Study of domestic wastewater in oil and gas field: A case study in the Cangkring river, Tuban, East Java

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Abstract. Mudi Field, Tuban is an oil and gas producing area in East Java. Pad B Mudi Field is an office area for the oil and gas industry. The oil and gas industrial office area in Pad B Mudi Field produces domestic wastewater, which is channeled into the Cangkring River. Domestic wastewater flows directly into rivers. This study aims to determine the water quality of the Cangkring River region, which is mixed with domestic wastewater from Pad B Mudi Field. Samples of river water were taken at 3 points along with the river flow. Sample evaluation included physical, chemical, and biological characteristics. Sample test results were adjusted according to domestic wastewater quality standards and water quality standards. Parameters tested include temperature, TSS, pH, BOD5, COD, ammonia (NH3), phosphate (PO43-), chromium, oils and fats, and total coliforms. The highest values of the three samples for each parameter were temperature of 20.8 °C, TSS of 13 mg/L, pH of 7.8, BOD5 of 6.53 mg/L, COD of 17.38 mg/L, ammonia (NH3) of 6.13 mg/L, phosphate (PO43-) of 1.15 mg/L, chromium of 0.01 mg/L, oils and fats of 1.6 mg/L, and total coliform of 2400/100 mL. The values of the three points of the Cangkring River water test results met all the parameters of the domestic wastewater quality standards. In testing water quality standards, Cangkring River water met all parameters of class 4 water quality standards, namely water quality that can be used to irrigate agriculture. So it can be concluded that the condition of the Cangkring River water is safe for the community but is not suitable for drinking water, recreational infrastructure, and aquaculture.

1. Introduction

The Cangkring River is one of the rivers located around the area of operation of the oil and gas industry, namely Mudi Field, Tuban Regency, East Java Province. The Cangkring River is a tributary of the Bengawan Solo River in the southern part of the Tuban Regency. The Cangkring River has an average width of 5 meters, an average depth of 78 cm, and a daily volumetric flow rate of 6.8 m3/second. The Cangkring River is used by the community to irrigate rice fields. Mudi Field is an operational field for the oil and gas industry in Tuban Regency, East Java Province. Pad B Mudi Field is an office area for the oil and gas industry. The office area in Pad B Mudi Field has a domestic wastewater disposal channel that flows directly into the Cangkring River. Pad B Mudi Field produces domestic wastewater of 2.5 m3/month with fluctuating discharge [1]. A map of the location of the Cangkring River and Pad B Mudi Field in ArcGIS can be seen in figure 1.
The increase in economic growth resulted in higher environmental pollution problems. One of the environmental pollutions is the increasing domestic liquid waste [2]. Office activities at Pad B Mudi Field produce domestic wastewater, so it is necessary to test the Cangkring River water to determine its water quality. The water parameters to be tested were based on the Minister of Environment and Forestry Regulation No. 68 of 2016 regarding domestic wastewater quality standards [3]. Details of domestic wastewater quality standards according to regulations are shown in table 1.

| Characteristics | Parameter       | Unit | Maximum Rate |
|-----------------|-----------------|------|--------------|
| Physical        | TSS             | mg/L | 30           |
| Chemical        | pH              | -    | 6-9          |
|                 | BOD₅            | mg/L | 30           |
|                 | COD             | mg/L | 100          |
|                 | Ammonia (NH₃)   | mg/L | 10           |
| Oil and Fat     | Oil and fat     | mg/L | 5            |
| Biological      | Total Coliform  | quantity/100 mL | 3,000       |

To maintain river water quality, domestic wastewater from Pad B Mudi Field must meet water quality standards before being channeled into the Cangkring River. Water quality standards for various water categories refer to Government Regulation of the Republic of Indonesia No. 82 of 2001 concerning water quality management and water pollution control. In this regulation, water is classified into 4 (four) categories, namely first-class for drinking water, second class for water recreation facilities, the third class for aquaculture, and fourth class for irrigating crops [4]. The main parameters that must be met to analyze water quality standards by class are as shown in table 2.
Table 2. Water quality standards based on Government Regulation of the Republic of Indonesia No. 82 of 2001 [4].

