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Determination of Acai River Quality Status, Jayapura City Through Pollution Index Method Based on Its Designations

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Abstract

The river is a natural and/or artificial water channel or container in the form of a water drainage network with water in it, from the upstream to the estuary, with the right and left borders bounded by the boundary line. The problem that often occurs in the river area is pollution. This research is focused along the Acai River flow located in Abepura District, Jayapura City, Papua Province. Problems that often occur along the Acai River flow in Jayapura City are the accumulation of garbage in the river body and changes in the physical condition of the river, both color and odor. Therefore, the purpose of this study is to determine the status of water quality from the Acai River so that it can be used as a reference in determining the sustainable management of the Acai River. The method used to determine the status of water quality was the pollution index method. Measurements were carried out in the upstream, middle and downstream parts of the Acai River. The results showed that the Acai River Pollution Index (PI) in the upstream reaches ranged from 1.75 to 5.35. The middle part of the Acai River has a Pollution Index (PI) of 1.84 - 5.41, and the downstream part has a PI of 1.78 - 5.39. Based on these data it was known that the overall Pollution Index (PI) in the Acai River ranges between 1.75 - 5.41. Pollution that occurs in the Acai River was caused by pollution of organic material obtained from domestic waste. This was shown from the results of measurements of water quality where BOD levels are 2.58 - 4.54 mg / L and COD is 190 - 193 mg / L. The Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels of the Acai River have exceeded water quality standards. Based on the measurement results of the Pollution Index (PI) it can be concluded that the Acai River has experienced pollution from the low to moderate categories, for water classes ranging from Class I to Class IV. For this reason, it was suggested that an integrated domestic waste treatment plant be made which can accommodate domestic waste as a result of community activities and process it first before finally being discharged into the river water body.

Keywords: ***River Pollution, Pollution Index, Jayapura City***

1. Introduction

The Law Number 11 of 1974 concerning Irrigation states that water is all water contained in and or originating from water sources, both above and below the surface of the land, not including in this sense water contained in the sea. The Law also states that water sources are places and containers of water, both above and below the surface. One of the existing water sources is the river. PP No. 38 of 2011 explains that rivers are natural and / or artificial waterways in the form of water drainage networks along with water in them, starting from upstream to estuary, bounded right and left by border lines. Water in the river is used by many living things to support their lives. The community also uses river water to fulfill their needs, one of which is for drinking water.

However, various problems arise related to river water caused by human activities around the river. The problems that often occur in river areas are pollution. Pollution occurs as a result of human activities where humans still consider the river to be a final disposal site, which results in the entry of pollutants into river water.

The impact of river water pollution is that river water is not suitable for use or consumption. The river as one of the main sources of water resources providers is one place to be able to meet water needs, especially for humans. As a result of pollution that occurs in the river, river water is not suitable for consumption, resulting in a decrease in water sources to meet the needs of the community. Water deficit that occurs in several regions, one of which is caused by river water pollution. Other impacts caused by river water pollution are diseases and disasters. Disease arising from the condition of river water that has been contaminated mainly by bacteria. Disasters can also arise from river pollution, especially pollution from inorganic waste in the form of

garbage. The accumulation of garbage in the river flow can clog the river water flow so that if the intensity of rainwater that falls high can cause river water to overflow and inundate the area around the river.

One of the rivers that also experienced pollution was the Acai River. The Acai River is located in Waimorock Village, Abepura District, Jayapura City. The Acai River flows in areas that have a high population density so that community activities around it can have a direct influence on the water conditions in the Acai River. Pollution in the Acai River can be seen from water conditions that have undergone discoloration and have an unpleasant odor.

One effort that can be done to control the level of river pollution is by monitoring the condition of river water quality through setting the status of water quality. Based on Government Regulation Number 82 of 2001 concerning Management of Water Quality and Water Pollution Control, the status of water quality is the level of water quality conditions that indicate polluted conditions or good conditions in a water source within a certain time by comparing with the water quality standards set. By knowing the status of river water quality, it can be expected that these results can be used to manage river water quality so that the quality of river water can be controlled to be able to comply with the water quality standards that have been set.

