

Study of Monitoring Water Quality as Impact of Banko Steam Power Plant (SPP) Operational Activities in Tanjung Enim City Using Water Quality Pollution Index

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Study of Monitoring Water Quality as Impact of Banko Steam Power Plant (SPP) Operational Activities in Tanjung Enim City Using Water Quality Pollution Index

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Abstract: The construction of power plants is very necessary to anticipate the crisis of electricity resources and always increases every year. Tanjung Enim city has Steam Power Plant (SPP), one of them is Banko SPP which has 3 x 10 MW capacity. It was built to meet the demand for society electrical energy. The existence of this SPP construction can cause environmental degradation such as a decrease in water quality that does not meet environmental quality standards. The decline in environmental quality can also have a direct impact on the community around the Tanjung Enim SPP location. This is due to the existence of SPP operational activities that can produce liquid waste such as boiler blowdown, airheater blowdown, cooling system and domestic waste water from the manufacturing process. This research study aims to analyze water quality around Banko SPP based on the physical and chemical parameters by testing in the laboratory. The approach employed in this study was an experimental method that included laboratory sample and testing. The water quality pollution index (PI) which refers to the Ministerial Decree No. 115/2003 (Environmental Decree) was used to analyze the result of laboratory testing. The water quality samples examined in this study were wastewater treatment plant (WWTP) outlet, river water, and groundwater closest to the SPP's location. The phenol and chlorine parameters exceeded the quality requirements referred to in the South Sumatra Governor Regulation No. 16 of 2005, according to the findings of laboratory testing of river water samples. The mercury (Hg) parameter in the WWTP outlet samples surpassed the South Sumatra Governor Regulation No. 16 of 2005 quality criteria. Meanwhile, the manganese (Mn) parameter in groundwater samples surpasses the quality requirement established by the Government of South Sumatra Regulation No. 82/2001 as Class I clean water quality criteria. The water quality pollution index (PI) method achieves a score of 1.52 with the category of Lightly Polluted. Based on these findings, it can be concluded that the influence of SPP Banko's operations on water contamination is minor.

Keywords: environmental quality standards, groundwater, pollution index, steam power plant, WWTP outlet

Abstrak (Indonesian): Pembangunan pembangkit listrik sangat diperlukan untuk mengantisipasi krisis sumber daya listrik dan selalu meningkat setiap tahunnya. Kota Tanjung Enim memiliki Pembangkit Listrik Tenaga Uap (PLTU), salah satunya PLTU Banko yang berkapasitas 3 x 10 MW dibangun untuk memenuhi kebutuhan energi listrik masyarakat. Adanya pembangunan PLTU ini dapat menyebabkan degradasi lingkungan seperti penurunan kualitas air dan tidak memenuhi baku mutu lingkungan. Penurunan kualitas lingkungan juga dapat berdampak langsung pada masyarakat di sekitar lokasi PLTU Tanjung Enim. Hal ini dikarenakan adanya kegiatan operasional PLTU yang dapat menghasilkan limbah seperti boiler blowdown, airheater blowdown, sistem pendingin dan limbah cair domestik dari proses produksi. Penelitian ini bertujuan untuk menganalisis kualitas air di sekitar PLTU Banko berdasarkan parameter fisika dan kimia dengan pengujian di laboratorium. Metode yang digunakan pada penelitian ini adalah metode eksperimental dengan pengambilan sampel dan pengujian di laboratorium. Indeks pencemaran kualitas air (PI) yang mengacu pada Keputusan Menteri No. 115/2003 (Keputusan Lingkungan Hidup) digunakan untuk menganalisis hasil pengujian laboratorium. Sampel kualitas air yang diperiksa dalam penelitian ini adalah outlet instalasi pengolahan air limbah (IPAL), air sungai, dan air tanah yang terdekat dengan lokasi PLTU. Sesuai dengan hasil pengujian laboratorium, sampel air sungai untuk parameter fenol dan klorin melebihi persyaratan mutu sebagaimana dimaksud dalam Peraturan Gubernur Sumatera Selatan Nomor 16 Tahun 2005. Parameter merkuri (Hg) pada sampel outlet IPAL melampaui kriteria mutu Peraturan Gubernur Sumatera Selatan No. 16 Tahun 2005. Sementara itu, parameter mangan (Mn) dalam sampel air tanah melebihi persyaratan mutu yang ditetapkan Peraturan Pemerintah Sumatera Selatan No. 82 Tahun 2001 sebagai kriteria kualitas air bersih Kelas I. Metode Indeks Pencemaran Kualitas Air (PI) mencapai skor 1,52 dengan kategori Pencemaran Ringan. Berdasarkan temuan tersebut, dapat disimpulkan bahwa pengaruh operasi SPP Banko terhadap pencemaran air adalah kecil.