| Characteristics | Parameter     | Unit | Class I | Class II | Class III | Class IV |
|-----------------|---------------|------|---------|----------|-----------|----------|
| Physical        | Temperature   | °C   | 3 deviation | 3 deviation | 3 deviation | 5 deviation |
|                 | TSS           | mg/L | 50      | 50       | 400       | 400      |
| Chemical        | pH            | -    | 6-9     | 6-9      | 6-9       | 5-9      |
|                 | BOD₅          | mg/L | 2       | 3        | 6         | 12       |
|                 | COD           | mg/L | 10      | 25       | 50        | 100      |
|                 | Phosphate (PO₄³⁻) | mg/L | 0.2    | 0.2      | 1         | 5        |
|                 | Chromium      | mg/L | 0.05   | 0.05     | 0.05      | 0.01     |
| Biological      | Total Coliform | quantity/100 mL | 1,000 | 5,000 | 10,000 | 10,000 |

Continuous domestic wastewater pollution can cause environmental pollution and result in the emergence of various viruses that interfere with health [5] and cause various diseases in society [6]. In addition to human health, river water contaminated with domestic wastewater also causes health problems to domesticated and livestock animals [7]. The impact of irrigation that is fed with domestic wastewater containing lead, zinc, cadmium, and copper causes contamination of agricultural land, thus putting people at risk of eating vegetables contaminated with heavy metals [8]. Plants that are fed with domestic wastewater accumulate more proline and sugar, which can interfere with plant growth. Proline is classified as an amino acid which is an indicator to determine the level of physiological stress in plants [9]. Plants that are fed with treated domestic wastewater can improve physicochemical properties and fertilize the soil [9] [10]. The Cangkring River is a river that is used to drain the local community's agriculture, so the handling of domestic wastewater that enters this river must be tested and treated.

There are many references for simple wastewater treatment that have been applied on a small or household scale. The simplest method of managing small scale domestic wastewater is the filtration method. This filtration is able to reduce the levels of COD, BOD, and TSS of domestic wastewater before it is channeled into rivers [11]. Simple filtration with low cost, one of them using sand. Filtration with sand can reduce TSS by 93%, COD by 87%, and total coliform by 93% [12]. Continuous sand filtration can reduce the TSS, TDS, COD, and BOD of wastewater so that the water meets the standards for crop irrigation [13]. Sand Filtration can continuously be used for wastewater filtration directly in the field [14]. In addition to the filtration method, another fairly easy waste treatment is the use of photosynthetic bacteria (PSB). PSB is very effective in degrading pollutants in wastewater, even being able to add value to agriculture [15]. PSB to reduce the COD of domestic wastewater reaches a value below 80 mg/L [16]. Various methods of treating wastewater easily and cheaply can be an alternative to domestic wastewater treatment where domestic wastewater does not need a complicated process because the pollutant content is not too high.

This study aims to determine the water quality of the Cangkring River which is drained by domestic wastewater from the oil and gas industry office area in Pad B Mudi Field. The results of the Cangkring River water test were assessed based on the parameters of the domestic wastewater quality standard and the water quality standard based on class. The results of the study concluded that the current condition of the Cangkring River water was drawn. The water condition of the Cangkring River needs to be known by the community because they use river water for agricultural activities.

2. Materials and Method

2.1. Material

The material to be tested in this study is Cangkring River water which is affected by domestic wastewater from the disposal channel in the oil and gas office area in the Pad B Mudi Field. There are 3 points for water sampling: point 1 which is in the flow before the sewer, point 2 which is very close to the sewer,
and point 3, after the sewer. An illustration of the sampling location can be seen in figure 2. Point 1 is used to see the condition of river water that has not been drained of domestic wastewater. Point 2 is used to determine the highest pollution because it is directly related to domestic wastewater outlets. Finally, point 3 is used to determine the condition of the water flowing with domestic wastewater and has been mixed with river water. The distance between point 1 to point 2 and point 2 to point 3 is 300 m each.

