Mapping river water quality with the STORET and exponential smoothing methods in Tana Tidung District, North Kalimantan, Indonesia

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Abstract. The rivers in Tana Tidung Regency are a source of water for the community. Decreases in river water quality are occurring, however, associated with population growth and land use around the river, such as increasing use of land for plantations, forest clearing, household activities and decreasing lake water quality affecting the associated rivers. At the same time, sedimentation rates in the streams are increasing. The purpose of this study is to map the analysis of river water quality with the STORET and Exponential Smoothing Methods, to aid in the management and monitoring of river quality. Determining river water quality in Tana Tidung Regency used the STORET method by the Minister of Environment Decree No. 115 of 2003. Another method used was the exponential smoothing forecasting method, which predicts river water pollution levels using data obtained based on time series plots. Based on the calculation of STORET status of river water quality in Tana Tidung Regency, the Sebidai and Betayau Rivers have reached excellent levels in class IV and III qualifications, while levels are good to moderate in class I and II qualifications. Based on the calculation of the exponential smoothing forecasting method, the Sebidai, Betayau, and Seputuk Rivers the levels of biochemical oxygen demand (BOD), dissolved oxygen (DO), manganese, zinc, nitrite, nitrate, sulfide, iron, and lead are predicted to increase in 2021. This condition is caused by pollution of organic matter produced by human activities such as industrial waste, households and agricultural activities
Key Words: water quality, storet, exponential smoothing, pollution.

Introduction. Tana Tidung Regency as well as other regions in North Kalimantan, Indonesia are areas that have seen increasing population growth and development in the region. This has placed pressure on the natural resources of the region including water resources (Environmental and Transportation Service of Tana Tidung Regency 2014). The development of plantations, mining, agriculture, aquaculture, industry, home industries, transportation services and the increasing number of settlements and offices all have the potential to reduce water quality.

In connection with this, the pressures on water resources should be controlled so that humans can still meet their needs and ensure that the ecosystem remains intact. In a watershed system, a river functions as a reservoir of water is always at the lowest position in the nearby landscape. Therefore, the condition of a river cannot be separated from the condition of its watershed. Changes in land-use patterns from natural ecosystems to agricultural land, settlements and increased industrial activities all will have an impact on hydrological conditions in a watershed. Changes in land-use patterns mean there has been a change in the extent and types of vegetation cover (Asdak 2010). Wiwoho (2005) noted an increase in the runoff coefficient, i.e., an increase in runoff water volume as a result of the increasingly widespread residential area and reduced forest area and moor, adding to the amount of river sediment in Babon, Semarang, Indonesia. Also, various human activities such as industrial activities, household activities, and agriculture produce waste that also contributes to decreasing river water quality (Suriawiria 1996).

At present, there are many polluted rivers, having a high wastes content resulted from human activities. The disposal of various types of wastes and pollutants to water bodies, both biodegradable and non-biodegradable substances, amongst other things, causes more material to be born by the river. If the load received by the river exceeds a set threshold based on quality standards in Government Regulation No. 82 of 2001 Concerning Management of Water Quality and Water Pollution Control, then the river is categorized by the Indonesian Government as being polluted, both physically, chemically, and biologically.

The decline in water quality will degrade the efficiency, effectiveness, productivity, and carrying capacity of water resources, which will, in turn, reduce the wealth of its natural resources. Polluted waters in addition to endangering human health will also harm other living resources and ecological systems and damages water structures. The increasing number of pollutants in the waters causes losses in the fisheries sector, which can be either direct losses resulting in the death of fish or indirect losses in the form of decreased productivity due to decreasing environmental quality. Water pollution, among others, can cause a) disruption of the life balance of aquatic organisms due to lack of oxygen content; b) explosion of algae and aquatic plants (eutrophication), and c) sedimentation of waters bottom (siltation) (Yudo 2007).

According to the river water quality monitoring's report, Tana Tidung Regency, Environmental and Transportation Agency (2018), some of the problems around rivers in the Regency area are the taking of critical land for plantation use, forest clearing, household activities and reduced lake water quality affecting several river locations. The sedimentation rates in rivers are very high. Eroded soil from excavation, industrial operations, deforestation, land clearing, and road infrastructure development will eventually be deposited in the lower reaches of the water body. Years of excessive soil erosion can also adversely affect water quality, including a decrease in turbidity, and an increase in the values of physical, biological and chemical pollution parameters. The objectives of this research were to perform a monitoring of river water quality and to determine the local government policies so that the quality of the river to be well maintained.

Material and Method

Description of the study sites. The study was carried out in the Tana Tidung Regency, in the Sebidai (N 03°35’43”, E 116°55’30.94’’), Betayau (N 03°29’05”, E 116°59’57.16’’), Seputuk (N 03°28’38” E 116°43’05.94’’) rivers. Water samples were obtained by using purposive sampling, where the sampled observation stations were determined by taking into account various considerations about the conditions of activities on land, settlements and river inlets that are thought to influence river water quality. Sampling of water at each research site for measurement of physical, chemical and microbiological parameters took place at distances of 0 m, 50 m and 200 m from land. The reason for taking these sampling points is the consideration of stirring up the mass of water by inflating the mass of water by wind and water currents and the flow of water resulting in pollutant parameters being well distributed. Sampling was carried out on river inlets in 2012, 2014, 2016, 2017, 2018 to obtain comparisons and changes in river water quality status over time.

Water quality evaluation. In Indonesia, water quality is classified into four classes (Table 1), according to Regulation 82 of 2001, namely:

a. Class I, water for which the designation can be used for drinking water, and other design that requires water quality that is the same as that of use;

b. Class II, the water for which the designation can be used for water recreational infrastructure/facilities, cultivation of freshwater fish, livestock, water for irrigating plantations, and other designs that require water quality that is the same as those uses;

c. Class III, the water for which the designation can be used for the cultivation of freshwater fish, livestock, water for irrigating plantations, and other designs that require water that is the same as that use;

d. Class IV, the water for which the designation can be used for irrigating, planting and/or other designation which requires the same water quality as that use.