The importance of determining the status of river water quality and seeing the problems that occur in the Acai River, Jayapura City, this study was conducted with the aim of establishing the water quality status of the Acai River in Jayapura City as the basis for making efforts to control river pollution.

2. Material and Method

2.1. Research Location and Time

This research focused on along the Acai River river located in Abepura District, Jayapura City, Papua Province. The Acai River flows from upstream which was located in Kota Baru Village and empties into Yotefa Bay. The central part of the river was located in Wai Mhorock Village. The choice of location was the pollution of river water caused by human activities along the river. This research was conducted in July - August 2018.

2.2. Research Type

This type of research was Quantitative Descriptive research with the research method was the survey method. Survey method was an investigation that was held to obtain facts from existing symptoms and look for information factually from a group or an area (Nazir, 2005). The survey was conducted to look at the physical condition of the Acai River and the condition of the surrounding area along the Acai River.

2.3. Data Collection Technique

Data collection was done to find information and data relating to the purpose of the study. Data collected includes primary data and secondary data. The data collection techniques carried out in this study are direct observation or observation, interviews and documentation.

Direct observation and interviews were conducted to collect data on the condition of river water quality, environmental conditions around the river and the socio-economic and cultural conditions of the people around the Acai River. Documentation is the collection of data in the form of documents or supporting data for research that has been collected by the relevant agencies. The supporting documents or data collected include: demographic data, watershed area, rainfall data and land usage.

2.4. Data Processing

Data processing was done to process data that has been collected in the field so that the data can be analyzed. Data processing methods were carried out using the Pollution Index Method. This method was done by comparing between the results of the analysis of river water samples (Ci) with the quality standard (Lij) set by the Government in PP No. 82 of 2001 concerning Management of Water Quality and Water Pollution Control.

The price of this PIj can be determined by:

1. Parameters were selected which if the price parameter was low then the water quality will improve.
2. Select the default concentration parameter that has no range.
3. Calculate the Ci / Lij price for each parameter at each sampling location.

4. If the decreasing concentration value parameter states that pollution increases, for example DO. Determine the theoretical value or maximum value of Cim (eg for DO, then Cim was the saturated DO value). In this case the Ci / Lij value of the measurement result was replaced by the Ci / Lij value of the calculation, namely:

$$(C_i/L_{ij})_{new} = \frac{C_{im} - C_{i(measurement\ results)}}{C_{im} - L_{ij}}$$

5. If the standard value of Lij has a range:

   a. For $C_i \leq L_{ij}$ average

$$(C_i/L_{ij})_{new} = \frac{[C_i - (L_{ij})_{(average)}}{\{(L_{ij})_{minimum} - (L_{ij})_{average}\}}$$

   b. For $C_i > L_{ij}$ average

$$(C_i/L_{ij})_{new} = \frac{[C_i - (L_{ij})_{(average)}}{\{(L_{ij})_{maximum} - (L_{ij})_{average}\}}$$

6. If two values (Ci / Lij) were closed to the reference value of 1.0, for example Ci / Lij = 0.9 and Ci / Lij = 1.1 or very large differences, for example Ci / Lij = 5.0 and Ci / Lij = 10.0. In this example the level of damage to water bodies was difficult to determine, so the way to overcome this difficulty was:

   a. Value usage $(C_i/L_{ij})_{\text{measurement results}}$ if this value was smaller than 1.0.

   b. Penggunaan nilai $(C_i/L_{ij})_{new}$ if this value $(C_i/L_{ij})_{\text{measurement results}}$ was bigger than 1,0.

$$(C_i/L_{ij})_{new} = 1{,}0 + P.\log(C_i/L_{ij})_{\text{measurement results}}$$

   P was a constant and its value was determined freely and adjusted to the results of environmental observations and or the desired requirements for an allocation (usually a value of 5).