![Sampling point on the Cangkring River](image)

**Figure 2.** The sampling point on the Cangkring River.

2.2. **Method**

Domestic wastewater parameters to be measured are TSS, BOD5, COD, Ammonia, and Phosphate [17]. Several studies have added pH parameters to determine the process of removing phosphorus in domestic wastewater [18] and to neutralize wastewater [19]. Someone added the use of chromium parameters to determine the water content of rivers [20]. In addition to physical and chemical testing, there is also water quality testing using biology, namely by knowing the total coliform [21][22]. Meanwhile, to test river water quality, the parameters that are often used are pH, TSS, temperature, EC, ions, ammonia, fluoride, phenol, and heavy metals [23]. Monitoring river water conditions in real-time uses the parameters of water flow pressure, pH, color, and turbidity [24]. Testing of TSS, BOD5, COD, Ammonia, and Phosphate was carried out in the Environmental Hydrology and Climatology Laboratory, Gadjah Mada Universiti, while the pH was measured in situ. Water quality is expected to meet domestic wastewater quality standards, which refer to the Regulation of the Minister of Environment and Forestry No. 68 of 2016 [3], including temperature, total suspended solids (TSS), pH, biological oxygen demand (BOD5), chemical oxygen demand (COD), ammonia (NH3), oil and fat, and total coliform. Meanwhile, additional tests for the analysis of water quality standards according to class referring to Government Regulation No. 82 of 201 are phosphate (PO43-) and chromium tests [4]. Details of the differences and similarities of the tested parameters can be seen in table 1 and table 2.

After testing, the analysis is carried out in the form of tables and graphs. The appearance of the data in the table is to find out the details of the test, while the appearance of the data is in the form of images or graphs to make it easier to see the data visually. This is very helpful in analyzing the suitability of the test results against domestic wastewater quality standards and water quality standards based on class. The results can be used to assess the condition of the Cangkring River water fed by domestic wastewater from the oil and gas industry office area in Pad B Mudi Field. The stages in the research from the beginning to the assessment of river water conditions can be seen in figure 3.

3. **Results and Discussion**

3.1. **Test results and discussion**

The results of testing the Cangkring River water at three different points based on the characteristics of physics, inorganic chemistry, organic chemistry, and biology can be presented in table 3. The test results include ten parameters that are discussed based on domestic wastewater quality standards and water
quality standards based on class. Domestic wastewater quality standards as in table 1, only use seven parameters, while water quality standards based on class as in table 2, only use eight parameters.

3.1.1. Domestic wastewater quality standard. In the discussion of domestic wastewater quality standards, the physical parameters only include total suspended solids (TSS). TSS are solids in water that are netted or trapped when filtered. The netted residue was dried at a temperature of 103-105 °C [25]. Based on the maximum standard of TSS in domestic wastewater quality standard is 30 mg/L. The value of the TSS test results at point 1, point 2, and point 3 showed the same data, which was 13 mg/L. The TSS value at the three points is still far below the TSS quality standard value in domestic wastewater. A visual image of the comparison of TSS in domestic wastewater can be seen in figure 4a.

The allowable pH value in domestic wastewater is between 6 to 9. The results of pH testing in river water are 7.8, 7.76, and 7.61, respectively. The three points indicate that the pH of river water is neutral because all of them are in the range of number 7. The three points also still meet the quality standards of domestic wastewater because they are still in the range of numbers 6 to 9 seen in figure 4b.

The following parameter is biological oxygen demand (BOD), which is the amount of oxygen needed for the oxidation of wastewater by bacteria. BOD is usually expressed in units of 5 days at a temperature of 20 oC, so it is often abbreviated as BOD5 [26]. The standard value for BOD5 is 30 mg/L. The test results show the value at point 1 is 6.53 mg/L, at point 2 is 4.6 mg/L, and at point 3 is 1.7 mg/L. At all three points, all of them meet the BOD5 quality standard for domestic wastewater. The graphic image of the comparison of the results of the BOD5 test to the maximum limit of the domestic wastewater quality standard can be seen in figure 4c.

Table 3. Cangkring river water test results.

| Characteristics | Parameter            | Unit       | River Water Test Results |
|-----------------|----------------------|------------|--------------------------|
|                 |                      |            | Point 1 | Point 2 | Point 3 |
| Physical        | Temperature          | °C         | 20.8    | 20.1    | 20.0    |
|                 | TSS                  | mg/L       | 13      | 13      | 13      |
| Chemical        | pH                   | -          | 7.80    | 7.76    | 7.61    |
|                 | BOD5                 | mg/L       | 6.53    | 4.60    | 1.70    |
|                 | COD                  | mg/L       | 17.38   | 13.95   | 12.31   |
|                 | Ammonia (NH3)        | mg/L       | 4.25    | 4.07    | 6.13    |
|                 | Phosphate (PO4³⁻)    | mg/L       | 1.15    | 1.06    | 0.99    |
|                 | Chromium             | mg/L       | 0.0100  | 0.0036  | 0.0036  |
| Oil and Fat     | Oil and fat          | mg/L       | 1.60    | 1.60    | 1.60    |
| Biological      | Total Coliform       | quantity/100 mL | ≥ 2,400 | ≥ 2,400 | 1.100   |
a. TSS  
b. pH (between 6-9)  
c. BOD₅  
d. COD  
e. Ammonia (NH₃)  
f. Oil and fat  
g. Total Coliform