Table 1

The variables measured in the monitoring study of water quality status in the rivers from Tana Tidung Regency

No.	*Parameter*	*Unit*	*Class I*	*Class II*	*Class III*	*Class IV*	*Method specifications*
	Physical						
1	Temperature	°C	22-28	22-28	22-28	20-30	Thermometer
2	Manganese (Mn)	mg L^{-1}	0.1	-	-	-	Colorimetric
3	Zinc (Zn)	mg L^{-1}	0.05	0.05	0.05	2	Colorimetric
4	Free chlorine (Cl_2)	mg L^{-1}	0.03	0.03	0.03	-	Colorimetric
5	Nitrite (NO_2-N)	mg L^{-1}	0.06	0.06	0.06	-	SNI 6989.9-2004
6	Sulfide (H_2S)	mg L^{-1}	0.002	0.002	0.002	-	SNI 6989.70-2009
	Chemical						
7	pH	-	6.0-9.0	6.0-9.0	6.0-9.0	5.0-9.0	SNI 06-6989.11-2004
8	BOD_5	mg L^{-1}	2	3	6	12	SNI 6989.72-2009
9	DO	mg L^{-1}	6	4	3	0	SNI 6989.73-2009
10	Nitrate (NO_3-N)	mg L^{-1}	10	10	20	20	Brucine
11	Copper (Cu)	mg L^{-1}	0.02	0.02	0.02	0.2	SNI 6989.6-2009
12	Iron (Fe)	mg L^{-1}	0.3	-	-	-	Colorimetric
13	Lead (Pb)	mg L^{-1}	0.03	0.03	0.03	1	SNI 6989.46-2009
14	Oil and fat	ug L^{-1}	1000	1000	1000	-	SNI 06-6989.10-2009
15	Hardness	mg L^{-1}	50	-	-	-	SNI 06-6989.12-2004
	Biological						
16	Fecal coliform	JmL/100 mL	100	1000	2000	2000	APHA,9221 MTF-E, 22^{nd}, 2012
17	Total coliform	JmL/100 mL	1000	5000	10000	10000	APHA,9221 MTF-B, 22^{nd}, 2012

The STORET method is used to determine the status of the waters especially of D. Sentani based on Hardjono & Djokosetiyanto (2005) and the Minister of Environment LH Number 115 of 2003. The STORET is a commonly used method to determine water quality. With the STORET method, the number of quality classification parameters that have met or exceeded water quality standards can be determined. Determination of water quality status with the STORET system is intended as a reference in monitoring the quality of groundwater with the aim to determine the quality of an aquatic system. Determination of water quality status is based on analysis of physical, chemical and biological parameters. Good water quality will be by the regulations issued by the government with the maximum levels (concentrations) allowed. The results of the chemical analysis of water samples are then compared with the quality standards. Water quality is assessed based on the provisions of the STORET system issued by the Environmental Protection Agency (EPA 2001) which classifies water quality into four classes, namely:

(1) Class A: very good, score = 0 meets the quality standard;
(2) Class B: good, score = -1 to -10 mild pollution;
(3) Class C: moderate, score = -11 to -30 moderate pollution;
(4) Class D: bad, score = -31 heavily polluted.

Based on Hardjono & Djokosetiyanto (2005) and the Minister of Environment LH Number 115 of 2003, the determination of water quality status using the STORET method is carried out by the following steps: a) comparing the measurement data from each water parameter with the quality standard values that are by the water class; b) if the measurement results is in accordance with the quality standard (measurement results < quality standard) then it is given a score of 0; c) if the measurement results are not in accordance with the water quality standards (measurement results > quality standards) then given < quality standard score; d) the negative number of all parameters (physical, chemical and biological) were calculated and determined the quality status of the number of scores (Table 2).

Table 2

The value systems for determining the status of water quality

Number of example	*Value*	*Parameters*		
		Physical	*Chemical*	*Biological*
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
< 10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-18

Another method used is the prediction of exponential smoothing. Exponential smoothing is a group of methods that show weighting decreases exponentially over the values of a long-term observation series. The data used in this paper are secondary data and data collected by the DLHP of Tana Tidung Regency. The data were obtained in the form of monthly time series data. The data used are from Environmental and Transportation Service of Tana Tidung Regency (2012, 2014, 2016, 2017, 2018), which amounts to 5 years. Forecasting in this paper is quantitative, using the time series method. The Exponential Smoothing method of river pollution forecasting analysis used is Winter's method, $F_t = (1-\alpha).F_t + \alpha.F_c$. The parameter F_t is total value, α is smoothing constant and F_c is current value (Pieczywek et al 2017). In predicting water pollution levels in the 3 (three) rivers at the Summit it is assumed that no additional treatment is applied in the river. Using ETS data is obtained based on time-series plots. The predictions were made in the 8th year.

Results and Discussion

The storet method for mapping river water quality. Tana Tidung Regency has several rivers that are directly utilized by the surrounding community for water consumption needs and household needs. Among the streams that are directly used by the community are Sebidai River, Betayau River and Seputuk River. Over the years sampled, their status has improved. The level of pollution is provided in Tables 3-5.

Table 3
The results of calculation of water quality status of the Sebidai River in Tana Tidung Regency

Year	*Water quality classification*			
	Class I	*Class II*	*Class III*	*Class IV*
2012	Enough	Good	Good	Very good
2014	Enough	Enough	Enough	Good
2016	Enough	Enough	Enough	Very good
2017	Enough	Enough	Good	Very good
2018	Enough	Good	Good	Very good

Table 4
The results of calculation of water quality status of the Betayau River in Tana Tidung Regency

Year	*Water quality classification*			
	Class I	*Class II*	*Class III*	*Class IV*
2012	Good	Good	Very good	Very good
2014	Enough	Good	Good	Very good
2016	Enough	Enough	Enough	Very good
2017	Enough	Good	Good	Very good
2018	Enough	Good	Good	Very good

Table 5
The results of calculation of water quality status of the Seputuk River in Tana Tidung Regency

Year	*Water quality classification*			
	Class I	*Class II*	*Class III*	*Class IV*
2012	Good	Good	Good	Very good
2014	Enough	Good	Good	Very good
2016	Enough	Enough	Good	Very good
2017	Enough	Good	Good	Very good
2018	Enough	Good	Good	Very good

The level of pollution in Tana Tidung Regency has fluctuated towards an improved level. Based on the results of field observations, changes in status from moderate conditions are good because it indicates the watershed is still maintained. Environmental monitoring is carried out by involving elements of government, society, industry, and traditional/community leaders. According to Environmental and Transportation Service of Tana Tidung Regency (2014), the contamination waste reaches 50%, whereas in 2015 contamination waste is not feasible, or more or less, reaches 65%, which is approximately 35%. In 2016, improper pollutant waste reached 22%, while domestic wastewater was 78%. Based on field observations, it was found that there was monitoring of the environmental service with the community regarding the management of wastewater entering the river body. As seen in Tables 3, 4 and 5, the Sebidai River, Seputuk River, and Betayau River monitoring of the watershed still looks good and is still monitored by the environmental agency. It can be seen in Figure 1 that along the watershed there are residents and protected forest areas.

