sediments will be affected by the activities of various organisms at the bottom of the lake. Thus easy to understand when sediment TP and TN, as shown in Table 4 also correlated with temperature, DO, and pH and other compounds. The amount of sediment in Maninjau Lake of various wastes, especially waste KJA predicted during the last 10 years approximately 167,790.91 tons that has accumulated in the lake water body. The sediment contained in the water more there are many in Koto Kaciek and Koto Malintang, because the area is much ramps and shallow resulting in more turbid waters. Alleged that the sediment resuspension process can result in reduction of light penetration and increase the quantity of particles dissolved in the water. At locations that are west Sigiran more steep, so the sediment below KJA not much accumulate and may have piled on the bottom of the lake deeper. With increasing organic load can be predicted by the sediment oxygen uptake will be more than 85% so that it appears anoxic conditions.

Accumulation of organic matter in the sediments is often followed by the enrichment process waters, especially with increasing orthophosphate. According to Liam and Kelly (1992) that the orthophosphate compounds are released from the sediment diffuses into the upper layers that can directly be used by the plant components such as phytoplankton. Effendi (2003) states that orthophosphate is a form of phosphorus that can be used directly by aquatic plants.

CONCLUSION

Important water quality parameters were observed between different research stations in general are very real and groupings among the research station. Total organic content (TOM) on which there are many locations in the waters of the KJA Koto Malintang, Koto Kaciek and Sigiran larger location than bit number that is in the waters Bayur KJA and hydropower intake (outlet) Maninjau Lake. TOM accumulation in Maninjau Lake was 10.59 mg / L (0.1059 kg.m-3) or 53.10% of the incoming load of KJA. KJA organic load of waste since 2001 - 2012 in Maninjau Lake have accumulated as much as 167,790.91 tons per year as the average load 13982.57 tons.

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