Information:
Point 1: River water test results at point 1
Point 2: River water test results at point 2
Point 3: River water test results at point 3
Min: Min domestic wastewater quality standard (residential and office)
Max: Max domestic wastewater quality standard (residential and office)

Figure 4. Comparison of river water test results with the maximum level of domestic wastewater quality standards.
Next is chemical oxygen demand (COD), which is the process of oxidizing organic compounds in wastewater with a chemical solution (dichromatic acid) into carbon dioxide and water. The COD testing process is very fast, which is about 3 hours with a turnaround time of about 95% of the total process [26]. The COD quality standard value in domestic wastewater is 100 mg/L. The test results show that at point 1 it is 17.38 mg/L, at point 2 it is 13.95 mg/L, and at point 3 it is 12.31 mg/L. At the three points, the results show that the results are far below the COD quality standard in domestic wastewater so that the COD test at all points meets the domestic wastewater quality standard. The graphic image of the comparison of COD test results to the maximum limit of domestic wastewater quality standards can be seen in figure 4.d.

Ammonia (NH₃) is the amount of dissolved ammonia gas in domestic wastewater. Ammonia concentration (NH₃) > 0.5 mg/L is already toxic to fish [26], however for sensitive fish 0.2 mg/L is already toxic [4]. This test is not included in the discussion of water quality standards because the maximum limit is only for Water I (drinking water quality) which is 0.5 mg/L. The standard value for ammonia (NH₃) in domestic wastewater is 10 mg/L. The test results showed that the value of ammonia (NH₃) at point 1 was 4.25 mg/L, at point 2 was 4.07 mg/L, and at point 3 was 6.13 mg/L. The test results at the three points show that the ammonia (NH₃) levels still meet the quality standards of domestic wastewater. The graphic image of the comparison of ammonia (NH₃) test results against domestic wastewater quality standards can be seen in figure 4e.

The following parameter is oil and fat. Oils and fats are included in the criteria for organic chemistry, which are usually obtained from kitchen waste [27] [28]. The standard value for the quality of oil and fat in domestic wastewater is 5 mg/L. The results of the oil and fat test at the three points obtained the same value, namely 1.6 mg/L. The three points meet the quality standards for oils and fats in domestic wastewater. The comparison graph between the results of the oil and fat test against the domestic wastewater quality standard can be seen in figure 4f.

Total coliform is the number of E Coli bacteria (Escherichia coli) in every 100 mL. E Coli usually forms blue colonies when incubated at 37 °C for 24 hours [26]. The total coliform quality standard in domestic wastewater is 3,000/100 mL. The test results at point 1 obtained the number ≥ 2,400/100 mL, at point 2 an amount of ≥ 2,400/100 mL, and at point 3 an amount of 1.100/100 mL. The three points meet the total coliform quality standard in domestic wastewater. The graph of the comparison of total coliform test results with quality standards in domestic wastewater can be seen in figure 4g.

3.1.2. Water quality standards by class. In the discussion of water quality standards based on class, they are divided into 4 classes. The water quality standard for class 1 is called Water I, the quality standard for class 2 water is called Water II, the quality standard for class 3 water is called Water III, and the water quality standard for class 4 water is called Water IV. In addition, to make it easier to see the test results, each point meets the water quality standard for what class; it is presented in tabular form, namely table 4, while the test results in graphical form can be seen in figure 5.