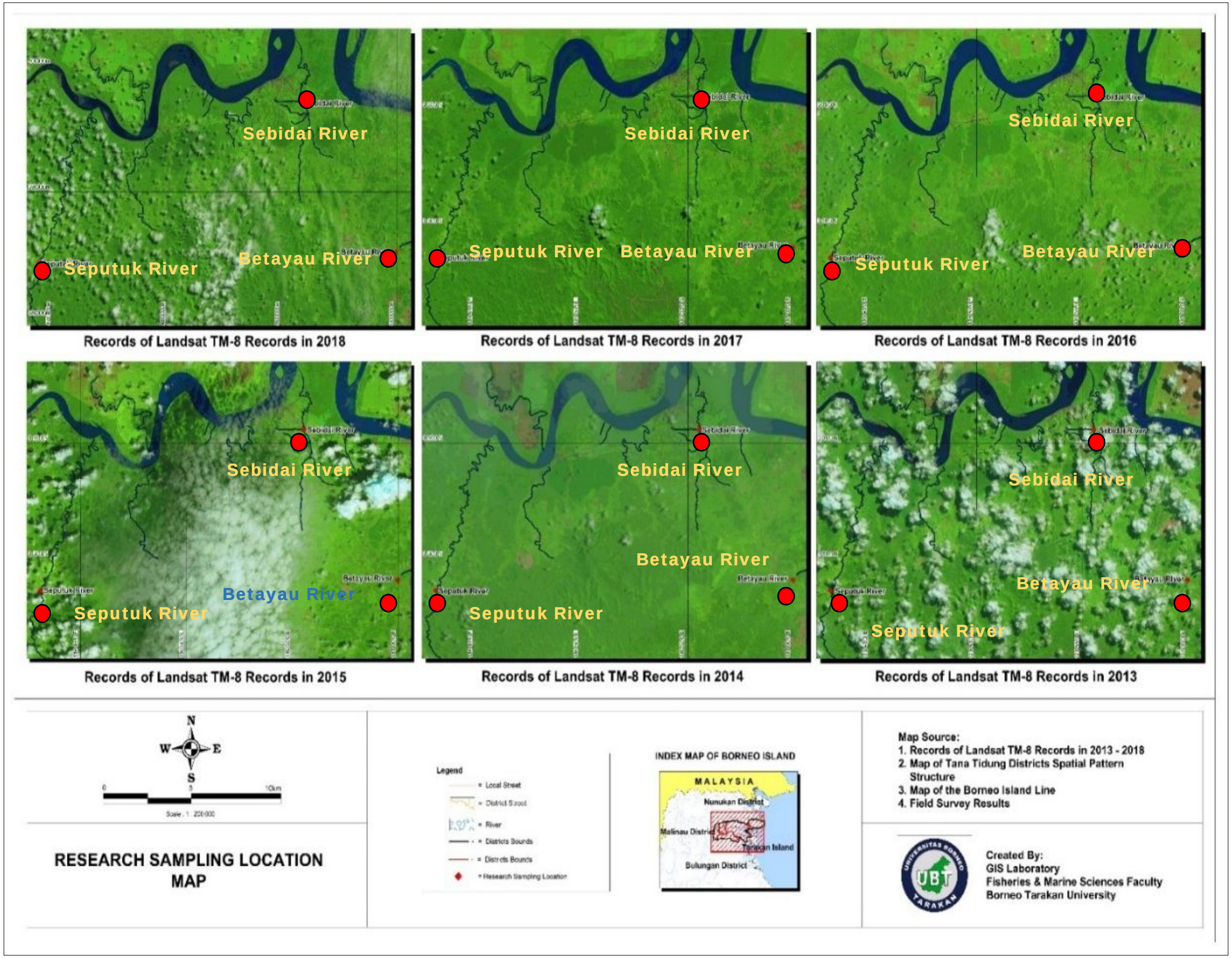

Figure 1. Imagery of the Sebidai, Seputuk, and Betayau Rivers in Tana Tidung Regency from 2018, 2017, 2016, 2015, 2014, and 2013.

Several sources of contamination are detected in rivers and challenging to control, namely dissolved oxygen, iron (Fe), zinc (Zn) metals and fecal coliform. In residential areas animals are kept, and the structure of river subtracts on peatlands, and there is water seepage from the mining and agricultural industries around the Tana Tidung Regency area. Dahuri (2003) stated that water pollutant source factors are domestic (urban) waste - domestic-urban wastes, urban stormwater, residential wastewater (sewage), mining, industrial wastes, agricultural waste, fishery waste cultivation and shipping wastewater.

Forecasting river water quality in Tana Tidung Regency by using Winter's exponential smoothing method. River water quality in Tana Tidung Regency, North Kalimantan, namely the Sebidai, Betayau and Kapuak Rivers was forecasted. In predicting water pollution levels in the three rivers it is assumed that no additional treatment is applied in the river. ETS data was obtained based on time series plots. Values were forecasted for the coming period up to the 8th year post initial sampling in 2012, i.e., 2021. Graphs and river water quality forecast values in Tana Tidung Regency used Winter's Exponential Smoothing method for additive models with smoothing constants $\alpha = 0.5$, $\beta = 0.1$, $\gamma = 0.1$, shown in Figure 2.