7. Determine the average value and maximum value of the entire Ci / Lij.

8. Determine the price of PI_j

$$PI_j = \sqrt{\frac{(C_i/L_{ij})_M^2 + (C_i/L_{ij})_R^2}{2}}$$

9. Determine the results of the evaluation of the PI value:

   a. $0 \leq PI_j \leq 1{,}0$
      Meet quality standards
   b. $1{,}0 \leq PI_j \leq 5{,}0$
      Lightly polluted
   c. $5{,}0 \leq PI_j \leq 10$
      Medium polluted
   d. $PI_j > 10$
      Heavily polluted

2.5. Data Analysis

Data analysis used in this study uses quantitative descriptive analysis. This analysis clearly illustrates the condition of the level of water pollution that occurs in the Acai River based on the calculation of its water quality status, starting from the upstream to the downstream of the river, so that the level of pollution that occurs in the Acai River as a whole was known.

3. Results & Discussions

3.1. Overview of Research Sites

3.1.1.Geographical and Climatological Conditions

The Acai River was one of the rivers that belongs to the Sentani Watershed. Morphologically, the Acai River has a length of 2.25 km with a width of 12.50 m and a depth of 4.50 m. The Acai River was included in the Abepura District which has a height of 10 meters above sea level. The location of the Acai River was listed in **Figure 1.**

Climate conditions in the Acai River follow climate conditions in Abepura District. During 2016, Abepura District experienced the highest temperatures in April and November which reached 32.0^0C, while the lowest temperature occurred in July which reached

25.1^{0}C. The air humidity of the city of Jayapura was classified as wet. The air humidity that occurred during 2016 ranged from 80.0% - 85.3%. The lowest monthly humidity occurs in April at 80.0% and the highest in December at 85.3%. The city of Jayapura did not recognize the rainy season or the dry season, almost every rainy month. The total rainfall in Abepura District in 2016 was 2886 mm or classified as having a high level of rainfall (BPS, 2017).

3.1.2. Demographics

Based on BPS (2017) data, Abepura District has a population of 82,090 people, with a total of 44,031 men and 38,059 women. The population growth rate of the Abepura District from 2010 to 2016 was 12.21%. While the population in Kota Baru and Wai Mhorock Villages, which were the focus of the study, were 9,000 and 10,505 people. Wai Mhorock and Kota Baru Village were large areas in Abepura District after Vim Village (15,307 people) and Awiyo Village (13,537 people).