Physical parameters in the discussion of water quality standards are added by measuring temperature. Temperature measurement is an important parameter in checking environmental conditions. Most bacteria grow well at a temperature of 15-40 °C [26]. Less or more than that temperature is very difficult for bacteria to grow. The temperature limit or quality standard in Water I-III is a deviation of 3 °C (plus minus the normal temperature of the river), and at Water IV, it is a deviation of 5 °C. Where the normal temperature of the river is 25 °C [29], then the temperature quality standard at Water I-III is 22-28 °C, and at Water IV is 20-30 °C. Based on the test results in the field, the temperature at point 1 is 20.8 °C, point 2 is 20.1 °C, and point 3 is 20 °C. Based on these three points, the three points meet the Water IV quality standard only, as shown in table 4.
Information:
Point 1: River water test results at point 1
Point 2: River water test results at point 2
Point 3: River water test results at point 3

Water I: Class I water quality standard (drinking water)
Water II: Class II water quality standard (recreation)
Water III: Class III water quality standard (fishery)
Water IV: Class IV water quality standards (agriculture)

**Figure 5.** Comparison of river water test results with maximum levels of water quality standards based on class.
There are 5 parameters for testing water quality standards, which are the same as those for testing domestic wastewater quality standards, namely TSS, pH, biological oxygen demand (BOD₅), chemical oxygen demand (COD), and total coliform. Based on table 4, it can be seen that the TSS value and pH value meet the Water I-IV quality standards. In the results of the biological oxygen demand (BOD₅) test, each point meets a different quality standard, namely at point 1, it meets the Water IV quality standard, at point 2, it meets the Water III & IV quality standard, and at point 3 it meets the Water II-IV quality standard. The test results used are the largest BOD₅ values, so in general, the BOD₅ test results only meet the Water IV quality standard. The results of the chemical oxygen demand (COD) test at the three points meet the Water II-IV quality standards. The following parameter is total coliform, which is a parameter that is often used to determine river water quality [30]. The total coliform test results show that at all three points, it meets the Water II-IV quality standard.

Parameters for testing the added water from domestic wastewater testing are phosphate (PO₄³⁻) and chromium. Phosphate (PO₄³⁻) needs to be reduced or even removed to reduce the potential for eutrophication in waters [31]. Based on table 4, the results of the phosphate test can be seen that at point 1 and point 2 meet the Water IV quality standard, while at point 3 it meets the Water III & IV quality standard. Overall it can be said that the Phosphate (PO₄³⁻) meets the Water IV quality standard. Chromium is a heavy metal that is very detrimental to health and has a negative effect on the surrounding environment [32]. Based on table 4, the results of the chromium test at point 2 and point 3 meet the Water I-IV quality standards, while at point 1 meet the Water IV quality standards. In general, the chromium test results meet the Water IV quality standard.

3.2. Assessment of Cangkring river water condition

The results of the Cangkring River water testing; the domestic wastewater quality, and water quality standards, are displayed in table 5. Among the 10 parameters tested, 7 parameters which are TSS, pH, BOD₅, COD, ammonia (NH₃), oil and fat, and total coliform meet domestic wastewater quality standards according to the Regulation of the Minister of Environment and Forestry No. 68 of 2016 [3] and 8 parameters, namely temperature, TSS, pH, BOD₅, COD, phosphate (PO₄³⁻), chromium, and total coliform meet the water quality standards for each class according to the Government Regulation of the Republic of Indonesia No. 82 of 2001 [4]. In table 5, the column meets the quality standard, which is the fulfillment for all points. This is because to conclude the overall river water, the test results are taken as a whole. While the stripe (-) can be interpreted that the parameter is not tested for compliance with domestic wastewater quality standards or water quality standards. Meanwhile, in the water quality sub-column, the quality standards are divided into 4 classes called Water I, II, III, and IV. In the description column, show that from the three points, there are different results. It can be concluded that the Cangkring River water meets the domestic waste quality standard and meets the class 4 water quality standard (Water IV).

Based on the studies and discussions that have been carried out, it can be stated that the domestic wastewater flowing from the oil and gas industry office area in the Pad B Mudi Field meets the class 4 water quality standard. Based on this, it can be concluded that the condition of the Cangkring River water is safe for the community. Based on the Government Regulation of the Republic of Indonesia No. 82 of 2001, the class 4 water quality standard indicates that the Cangkring River water can be used for plant irrigation but is not suitable for drinking water, recreational facilities, and aquaculture [4]. Another interesting thing to note apart from the assessment of the water condition of the Cangkring River, is the fact that untreated domestic wastewater can already meet the water quality standard of class 4 (Water IV). Therefore, it is necessary to conduct further research to test the quality of domestic wastewater at the inlet and outlet at Pad B Mudi Field to determine the quality of domestic wastewater at Pad B Mudi. Complementary to this research, it is necessary to conduct research on year-round water monitoring and research on the effects on plants watered by the Cangkring River.
Table 4. Comparison of sample test results at three points against class-based water quality standards according to Government Regulation of the Republic of Indonesia No. 82 of 2001 [4].