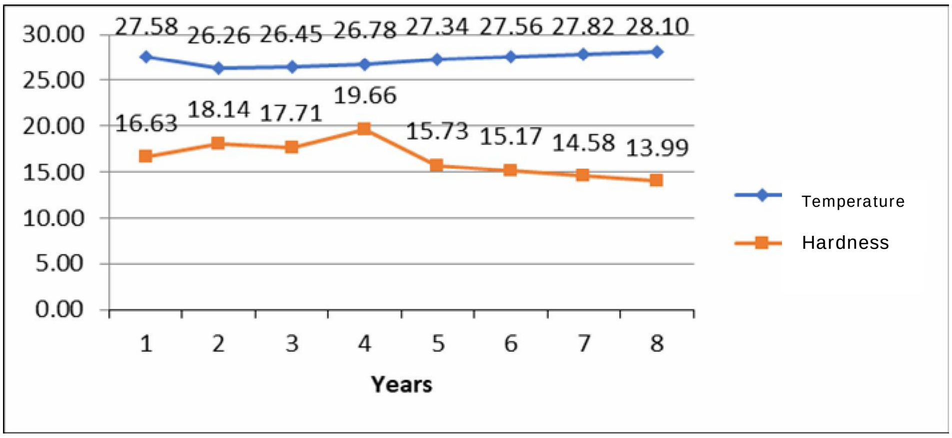

Figure 2. Plots of temperature and hardness data on the Sebidai River.

As seen in Figure 2, the temperature in the river had reached its lowest point in the second year with a temperature of 26^{o}C and predicted that in the 8th year it would reach 28^{o}C while the hardness content reached the highest point in the 4th year with a value of 19.66 and it was predicted in the year the 8th will go down to 13.99.

As seen in Figure 3, pH, BOD and DO experienced less significant fluctuations; the pH in the year experienced an increase of up to 6.86 but still met the standard quality of clean water quality I. BOD and DO experienced increases in the 8th year, though not significantly, but did not meet the criteria for quality clean water raw material I.

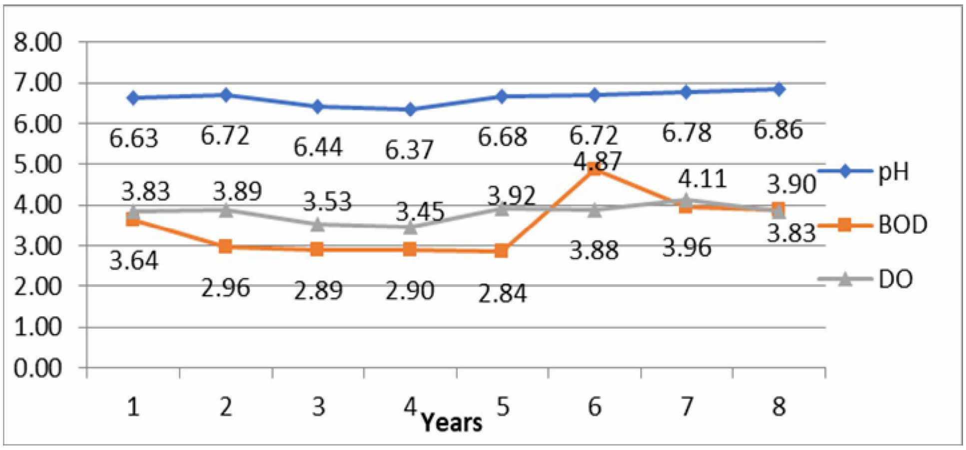

Figure 3. Plots of data on pH, BOD, and DO on the Sebidai River.

As seen in Figure 4, the Sebidai River experienced a significant increase in the parameter's nitrite, zinc, sulfide, and manganese in the 8th year, and did not meet the class I clean water quality standard.

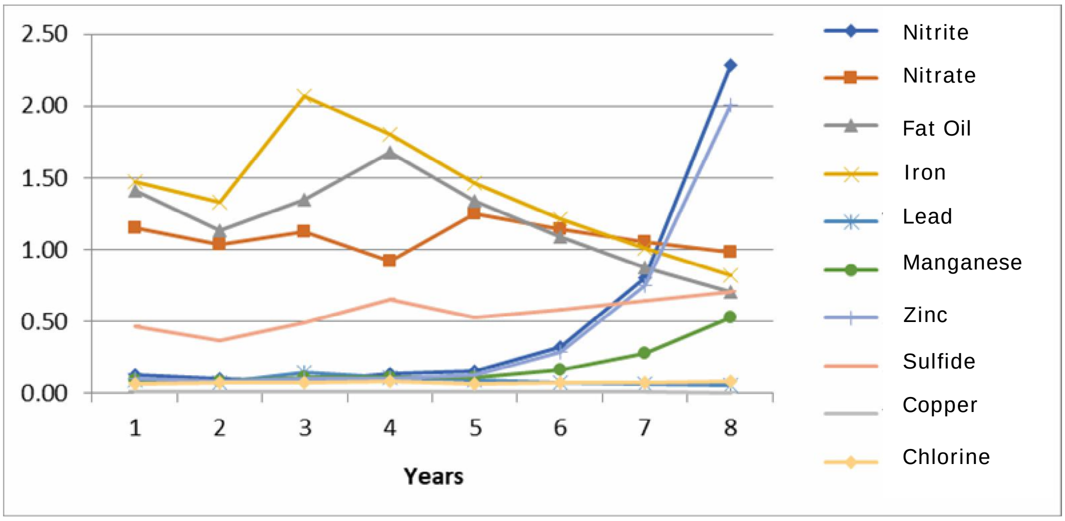

Figure 4. Plots of data on nitrite, nitrate, fat oil, iron, lead, manganese, zinc, sulfide, copper, and chlorine on the Sebidai River.

As shown in Figure 5, the Sebidai River experienced a significant decrease in biological parameters such as fecal coliform and total coliform in the 8th year.