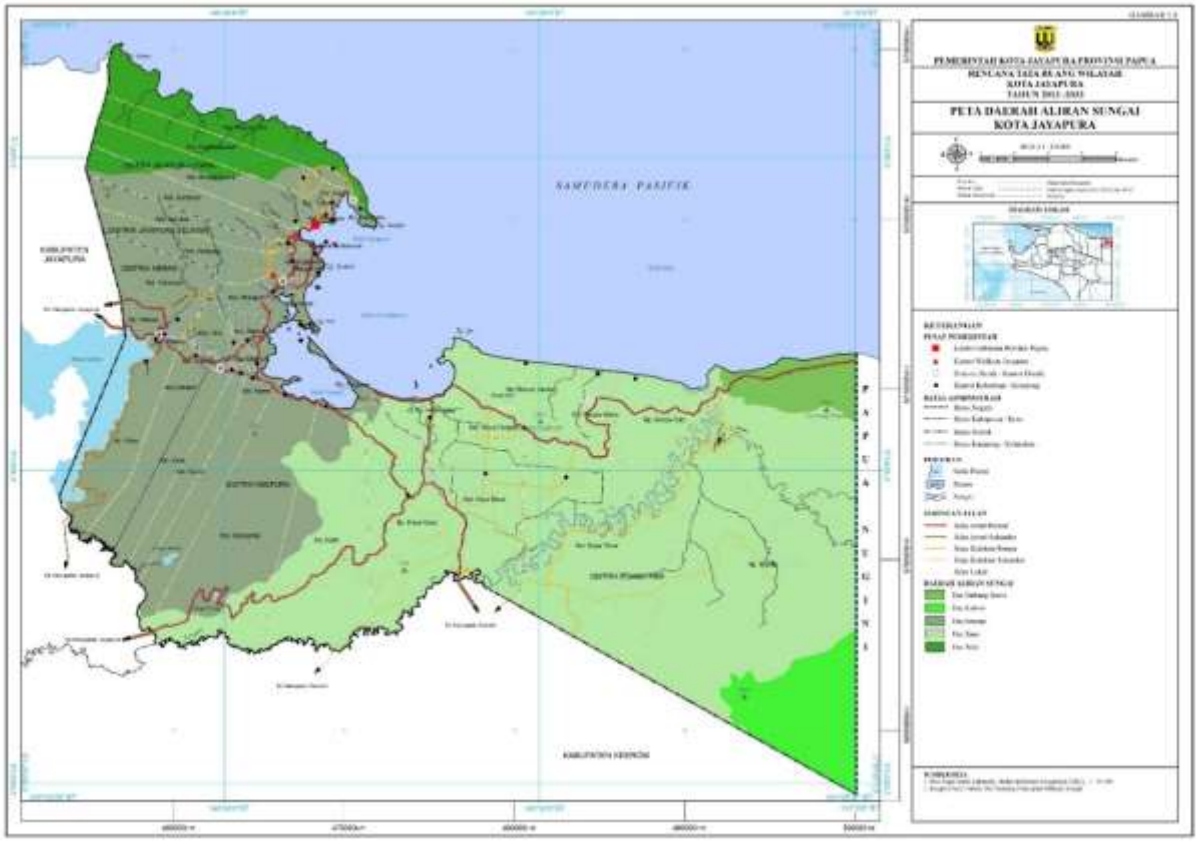

Figure 1. Map of Jayapura City Watershed
(Source: BAPPEDA Jayapura City, 2013)

3.2. Water Quality Analysis

Analysis of river water quality was one way to determine the condition of river water based on water quality parameters. The measurement of river water quality in the Acai River was carried out in 3 (three) points, namely: upstream, middle and downstream. Based on the results of measurements of river water quality in the Acai River data were obtained as presented in **Table 1.**

The water quality standard used as a comparison in the measurement of the water quality of the Acai River was the Water Quality Standard for Class I, where its designation can be used for raw water for drinking water and other purposes which require water quality that was the same as the utility. Based on the results of measurements of water quality in the Acai River, there were several parameters that exceed water quality standards, namely Dissolved Oxygen

(DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD). These parameters exceed the quality standards both in the upstream, middle and downstream areas.

The high levels of DO, BOD and COD indicate that the organic matter content in the Acai River water was also high. Fair et al. (1979); Sugiharto (1987) in Kodoatie and Sjarief (2008) explained that domestic wastewater contains more than 90% of liquid. Substances contained in waste water include organic suspended and dissolved elements such as proteins, carbohydrates and fats and also inorganic elements such as granules, salts and metals and microorganisms.

Table 1. Analysis Results of River Water Quality in the Acai River in 2018

Parameter	Unit	water quality standards (Group I)	Sampling Location		
			Upstream	Middle	Downstream
Temperature	^{0}C	Deviasi 3	27,2	28	28,1
pH	-	6 – 9	7,01	7,60	8,00
DO	mg/L	6	**7,15**	**7,84**	**6,80**
BOD	mg/L	2	**3,62**	**2,58**	**4,54**
COD	mg/L	10	**190**	**193**	**192**
TSS	mg/L	50	0,100	0,095	0,152
TDS	mg/L	1000	220	**1140**	390
Oil and Fat	mg/L	1	0,16	0,16	0,18
Colour	TCU	15	No colour	Light Brown	Light Brown
Smell	-	No smell	No smell	Smells	No Smell

Data sources are processed from PS imia FMIPA Uncen

These elements characterize the quality of waste water in physical, chemical and biological properties. Salim (2002) added that the composition of domestic waste was generally dominated by organic nitrogen (NH3, NO2, NO3), phosphorus (total phosphorus and PO4), detergents, phenols and bacterial bacteria. From these organic wastes, the key parameters commonly used were BOD and COD. The burden of domestic pollution for each person varies. Everyone in Indonesia was expected to issue BOD of 25 g / person / day and COD of 57 g / person / day.