| Parameter          | Unit | Point 1 | Point 2 | Point 3 | Graphic Picture |
|--------------------|------|---------|---------|---------|-----------------|
|                    |      | Result  | Meet Quality Standards | Result | Meet Quality Standards | Result | Meet Quality Standards |
| Temperature        | °C   | 20.8    | - Water IV (20-30)      | 20.1   | - Water IV (20-30)      | 20.0   | - Water IV (20-30)      |
| TSS                | mg/L | 13      | - Water I & II (50)     | 13     | - Water I & II (50)     | 13     | - Water III & IV (400)  |
| pH                 |      | 7.80    | - Water I, II, III (6-9) | 7.76   | - Water I, II, III (6-9) | 7.61   | - Water I, II, III (6-9) |
| BOD₅               | mg/L | 6.53    | - Water IV (12)         | 4.60   | - Water III (6)         | 1.70   | - Water IV (12)         |
| COD                | mg/L | 17.38   | - Water II (25)         | 13.95  | - Water III (50)        | 12.31  | - Water IV (100)        |
| Phosphate (PO₄³⁻)  | mg/L | 1.15    | - Water IV (5)          | 1.06   | - Water IV (5)          | 0.99   | - Water III (1)         |
| Chromium           | mg/L | 0.0100  | - Water I, II, III (0.05) | 0.0036 | - Water I, II, III (0.05) | 0.0036 | - Water IV (0.01)       |
| Total Coliform     | quantity/100 mL | ≥ 2,400 | - Water II (5,000)     | ≥ 2,400 | - Water II (5,000)     | 1,100  | - Water III & IV (10,000) |

Figure 5.a. Figure 5.b. Figure 5.c. Figure 5.d. Figure 5.e. Figure 5.f. Figure 5.g. Figure 5.h.
Table 5. Resume of the results of the Cangkring River water test on domestic wastewater quality standards and water quality standards.

| Parameter       | Meet the Quality Standards | Description                                      |
|-----------------|----------------------------|---------------------------------------------------|
| Temperature     | -                          | Water IV                                         |
| TSS             | Meet                       | Water I – IV                                     |
| pH              | Meet                       | Water I – IV                                     |
| BOD₅            | Meet                       | Water IV                                         |
|                 | -                          | At point 1 meets Water IV                         |
|                 | -                          | At point 2 meets Water III-IV                     |
|                 | -                          | At point 3 meets Water I-IV                       |
| COD             | Meet                       | Water II-IV                                      |
| Ammonia (NH₃)  | Meet                       | -                                                |
| Phosphate (PO₄³⁻) | -                          | Water IV                                         |
|                 | -                          | At point 1 & 2 meet Water IV                      |
|                 | -                          | At point 3 meets Water III & IV                   |
| Chromium        | -                          | Water I-IV                                       |
| Oil and fat     | Meet                       | -                                                |
| Total Coliform  | Meet                       | Water II-IV                                      |

4. Conclusion
Based on the results and discussion of the Cangkring River water testing, which is fed with domestic wastewater from the oil and gas industry office area in Pad B Mudi Field, it can be concluded that the water in the Cangkring River meets all domestic wastewater quality standards under the Regulation of the Minister of the Environment and Forestry No. 68 of 2016. Parameters for testing the quality of domestic wastewater include TSS, pH, BOD₅, COD, ammonia (NH₃), oil and fat, and total coliform. As for water quality standards, the Cangkring River water meets all class 4 water quality standards under Government Regulation of the Republic of Indonesia No. 82 of 2001. Parameters for testing water quality standards include temperature, TSS, pH, BOD₅, COD, phosphate (PO₄³⁻), chromium, and total coliform. The conclusion from the study of the Cangkring River water is that the Cangkring River water meets the class 4 water quality standard which is intended for plant irrigation, but does not meet the water quality standard for drinking water, water recreation infrastructure, and aquaculture.

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