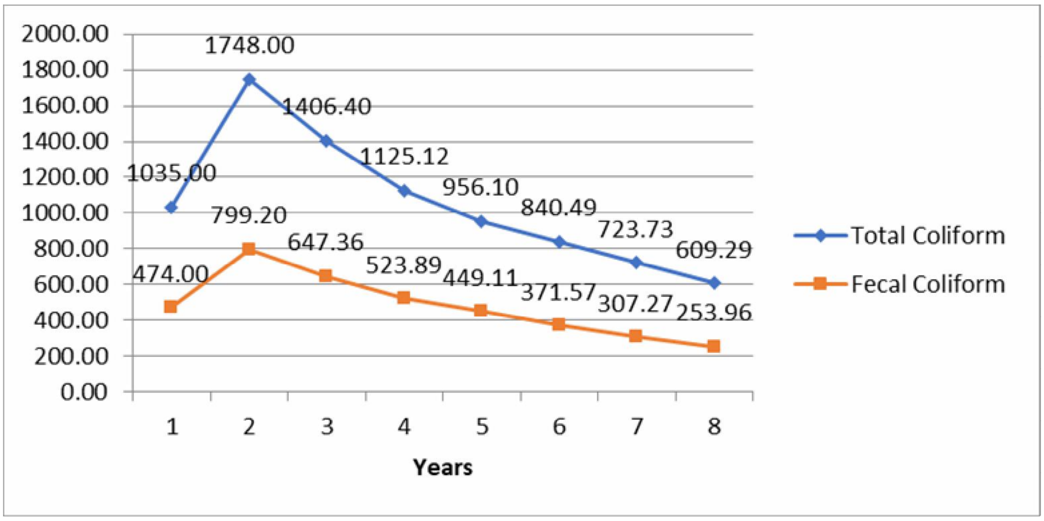

Figure 5. Plot of total coliform and fecal coliform data on the Sebidai River.

It can be seen in Figure 6 that the temperature on the Batayau River reached its lowest point in the second year with a temperature of 25.15^{o}C and predicted that in the 8th year it would reach 28^{o}C while the hardness content reached the highest point in the 4th year with a value of 33.98 and predicted at the 8th year will go down to 23.33.

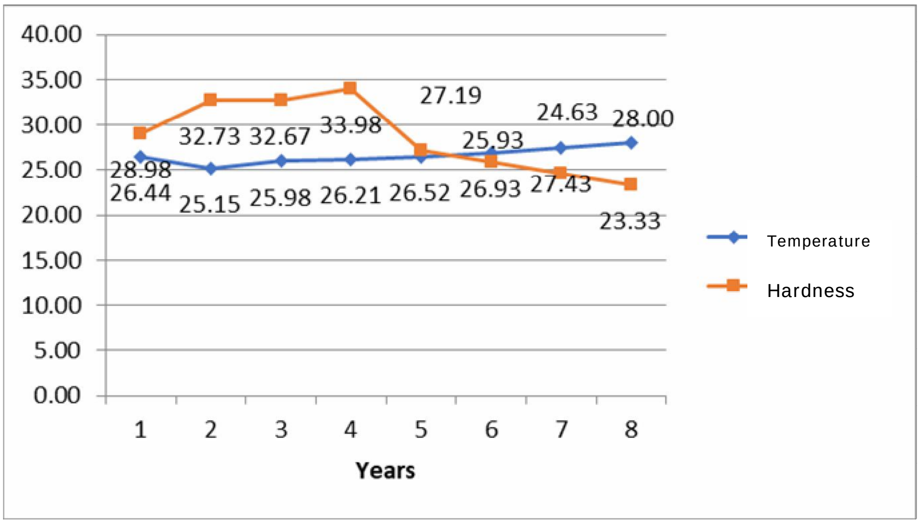

Figure 6. Plots of temperature and hardness data on the Betayau River.

As seen in Figure 7, the Betayau river, pH, BOD and DO parameters are predicted to be seen to increase in the 8th year, but for pH, it still meets the quality standards of drinking water quality on class I, while DO does not meet the class I drinking water quality standards. In the 8th year, it decreased, but it did not meet the class I consumption water quality standards.

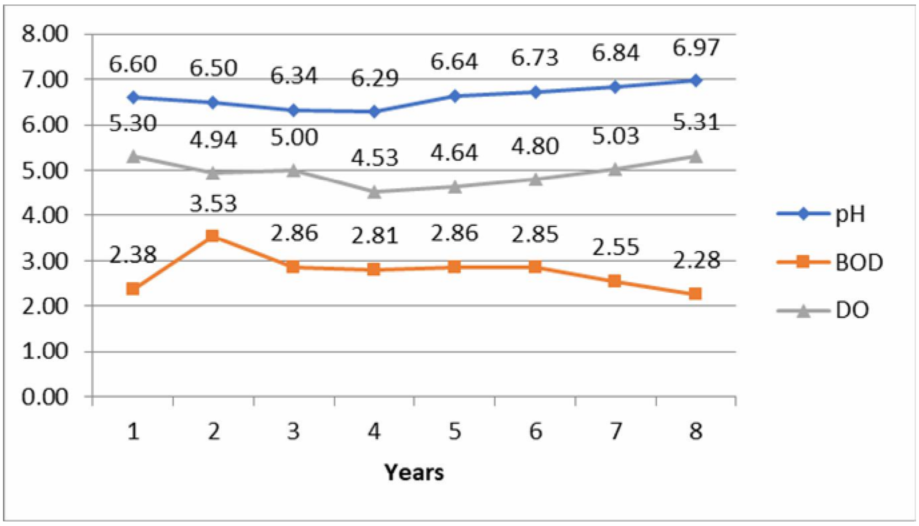

Figure 7. Data plots of pH, BOD, and DO on the Betayau River.

As seen in Figure 8, the parameters of manganese, zinc, nitrite, and iron in the 8th year in the Betayau river were predicted to increase from the previous year and did not meet the quality standards class I drinking water quality, while lead decreased but still did not attend class I drinking water quality standards.

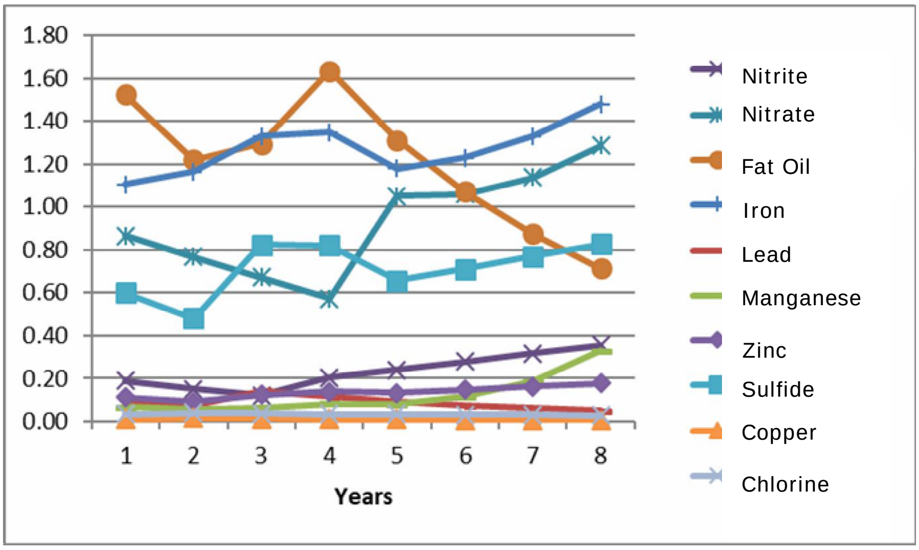

Figure 8. Plots of data on nitrite, nitrate, fat oil, iron, lead, manganese, zinc, sulfide, copper, and chlorine on the Betayau River.