Kata kunci: air tanah, baku mutu lingkungan, indeks pencemaran, pembangkit listrik tenaga uap, outlet IPAL.

1. Introduction

Water fulfills a range of functions as a source of energy for living animals and other organisms. Water is also necessary for chemical and biological activities in living beings' bodies in the components of the living environment. The deterioration in water quality is due to human activities that utilize the environment excessively, such as industrial operations, settlements, agriculture, and so on. The water quality necessary for each activity will create waste, resulting in contamination of the aquatic ecosystem. [6,15,16]. Testing is required to determine the application of a quality's identity since water quality has varying quality criteria. [15]. The expansion of industry and communities along the river has had an impact on the quality of river water. Depending on the products generated, the types of industrial waste might be rather different. Liquid Waste, Solid Waste, Gas Waste, and Hazardous Waste are the four categories of industrial waste, respectively.

When these wastes infiltrate the environment, it is referred to as contaminated since it might cause harm to the living organisms in the area. For example, even while some residents on the river's banks still use water for their daily needs, changes in color and odor indicate a reduction in water quality [9]. A Steam Power Plant (SPP) is a generator that generates electricity using mechanical energy from the steam. The primary energy transformed into electrical energy in SPP is fuel. Coal (solid), oil (liquid), or gas can all be utilized as a source of energy. SPP uses a combination of many sorts of these fuels at times [12]. The development of power plants is extremely important to anticipate energy resource shortages, and it continues to rise year after year. The 3 x 10 MW SPP Banko developed by PT Bukit Asam in Tanjung Enim was created to address the need for electricity. This industrial sector's existence has been able to make a substantial contribution, particularly to Indonesia's economic success. On the other hand, the industry's growth has resulted in a reduction in environmental quality.

Environmental degradation may have a direct impact on the communities surrounding the Tanjung Enim SPP site. This is owing to the occurrence of SPP operational activities that can produce gas emissions during the combustion process to generate electrical energy, potentially resulting in pollutants that are hazardous to human health [11]. Some further wastes/pollutants can pollute the water quality around the SPP Banko, in addition to gas emissions. The purpose of this research is to assess water quality in the vicinity of SPP Banko using the water quality pollution index (PI), which is based on the Indonesia Ministerial Decree No. 115/2003 (Environmental Decree).

2. Research Method

The research was conducted in the Tanjung Enim area, Muara Enim Regency, precisely at the SPP Banko Tanjung Enim located on Lingga Raya road (West Banko) shown in Figure 1.

Table 1. Coordinate location of water sample

No.	Water Quality Sample Code	Sample Coordinates
1	API	3°43'34.8"S
	River water	103°48'45.5"E
2	AP2	3°43'39.9"S
	WWTP outlets	103°48'31.0"E
3	AT	3°43'56.8"S
	Groundwater	103°48'29.7"E



Figure 1. Water Sampling Location

A sampling of water quality is carried out by direct sampling at the planned location points (SNI 6989.59:2008) The methods for collecting water quality samples are as follows:

- 1) The sampling device must meet the requirements and be made of materials that do not affect the nature of the sample.
- 2) There must be a sufficient quantity of clean containers for sample storage.
- 3) Storage of water samples in plastic bottles with a volume of 1000 mL.
- 4) Water quality samples to be taken and analyzed in the laboratory using the method according to the Indonesian National Standard (SNI) which can be shown in the table below:

Table 2. Water Quality Parameter Analysis Method

Parameter	Unit	Analysis Method
Temperature	Celcius	SNI 06 - 6989.23-2005
pH	-	SNI 06 - 6989.11-2004
Suspended residue (TSS)	mg/L	SNI 06 - 6989.3-2004
BOD	mg/L	SNI 06 - 6989.72-2009
COD	mg/L	SNI 6989. 2.2019
DO	mg/L	SNI 06 - 6989.14:2004
Heavy metal	mg/L	SNI 6989. 84.2009