3.3. Determination of river water quality status

Analysis of water quality status was intended to determine the level of water pollution that occurs in a body of water. The method used in determining the status of water quality in this study was the Pollution Index Method. One important component in this method was water quality data from water bodies. The water quality data used in this study includes several main parameters in measuring pollution levels, namely: pH, TSS, TDS, DO, BOD, COD, oil and fat. The values of these parameters were then compared with the quality standards set by the Government through Government Regulation No. 82 of 2001 concerning Management of Water Quality and Water Pollution Control. Furthermore, the status of water quality from the Acai River was explained according to its designation through water quality standards of each class or water group.

3.3.1.Water Quality Status For Drinking

Based on PP No. 82 of 2001 concerning Management of Water Quality and Control of Water Pollution, first class water was water whose designation can be used for raw water for drinking water, and / or other designation which requires water quality equal to that use.

Based on the calculation of the level of pollution of the Acai River water for drinking water, it was known that the Acai River water was in the category of moderate contamination.

This was known from the calculation results where the PI value for the upstream, middle and downstream of the river was 5.35; 5,41; and 5.39. Where if the PI value ranges from 5.0 - 10.0 was medium polluted.

Table 2. Status of Acai River Water Quality for Drinking Water

Parameter	Unit	Quality Standards (Li)	Upstream		Middle		Downstream	
			Ci	Ci/Li	Ci	Ci/Li	Ci	Ci/Li
pH	-	6 – 9	7,01	0.93	7,60	1.03	8,00	1.14
DO	mg/L	6	7,15	0.06	7,84	0.06	6,80	0.06
BOD	mg/L	2	3,62	2.29	2,58	1.55	4,54	2.78
COD	mg/L	10	190	7.39	193	7.43	192	7.42
TSS	mg/L	50	0,100	0.00	0,095	0.00	0,152	0.00
TDS	mg/L	500	220	0.44	1140	2.79	390	0.78
Oil and Fat	mg/L	1	0,16	0.16	0,16	0.16	0,18	0.18
Pij			**5.35**		**5.41**		**5.39**	

3.3.2. Status of Water Quality for Class II Water Quality Standards

Based on PP No. 82 of 2001 concerning Management of Water Quality and Water Pollution Control, second class water was water whose designation can be used for infrastructure / facilities for water recreation, cultivation of freshwater fish, livestock, water for irrigating crops, and / or other designations that require the same water quality with these uses.

Table 3. Status of Acai River Water Quality for Class II Water Quality Standards

Parameter	Unit	Quality Standards (Li)	Upstream		Middle		Downstream	
			Ci	Ci/Li	Ci	Ci/Li	Ci	Ci/Li
pH	**-**	6 – 9	7,01	0.93	7.6	1.03	8	1.14
DO	mg/L	4	7,15	0.06	7.84	0.06	6.8	0.06
BOD	mg/L	3	3,62	1.41	2.58	0.86	4.54	1.90
COD	mg/L	25	190	5.40	193	5.44	192	5.43
TSS	mg/L	50	0,100	0.00	0.095	0.00	0.152	0.00
TDS	mg/L	500	220	0.44	1140	2.79	390	0.78
Oil and Fat	mg/L	1	0,16	0.16	0.16	0.16	0.18	0.18
Pij			**3.91**		**3.98**		**3.96**	

Based on the results of the calculation of the level of water contamination of the Acai River for Group II Water it was known that the Acai River water was in the category of mild polluted. The results of the calculation of PI values indicate that upstream, middle and downstream of the river was 3.91; 3.98 and 3.96, where if the PI value ranges from 1.0 - 5.0 was included in the category of lightly polluted.

3.3.3. Status of Water Quality for Class III Water Quality Standards

Based on PP No. 82 of 2001 concerning Management of Water Quality and Control of Water Pollution, third class water was water whose designation can be used for the cultivation of freshwater fish, livestock, water for irrigating plantations, and / or other allotments that require the same water quality as those uses.