In Figure 9, the total coliform and fecal coliform parameters on the Betayau river were predicted to increase from the previous year but still meet water quality standards of class I.

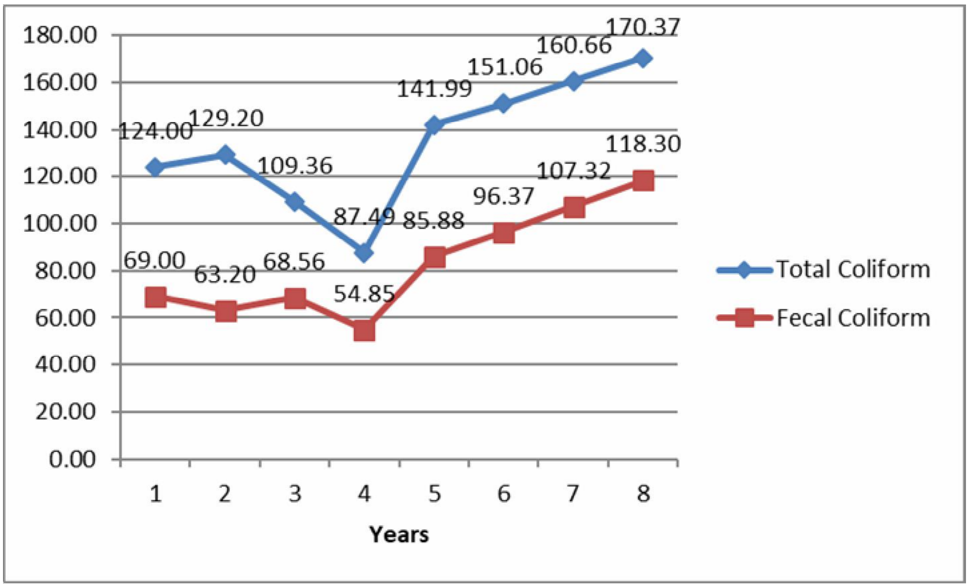

Figure 9. Plot data on total coliform and fecal coliform on the Betayau River.

As seen in Figure 10, the temperature of the Seputuk river reached its lowest point in the second year with a temperature of 26.14 ^{o}C and was predicted in the 8th year to reach 28.16^{o}C, while the hardness content reaches the highest point in the 3rd year with a value of 29.32 and was predicted in the 8th year to be 22.37.

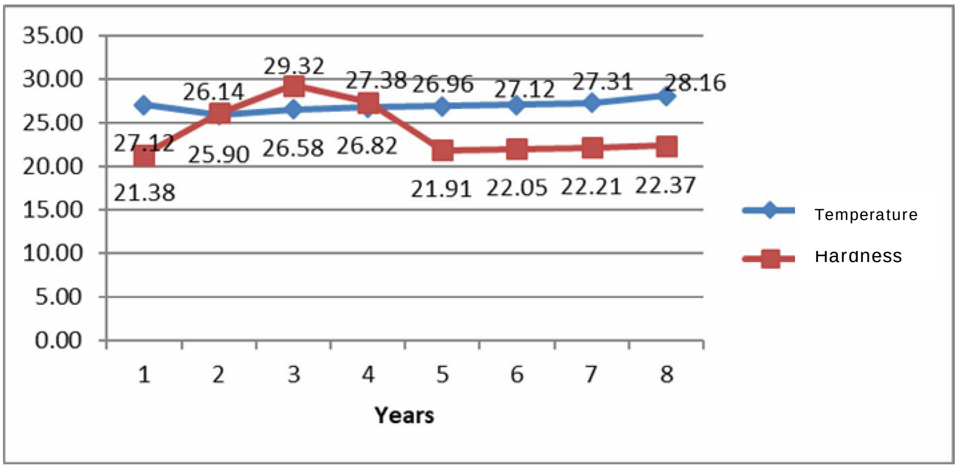

Figure 10. Plots of temperature and hardness data on the Seputuk River.

Furthermore, Figure 11 shows the river data such as pH parameter has reached above 7, where it is predicted that in the 8th year pH will rise to pH 7.26 while BOD is predicted in the 8th year to be 2.74, while DO levels are predicted to increase and the peak occurred in the 8th year, namely 5.29. For DO and BOD, the levels did not meet the class I drinking water quality standard.

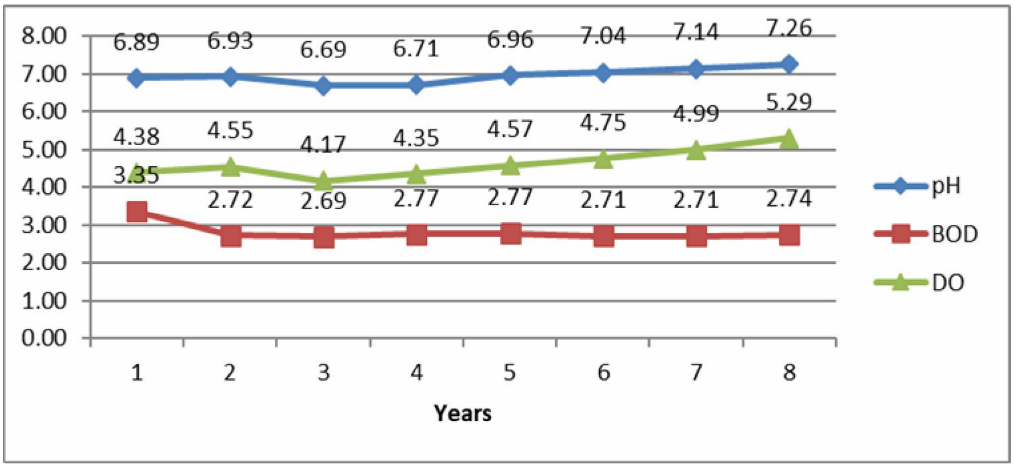

Figure 11. Plots of data on pH, BOD, and DO on Seputuk River.