Analysis of water pollution can use the Water Quality Pollution Index (PI) according to Attachment II to the Minister of the Environment of Indonesia's

Decree No. 115/2003³⁷ regarding the determination of water quality status, to determine the level of river pollution, which is, formulated [14]:

$$PI_j = \sqrt{\frac{\left(\frac{Ci}{Lij}\right)_M^2 + \left(\frac{Ci}{Lij}\right)_R^2}{2}} \dots\dots\dots (1)$$

Where:

- PI_j = for the designation j, the pollution index
- C_i = water quality parameter concentration
- L_{ij} = concentration of water quality parameter i listed in the water designation standard j.
- M = maximum value
- R = mean value

The criteria for the C_i/L_{ij} assessment are as follows:

- 1) Use the value (C_i/L_{ij}) of the measurement results if this value is less than 1.0.
- 2) Use the new value (C_i/L_{ij}) if the value (C_i/L_{ij}) of the measurement result is greater than 1.0 (C_i/L_{ij} > 1)

$$\left(\frac{Ci}{Lij}\right)_{new} = 1,0 + P. \log\left(\frac{Ci}{Lij}\right)_{measurement} \dots\dots\dots (2)$$

where: P is a constant value that is 5

The classification of the results of the Pollutant Index (PI) is defined in the following way:

- 1) Meets quality standards, with a PI value (0 < PI < 1)
- 2) Lightly polluted, with PI value (1 < PI < 5)
- 3) Moderately polluted, with PI value (5 < PI < 10)
- 4) Heavy polluted, with PI value (PI > 10)

3. Results and Discussion

The operation of the SPP Banko may result in environmental pollution, particularly water pollution, requiring water quality monitoring around the activity area. As a result of SPP Banko's operating activities, a total of three types of water samples were collected: river water samples (AP1), water samples from WWTP outlets (AP2), and groundwater samples (AT). Table 4 illustrates the results of river water quality testing, which are classified as Class I clean water quality requirements by the Government of South Sumatra Regulation No. 82/ 2001.

Several parameters limit the discussion of river water quality parameters, according to numerous research. Pohan [9] and Suroso [17] evaluated numerous water quality parameters in river water, including TSS, pH, COD, BOD, DO, Phosphate, and Chromium (Cr⁴⁺), but did not discuss the parameters of Cadmium (Cd). According to Usman [18], liquid waste from SPP processes has the potential to include Cadmium metal (Cd). This study examines the water quality factors suggested for river streams in greater

depth and makes no mention of season change's consequences.

TSS levels decreased from 23.3 to 17 mg/L in the TSS water quality parameters tested from April to June 2021, and this number did not exceed the environmental quality standards (Figure 1). TSS is a suspended material that can be used to raise the turbidity of water by adding suspended solid particles to it.

There were no residential activities around the sampling area, only SPP operational operations, indicating that the TSS level was not very high. TSS is correlated to dissolved oxygen in the water and is one of the water quality indicators that directly reflects changes on land and in water [16].

Table 4. Water Quality Test Results (AP1)

Parameter	Unit	Env. Quality standards	Results AP1		
			April 2021	May 2021	June 2021
Temperatur	°C	-	30,3	29,7	29,5
TSS	mg/L	50	23,3	20	17
pH	-	6-9	6,21	6,4	6,9
BOD	mg/L	3	1,51	1,81	1,56
COD	mg/L	25	9,28	8,63	8,96
DO	mg/L	4	6,44	6,3	6,1
Phosphate	mg/L	0,2	<0,2	<0,2	0,31
Ammonium	mg/L	0,1	0,007	0,003	<2,98.10 ⁻⁴
Chromium (Cr ⁴⁺)	mg/L	0,05	<	0,041	0,048
Chlorine	mg/L		0,015		
Phenol	mg/L	0,03	<0,03	0,08	0,04
		2000	6000	14000	3000

Env. Quality Standards : Government of South Sumatra Regulation No. 82/ 2001 as Class I