Table 4. Status of Acai River Water Quality for Class III Water Quality Standards

Parameter	Unit	Quality Standards (Li)	Upstream		Middle		Downstream	
			Ci	Ci/Li	Ci	Ci/Li	Ci	Ci/Li
pH	-	6 – 9	7.01	0.93	7.6	1.03	8	1.14
DO	mg/L	3	7.15	0.06	7.84	0.06	6.8	0.06
BOD	mg/L	6	3.62	0.60	2.58	0.43	4.54	0.76
COD	mg/L	50	190	3.90	193	3.93	192	3.92
TSS	mg/L	400	0.1	0.00	0.095	0.00	0.152	0.00
TDS	mg/L	500	220	0.44	1140	2.79	390	0.78
Oil and Fat	mg/L	1	0.16	0.16	0.16	0.16	0.18	0.18
Pij			**2.82**		**2.91**		**2.86**	

The results of the calculation of the level of water pollution of the Acai River for Group III Water indicate that the Acai River water was in the lightly polluted category. This was indicated by the calculation of PI values for upstream, middle and downstream of the river was 2.82; 2.91 and 2.86, where if the PI value ranges from 1.0 - 5.0 was included in the lightly polluted category.

3.3.4. Status of Water Quality for Class IV Water Quality Standards.

Based on PP No. 82 of 2001 concerning Management of Water Quality and Control of Water Pollution, fourth grade water was water whose designation can be used to irrigate plantations, and / or other designations which require water quality equal to those uses.

Table 5. Status of Acai River Water Quality for Class IV Water Quality Standards

Parameter	Unit	Quality Standards (Li)	Upstream		Middle		Downstream	
			Ci	Ci/Li	Ci	Ci/ Li	Ci	Ci/ Li
pH	-	6 – 9	7.01	0.93	7.6	1.03	8	1.14
DO	mg/L	0	7.15	0.06	7.84	0.06	6.8	0.06
BOD	mg/L	12	3.62	0.30	2.58	0.22	4.54	0.38
COD	mg/L	100	190	2.39	193	2.43	192	2.42
TSS	mg/L	400	0.1	0.00	0.095	0.00	0.152	0.00
TDS	mg/L	500	220	0.44	1140	2.79	390	0.78
Oil and Fat	mg/L	1	0.16	0.16	0.16	0.16	0.18	0.18
Pij			**1.75**		**1.84**		**1.78**	

The results of the calculation of the level of water contamination of the Acai River for Group IV Water indicate that the Acai River water was in the lightly polluted category. This was indicated by the calculation of the PI value for the upstream, middle and downstream of the river was 1.75; 1.84 and 1.78, where if the PI value ranges from 1.0 - 5.0 was included in the lightly polluted category.

3.3.5. Status of Acai River Water Quality for All Designations

Based on the calculation of water quality status from Class I to Class IV water, the status of the Acai River water quality can be displayed for all purposes, started from the upstream, middle and downstream parts, as listed in **Table 6.**

Table 6. Status of Acai River Water Quality for All Designations

No.	Designation	Water Quality Status (PIj)		
		Upstream	Middle	Downstream
1	Class I	5.35	5.41	5.39
2	Class II	3.91	3.98	3.96
3	Class III	2.82	2.91	2.86
4	Class IV	1.75	1.84	1.78

Based on the calculation results of the Pollution Index from the Acai River water, it can be seen that the Acai River water has been contaminated, started from Class I water to Class IV water allotment. The level of Acai River water pollution for Class I water designation was included in the medium polluted category, while Class II through IV water designation was included in the category of lightly polluted. Pollution of river water in the Acai River has occurred from upstream to downstream. Different levels of pollution were influenced by community activities around the observation location.

Pollution that occurs in the Acai River was caused more by pollution of organic matter. This can be seen from the analysis of the water quality of the Acai River where the levels of COD and BOD exceed the water quality standards that have been set. The organic material that was the source of the Acai River comes from domestic waste, both settlements and trade areas. Cordova (2008) explained that the main source of household wastewater from the community came from housing and trading areas. Pollution of this organic material starts from upstream to downstream. Increased pollution starts in the middle of the river. This happened because the middle part of the river was an area with a high population density. The behavior of the people in this area was very influential on river water conditions.