In Figure 12, zinc content, chlorine, nitrite and sulfide were predicted to increase and did not meet the class I drinking water quality standards.

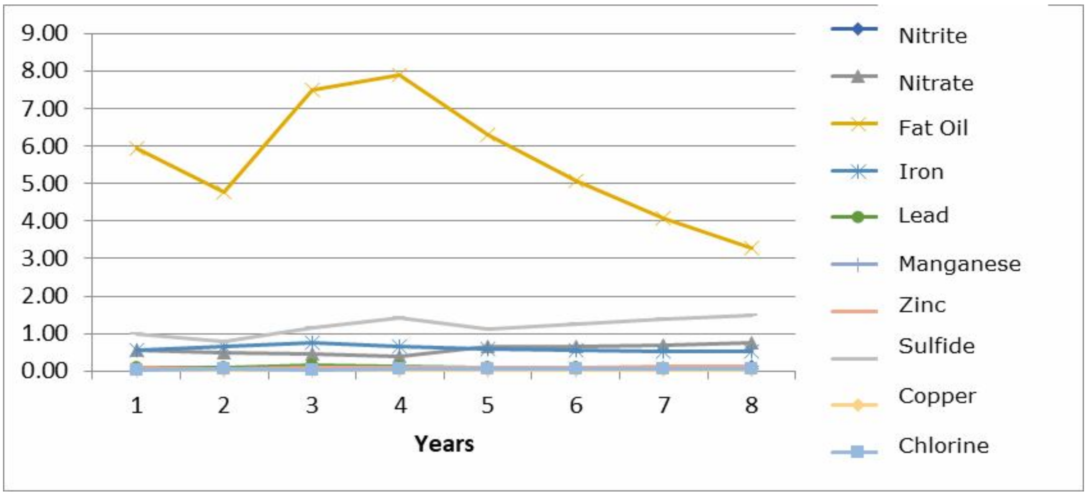

Figure 12. Plots of data on nitrite, nitrate, fat oil, iron, lead, manganese, zinc, sulfide, copper, and chlorine on Seputuk River.

While in Figure 13, the total content coliform and fecal coliform experienced the highest point in year 2 and were predicted to decline in the 8th year, and met the quality standard of drinking water quality class I.

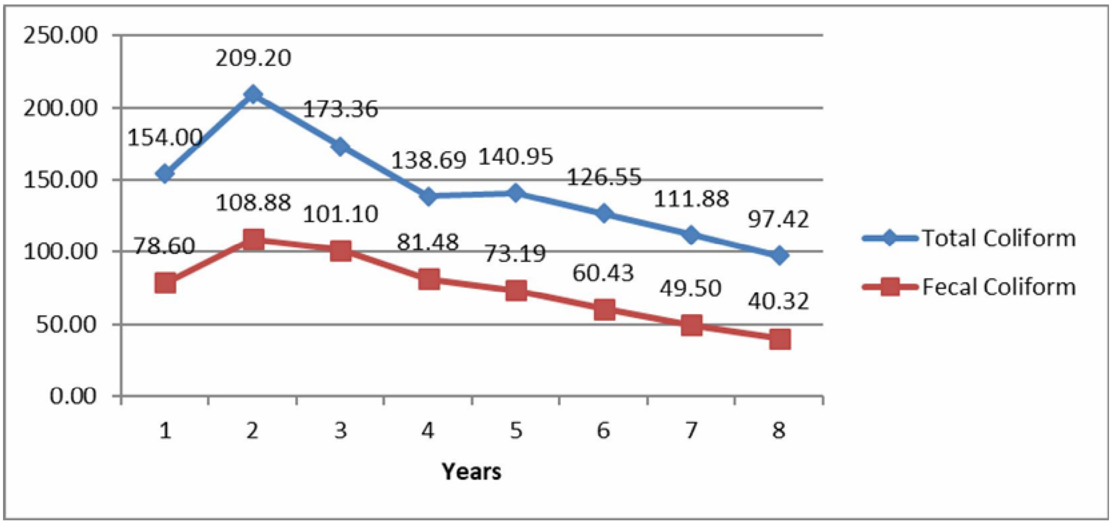

Figure 13. Plot data on total coliform and fecal coliform on Seputuk River.

Based on the calculation of the STORET method, the quality status of river water quality in the districts of Tana Tidung namely Sebidai River, Betayau River, and Seputuk River has shown fluctuations from year to year. The average quality for the class I water quality is experiencing moderate pollution, and the water quality in class II, III and IV is good to very good. The change in water quality is caused by the inclusion of domestic wastewater pollutants that increase the levels of the physical, chemical and biological condition of the river. Wastewater is broken down into organic compounds in the form of carbohydrates, fats, proteins, and nucleic acids. During the dry season when the river water flow decreases by 40%, organic material will enter the river body which will cause a decrease in water quality. The Sebidai River, Betayau River, and Seputuk River are predicted to have increased levels of BOD, DO, manganese, zinc, nitrite, nitrate, sulfide, iron, and lead in the 8th year. This condition is caused by pollution of organic matter caused by human activities such as industrial waste, household waste and agricultural activities (Effendi 2003; Mahyudin et al 2015).

Increased levels of BOD, DO, and coliform bacteria were caused by domestic waste pollution. According to Yudo (2007), local waste pollution generally contains several ingredients including BOD-COD, ammonia, detergent, and feces. River water pollution will also affect ecosystems and genetic changes in river organisms, especially fish. The environment and water quality more or less influence Nugroho et al (2017) state that changes in genetic material. With the change in the quality of water quality from year to year, the need for river pollution control is pressing. Specific recommendations are: 1) control of community behavior contributes to river water pollution, 2) optimization of coordination between agencies related to resource management water and water pollution control, 3) construction of a good community sanitation system, 4) maintaining river protection zones involving environmental cadres as supervisors and monitors, and 5) providing industrial/mining licenses in waste disposal by paying attention to aspects of the condition of river water pollution capacity . River water pollution will affect health, fisheries, livestock, and agriculture.