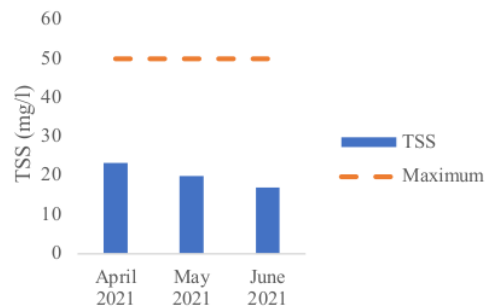


Figure 1. TSS test results

pH is a water quality measure that indicates the level of acidity; according to the test findings, pH ranged from 6.21 to 6.9 from April 2021 to June 2020. (Figure 2). The pH value changes depending on the presence of heavy metals, which can raise the acidity of the water. The pH of the analyzed water sample does not exceed the environmental quality threshold, allowing river water to be used according to its categorization.

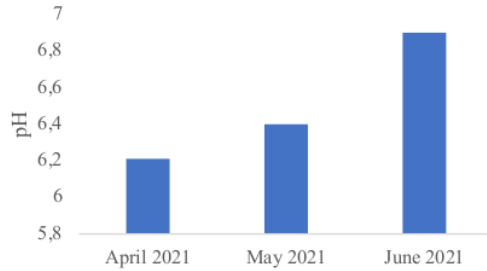


Figure 2. pH Concentration

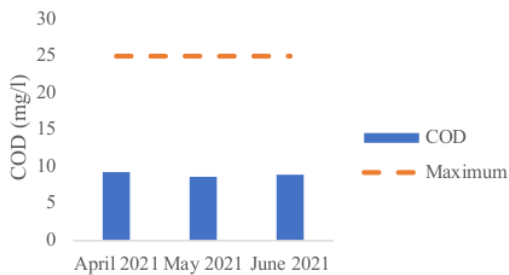


Figure 3. COD

COD is a water quality metric that indicates the amount of degradable organic and inorganic substances. COD values of 8.63 – 9.28 mg/l were found in water samples tested between April and June 2021, which did not meet environmental quality standards (Figure 3). A high COD value means the water quality is getting worse due to a lack of dissolved oxygen levels thus it can interfere with aquatic organisms.

The BOD value shows the amount of dissolved oxygen contained in river water used by organisms to decompose organic compounds. From the results of the water sample test, the BOD value from April 2021 to June 2021 ranged from 1.51 to 1.81 mg/l which did not exceed the environmental quality standard according to South Sumatra Governor Regulation No. 16 of 2005 (Figure 4). The BOD value obtained is not high so that the dissolved oxygen level is very high.

DO is the amount of dissolved oxygen in water produced by aquatic plants' photosynthesis, which varies depending on the number of plants, and from the atmosphere (air) that enters the water at a slow rate. From the test results of surface water samples, the DO value ranges from 6.1 to 6.44 mg/L which has met the environmental quality standard of at least 4 mg/L (Figure 5). The oxidation and reduction of organic and inorganic elements in aquatic biota is the purpose of this minimal content. The involvement of dissolved oxygen in the oxidation and reduction processes is critical for naturally reducing pollution loads in the waterways [13].



Figure 4. BOD

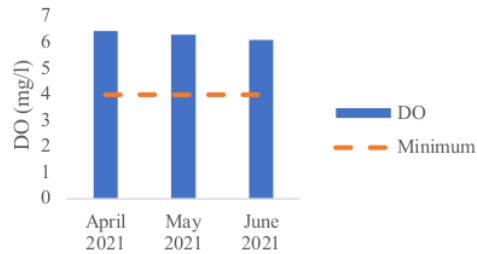


Figure 5. DO Test Results

The level of phosphate (P) in the surface water quality test results shows that the phosphate level in the water fulfills the environmental quality standard in April and May 2021 (Figure 6), but it surpasses the environmental quality standard in the current test results (June 2021).

The local community's plantation operations and household activities generated a rise in phosphate levels in river water at the sample location, allowing it to be transferred into the river. [8]. Domestic waste from bathing and washing latrines contributes considerably to the presence of phosphorus, as does runoff from agricultural regions that employ fertilizers. The high levels of phosphate in the water have the potential to generate massive algae growth and prevent sunlight from reaching the surface.