The high population density in Abepura District makes this area to be developed into a residential and trading area. As stated in the Jayapura City RTRW in 2013 - 2033, Abepura District was the development of high density vertical housing areas and medium density horizontal housing, supported by trade areas and services, offices, health, and green open spaces. The plan developed the area has an impact on the increasing number of people conducting activities in the region. High community activities have an impact on people's behavior in treating the surrounding environment, especially river areas.

Community behavior that can have a major influence on changes in river water quality was the behavior of throwing garbage into the river. Waste that was disposed consists of organic waste and inorganic waste. Organic waste in the form of food scraps and household waste, while inorganic waste in the form of plastic waste from wrapping food scraps.

Apart from the behavior of the community by removing plastic waste into the river, another factor that affects pollution in the Acai River was the entry of domestic waste into rivers that originate from the drainage channels in the residential area. Domestic waste that enters was from kitchen, washing and bathroom activities. Kodoatie and Sjarief (2008) explained that domestic wastewater was used water that cannot be used for its original purpose, either containing human waste (feces) or from the activities of kitchens, bathrooms and washing where the quantity was 50-70% of the average the use of

clean water was around 120-140 liters / person / day.

Figure 2. Trash piles on the middle of Acai River Body

The drainage channels in the settlement area and community business locations were not equipped with waste water treatment locations so that the waste water produced by the people who live in these locations directly flows the remaining water from household activities into the drainage canal. Furthermore, without undergoing first processing, the waste produced by the community will flow into the river. The accumulation of wastewater produced by the community causes the level of pollution in the Acai River to increase and exceed the established quality standards.

4. Conclusions

Conclusions that can be concluded from this study include:

1. The Acai River Pollution Index (PI) from upstream to downstream for Class I, II, III and IV water designations ranges from 1.75 - 5.41.

2. The status of the water quality of the Acai River from upstream to downstream was included in the category of lightly to medium polluted.

3. Pollution that occurs in the Acai River was caused by pollution of organic materials from domestic waste both household and commercial activities.

References

BAPPEDA Kota Jayapura. 2013. Rencana Tata Ruang Wilayah Kota Jayapura Tahun 2013-2033. Pemerintah Kota Jayapura. Jayapura

BPS Kota Jayapura. 2017. Distrik Jayapura Dalam Angka. Pemerintah Kota Jayapura. Jayapura

Cordova. 2008. Kajian Air Limbah Domestik di Perumnas Bantar Kemang, Kota Bogor dan Pengaruhnya pada Sungai Ciliwung. Skripsi. Departemen Manajemen Sumberdaya Perairan. Fakultas Perikanan dan Ilmu Kelautan. Institut Pertanian Bogor

Herlambang, A. 2006. Pencemaran Air dan Strategi Penanggulangannya. Jurnal Alam dan Lingkungan Volume 2, Nomor 1. Hal. 16-29

Kodoatie R.J. dan R. Sjarief. 2008. Pengelolaan Sumber Daya Air Terpadu. Penerbit Andi.Yogyakarta

Nazir, M. 2005. Metode Penelitian. Penerbit Ghalia Indonesia. Bogor Selatan

Pemerintah Republik Indonesia. Peraturan Pemerintah Republik Indonesia Nomor 82 Tahun 2001. Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air. Pemerintah Republik Indonesia. Jakarta

Pemerintah Republik Indonesia. Peraturan Pemerintah Republik Indonesia Nomor 38 Tahun 2011. Sungai. Pemerintah Republik Indonesia. Jakarta

Salim, H. 2002. Beban Pencemaran Limbah Domestik dan Pertanian Di DAS Citarum Hulu. Jurnal Teknologi Lingkungan, Vol. 3, No. 2, Mei 2002: 107-111

Pemerintah Republik Indonesia. Undang-Undang Republik Indonesia Nomor 11 Tahun 1974. Pengairan. Pemerintah Republik Indonesia. Jakarta