Conclusions. Based on the calculation of STORET status of the quality of river water quality in Tana Tidung Regency, the Sebidai and Betayau Rivers have reached excellent levels in class IV and III qualifications, while levels are good to moderate in class I and II qualifications. Based on the calculation of the Exponential smoothing forecasting method, it is known that the Sebidai River, Betayau River, and Seputuk River are predicted to have increased levels of BOD, DO, manganese, zinc, nitrite, nitrate, sulfide, iron, and lead in 2021. This condition is caused by pollution of organic matter caused by human activities such as industrial waste, households and agricultural businesses. Thus, there is a need for control of land use activities, as well as gardening, residential, mining, and industrial uses.

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References

APHA, AWWA, WEF, 2012 Standard Methods 9221 B. Standard Total Coliform Fermentation Technique. 29th edition, 54 pp.

Asdak, Chay, 2010 Hydrology and management of river watersheds. 5th edition, Gadjah Mada University Press Yogyakarta, 21 pp.

Dahuri R., 2003 Keanekaragaman Hayati Laut Aset Pembangunan Berkelanjutan Indonesia, Gramedia Pustaka Utama, Jakarta, pp. 25-26. [in Indonesian]

Dinas lingkungan hidup dan Perhubungan Kabupaten Tana Tidung, 2014 Laporan Pemantauan Kualitas Air Sungai. KTT, Kalimantan Utara, 14 pp. [in Indonesian]

Dinas lingkungan hidup dan Perhubungan Kabupaten Tana Tidung, 2016 Laporan Pemantauan Kualitas Air Sungai. KTT, Kalimantan Utara, 18 pp. [in Indonesian]

Dinas lingkungan hidup dan Perhubungan Kabupaten Tana Tidung, 2017 Laporan Pemantauan Kualitas Air Sungai. KTT, Kalimantan Utara, 22 pp. [in Indonesian]

Dinas lingkungan hidup dan Perhubungan Kabupaten Tana Tidung, 2018 Laporan Pemantauan Kualitas Air Sungai. KTT, Kalimantan Utara, 27 pp. [in Indonesian]

Effendi H., 2003 Telaah Kualitas Air: Bagi Pengelolaan Sumber Daya Alam dan Lingkungan Perairan. Penerbit Kanisius, Yogyakarta, pp. 71-72. [in Indonesian]

Environmental Protection Agency, 2001 Parameters of water quality: interpretation and standards. Environmental Protection Agency, Ireland, 132 pp.

Hardjojo B., Djokosetiyanto, 2005 Pengukuran dan Analisis Kualitas Air. Edisi Kesatu, Modul 1-6, Universitas Terbuka, Jakarta. [in Indonesian]

Keputusan Menteri Negara lingkungan Hidup Nomor 115 Tahun 2003 tentang Pedoman Penentuan Status Mutu Air: 23 [in Indonesian]

Mahyudin, Soemarno, Prayogo T. B., 2015 Analisis kualitas air dan strategi pengendalian pencemaran air Sungai Metro di Kota Kepanjen Kabupaten Malang. Jurnal Pembangunan dan Alam Lestari 6(2):105-114. [in Indonesian]

Nugroho E. D., Nawir D., Amin M., Lestari U., 2017 DNA barcoding of nomei fish (Synodontidae: *Harpadon* sp.) in Tarakan Island, Indonesia. AACL Bioflux 10(6):1466-1474.

Peraturan Pemerintah Nomor 82 Tahun 2001 tentang Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air, 42 pp. [in Indonesian]

Pieczywek P. M., Cybulska J., Zdunek A., Kurenda A., 2017 Exponentially smoothed Fujii index for online imaging of biospeckle spatial activity. Computers and Electronics in Agriculture 142:70-78.

Standart Nasional Indonesia, 2004 Air dan air limbah – Bagian 9: Cara uji nitrit (NO_2 - N) secara spektrofotometri. Badan Standardisasi Nasional, 42 pp. [in Indonesian]

Standart Nasional Indonesia, 2004 Air dan air limbah – Bagian 11: Cara uji derajat keasaman (pH) dengan menggunakan alat pH meter. Badan Standardisasi Nasional, 52 pp. [in Indonesian]

Standart Nasional Indonesia, 2004 Air dan air limbah – Bagian 12: Cara uji kesadahan total kalsium (Ca) dan magnesium (Mg) dengan metode titrimetric. Badan Standardisasi Nasional, 29 pp. [in Indonesian]

Standart Nasional Indonesia, 2009 Air dan air limbah – Bagian 70: Cara uji sulfida dg biru metilen secara spektrofotometri. Badan Standardisasi Nasional, 49 pp. [in Indonesian]

Standart Nasional Indonesia, 2009 Air dan Air Limbah – Bagian 72: Cara Uji Kebutuhan Oksigen Biokimia (Biochemical Oxygen Demand/ BOD). Badan Standardisasi Nasional, 56 pp. [in Indonesian]

Standart Nasional Indonesia, 2009 Air dan Air Limbah: Cara Uji COD Secara Titrimetri. Badan Standardisasi Nasional, 24 pp. [in Indonesian]

Standart Nasional Indonesia, 2009 Air dan air limbah – Bagian 6: Cara uji tembaga (Cu) secara Spektrofotometri Serapan Atom (SSA) – nyala. Badan Standardisasi Nasional, 26 pp. [in Indonesian]

Standart Nasional Indonesia, 2009 Air dan air limbah – Bagian 46: Cara uji kadar timbal (Pb) dengan Spektrofotometer Serapan Atom (SSA) secara tungku karbon Badan Standardisasi Nasional, 45 pp. [in Indonesian]

Standart Nasional Indonesia, 2009 Air dan air limbah – Bagian 10: Cara uji minyak nabati dan minyak mineral secara gravimetri. Badan Standardisasi Nasional, 32 pp. [in Indonesian]

Suriawiria U., 1996 Air dalam Kehidupan dan Lingkungan yang Sehat. Penerbit Alumni, Bandung, 128 pp. [in Indonesian]

Wiwoho, 2005 [Identification model of river contamination capacity with QUAL2E]. MSc Thesis, Diponegoro University, Semarang, 56 pp. [in Indonesian]

Yudo S., 2007 Kondisi pencemaran teluk Jakarta. Jurnal Hidrosfir Indonesia, BPPT. [in Indonesian]

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