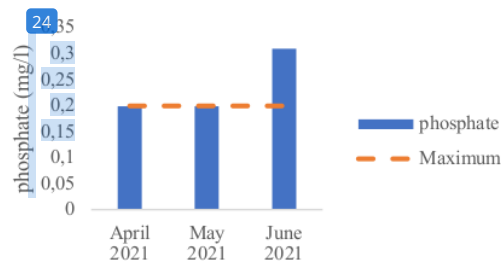


Figure 6. Phosphate (P) test results

Chromium (Cr^{4+}) is a heavy metal whose levels can rise dramatically as a result of industrial and other activities in which waste is dumped directly into bodies of water. The value of chromium (Cr^{4+}) in laboratory

testing varied from 0.015 to 0.048 mg/L, which did not exceed the environmental quality limit (Figure 7).

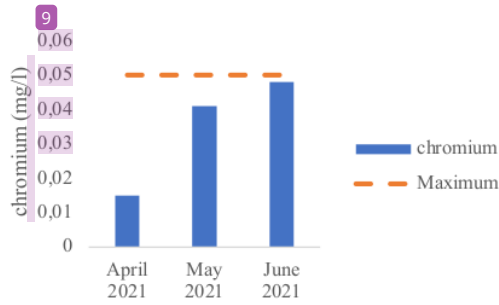


Figure 7. Chromium (Cr⁴⁺) test results

The amount of Chromium (Cr⁴⁺) in the body has an impact on pH, with the higher the pH, the higher the level of chromium (Cr⁴⁺). High pH causes complicated compounds to form, such as the transition of chromium from carbonate to hydroxide, which is difficult to dissolve in water and binds to other particles, causing it to sink to the bottom of the water [7].

Cadmium (Cd) is a hazardous heavy metal that is carcinogenic, poisonous, and poses a significant health risk. The value of Cadmium (Cd) laboratory testing ranged between 2.98.10⁻⁴ - 0.007 mg/L, which did not exceed the environmental quality level (Figure 8). Cadmium (Cd) is very influential on human health in the long term and accumulates in the body, especially the liver and kidneys [10].

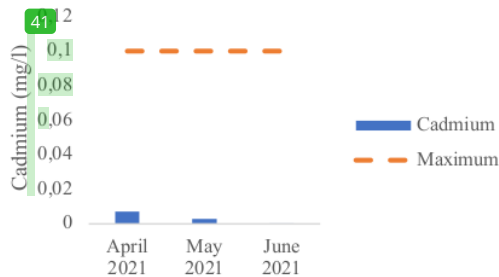


Figure 8. Cadmium (Cd) test results

When compared to the previous month, the parameters of Chlorine and Phenol exceeded the environmental quality criteria by 0.04 – 0.08 mg/L and 3,000 – 14,000 mg/L, respectively. This is caused by the decomposition of organic things including wood, bamboo, and leaves, as well as domestic waste, in the river. Phenol is a pollutant that is hazardous to one's health when it is present in the body, as it is poisonous and difficult for organisms to break down [2]. Domestic or other industrial operations, such as plastics, solvents, cement, pulp and paper, pesticides, metals, and power plants industries, all contribute to a rise in free chlorine in surface water.

River water pollution by free chlorine (Cl₂) has an impact on human health because chlorine is a strong oxidizing compound that has the potential to cause eye, skin, and respiratory tract irritation which has long-term effects [4].

Furthermore, the results of the AP1 sample water quality test were analyzed for the level of pollution using the Pollutant Index (PI). Table 5 is the result of the calculation of water quality analysis on the AP1 sample where the Ci value is the value of the water quality test results while Lij is the maximum parameter limit.

Table 5 presents the results of the pollution index calculation using quality requirements from the South Sumatra Government Regulation No. 82/2001. If the Ci/Lij value is more than 1, the water quality parameter is below the quality standard. There are three water quality parameter, namely Phosphor, Phenol, and Chlorine which have Ci/Lij value more than 1, meaning that the parameter exceeds the environmental quality standard. From the results of all parameters, the maximum Ci/Lij comparison value is 1.95 and the average Ci/Lij is 0.91 therefore:

$$PI = \sqrt{\frac{(1,95)^2 + (0,91)^2}{2}} = 1,52$$

Then the Pollutant Index (PI) value for the AP1 sample is 1.52 including the Lightly Polluted category.

Table 5. Calculation of the analysis of the water quality pollution index of the sample AP1

Parameter	Ci	Lij	Ci/Lij	Ci/Lij >1	Ci/Lij New
TSS	17	1000	0,02	-7,85	0,02
COD	8,96	25	0,36	-1,23	0,36
BOD	1,56	3	0,52	-0,42	0,52
P	3,10E-01	0,2	1,55	1,95	1,95
Cr ⁴⁺	4,80E-02	0,05	0,96	0,91	0,96
Cd	2,98E-04	0,1	0,00	-11,63	0,00
Chlorine	4,00E-02	0,03	1,33	1,62	1,62
Phenol	3,00E+03	2000	1,50	1,88	1,88
		Ci/Lij max			1,95
		Ci/Lij average			0,91
		Pollutant Index (PI)			1,52
		Category			Lightly Polluted

Env. Quality Standards : Government of South Sumatra Regulation No. 82/2001 as Class I

Table 6 shows the test results for water quality from the WWTP outflow. Some of the water quality indicators specified by South Sumatra Governor Regulation No. 08 of 2012 still fulfill environmental quality criteria. the Mercury (Hg) parameter in June 2021 has 5,74.10⁻³ mg/L which surpasses environmental quality standards of 0,002 mg/L. This is owing to the presence of an inefficient WWTP process or a rise in mercury content as a consequence of SPP operating operations, causing the WWTP to be unable of processing the mercury load. According to historical

statistics, mercury levels do not exceed the environmental quality limit, implying that there will be more SPP operating operations in June 2021 than the previous month.

Table 6. AP2 Sample Water Quality Test Results

Parameter	Unit	Env. Quality standard	Results AP2		
			April 2021	May 2021	June 2021
pH	45	6 – 9	6,04	7,0	7,3
BOD	mg/L	50	5,30	15,7	2,81
COD	mg/L	100	16,3	42,9	17,8
TSS	mg/L	100	3,05	9,50	4,11
Temperature	°C	38	30,2	31,7	28,1
Oils & fats	mg/L	10	1,3	2,4	1,1
Cu	mg/L	2	<0,060	<0,060	<0,032
Cr	mg/L	0,5	<0,031	<0,031	<0,031
Fe	mg/L	3	0,097	0,390	0,291
Mn	mg/L	2	<0,023	0,054	0,099
Hg	mg/L	0,002	<	<	5,74.10 ⁻³

Env. Quality Standards : Government of South Sumatra Regulation No. 82/ 2001 as Class I

The results of testing groundwater quality parameters can be seen in Table 7. below this. The groundwater quality parameters reviewed and tested refer to Aisyah's research [1] where the groundwater is intended to meet daily needs such as bathing and latrines. The parameters referred to for this designation are temperature, TDS, pH, Iron, Manganese, Nitrite, and Nitrate where the environmental quality standards refer to Government of South Sumatra Regulation No. 82/ 2001 as Class I clean water quality standards.

Based on the results of laboratory tests for groundwater quality, manganese parameters in April 2021 and June 2021 still exceed the existing quality standards. Manganese is a heavy metal element that is toxic/toxic. Water containing excess manganese will appear brownish/purple/black and also experience turbidity [3].

Table 7. Groundwater Quality Test Results

Parameter	Unit	Env. Quality standard	Results AT		
			April 2021	May 2021	June 2021
Temperature	12	-	28,8	30,6	28,5
TDS	mg/L	1000	84	54	47
pH	mg/L	6 – 9	6,11	7,0	7,1
Fe	mg/L	0,3	< 0,046	<0,046	<0,046
Mn	mg/L	0,1	0,111	0,087	0,150
Nitrite	mg/L	0,06	<0,0011	<0,0011	<0,0011
Nitrate	mg/L	10	0,4	<0,1	<0,1

4. Conclusion

Research on water quality monitoring for SPP Bangko in Tanjung Enim has been completed. With the category of Lightly Polluted, the water quality pollution index (PI) technique yields a score of 1.52. Based on these data, it can be inferred that SPP Banko's operations have a small impact on water pollution.

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