Water quality analysis of pucang river, sidoarjo regency to control water pollution

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RESEARCH ARTICLE

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Water quality analysis of pucang river, sidoarjo regency to control water pollution

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Abstract

This study aimed to analyze water quality and control water pollution in the Pucang River in Sidoarjo Regency. The method was used to identify water quality of the 11 parameters and compared them the Government Regulation number 22 of 2021 about water quality standards in Indonesia. Secondary data from 2018 to 2020 were used in this study. Determination of water quality status using the pollution indices method attached in Decree of the State Minister of the Environment number 115 of 2003. Analysis of water pollution control strategies using strengths, weaknesses, opportunities, and threats approach. The condition of the water quality of the Pucang River in 2018–2020, based on the water pollution parameter test, experienced a decrease in the rate indicated by the presence of parameters that exceeded the quality standard. Determination of the quality status of water quality in 2018–2020, there was an increase in water quality marked by the rise in the pollution indices value where the water quality was moderately polluted heavily polluted. The conclusion is that the water quality of the Pucang River in 2018–2020 has decreased from the moderately polluted category to the heavily polluted, and the condition of river water cannot be used for its designation.

KEYWORDS
environmental management, water pollution control, water quality

1 | INTRODUCTION

Rivers are surface water flows that flow from upstream to downstream and are used for irrigation, drinking water sources, agriculture, and other activities. Natural factors and human factors strongly influence river water quality. Natural factors can affect river conditions, such as high rainfall intensity resulting in a decrease in water quality and pollution originating from human activities, including waste disposal from industry, agriculture, and domestic (Li & Wu, 2019). River water that comes out of springs is usually of excellent quality, but the water will receive various kinds of pollutants (Brkić et al., 2019). Industry around the Pucang River Basin, Sidoarjo Regency can cause a decrease in river water quality because the rest of the production activities generated will most likely be discharged into the river.

The Pucang River is included in Class II water whose designation can be used for infrastructure or facilities for water recreation activities, freshwater fish cultivation, water husbandry to irrigate crops, and other uses requiring the same water quality as these uses. The Sidoarjo Regency Environmental Service (2018–2020) report shows that the water quality of the Pucang River is moderately polluted to heavily

EXHIBIT 1 Determination of the Pucang river sampling point, Sidoarjo Regency

Sampling Point	Location	Coordinate point	Description
POS 1	DAM Desa Karya Jimbaran Wetan, Kecamatan Wonoayu	07026′31.5 and 112037′48.6	upstream
POS 2	DAM Sumput Kecamatan Sidoarjo	07026′16.3 and 112040′57.0	residential activity
POS 3	Jembatan Lingkar Timur Kecamatan Bluru Kabupaten Sidoarjo	07026′48.6 and 112043′50.3	industrial activity
POS 4	Jembatan Desa Wonokasian Kecamatan Wonoayu	07025′55.5 and 112039′22.8	residential activity
POS 5	Jembatan Perumahan Desa Urangagung Kecamatan Sidoarjo	07026′06.0 and 112040′31.8	residential activity
POS 6	Jembatan Pucang Jl. A Yani Kecamatan Sidoarjo	07026′37.0 and 112043′10.3	trading activity
POS 7	Jembatan Desa Bluru Kidul Kecamatan Sidoarjo	07026′48.6 and 112043′50.3	downstream

EXHIBIT 2 Location of water sampling in Pucang river. (a) 6.6 km; (b) 3.4 km; (c) 4.3 km; (d) 7 km; (e) 2 km; (f) 3.4 km [Color figure can be viewed at wileyonlinelibrary.com]

polluted, Pucang River water status is an inferior category. Pollution of river water and water quality is caused by industrial waste, household waste, and agricultural waste. In addition to pollutants, changes in weather and land use also affect the quality of river water and the status of pollution quality. Monitoring of water quality and level of polluted water quality is a consideration in controlling the pollution of the Pucang River based on the Decree of the State Minister of the Environment number 115 of 2003 concerning Guidelines for Water Quality Status.

In several previous studies, an analysis of river water quality was carried out by determining the parameters of temperature, pH, TSS, DO, BOD, COD, N_2, N_3, NH_3, Fe, discharge, fecal coliform, *Escherichia coli*, and total coliform. Besides that, the analysis of river quality using several methods such as Pollution Indices (PI), storet, street, phelp, purposive sampling, and QUAL2Kw to determine the level of pollution load (water quality status) in the river. The weakness of previous research is that the analysis only measures 7–10 river water quality parameters. This study analyzed river water quality and efforts to control water pollution by measuring 11 parameters: temperature, pH, TDS, TSS, DO, COD, BOD, NO_2, NO_3, oil and grease and total coliform. The measurement results are then compared with Class II quality standards based on Government Regulation number 22 of 2021 concerning Water Quality Management and Water Pollution Control. Therefore, this study aimed to determine the water quality and control of water pollution in the Pucang River in Sidoarjo Regency.

2 | MATERIALS AND METHODS

This research is an observational study with a quantitative analysis approach. Secondary data from 2018 to 2020 were used in this study. The research sample is data water quality of Pucang River, Sidoarjo

Regency. The data area sampling is determined on a river along ± 26 km by considering the sources of pollutants that enter the Pucang River flow so that seven sampling locations are obtained (Exhibit 1) and (Exhibit 2).

This study analyzes primary data in the form of Pucang River water quality based on measurements of 11 parameters, including temperature, pH, TDS, TSS, DO, BOD, COD, NO_2, NO_3, oil and grease, total coliform for the last 3 years (2018–2020) and comparisons were made with the Class II quality standard by Government Regulation Number 22 of 2021 concerning Water Quality Management and Water Pollution Control. Water pollution quality indices for the last 3 years is calculated and adjusted according to the Decree of the State Minister of the Environment number 115 of 2003. A strategy for controlling Pucang River water pollution can be formulated using a SWOT analysis approach.

2.1 | Water pollution quality indices

River water quality was assessed by laboratory testing of 11 parameters using the Indonesian National Standard method there are temperature (SNI 6989.57:2008); pH (SNI 6989.57:2008); TDS (SNI 06-6989.27:2004); TSS (SNI 06-6989.3-2004); DO (SNI 6989.57:2008); BOD (2.14/IK-4.1/2008); COD (SNI 6989.2-2009); NO2 (SNI 06-6989.9:2004); NO_3 (SNI 06-6989.1:2004); Oil and Grease (SNI 06-6989.10:2004); and total coliform (MPN Method). The test results of these parameters are then compared with the water quality standards according to the Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Water Quality Management and Water Pollution Control.

The water pollution quality indices of the Pucang River are calculated using the pollution indices method, the measured parameter values in the river are compared with the water quality standard for the designation, namely the aquatic environmental quality standard following Government Regulation of the Republic of Indonesia Number 82 of 2001 concerning Water Quality Management and Water Pollution Control. Calculation of the pollution indices using the formula:

$$IP_j = \sqrt{\frac{\left(\frac{Ci}{Lij}\right)M + \left(\frac{Ci}{Lij}\right)}{2}}$$

Description:

L_{ij} = Concentration of water quality parameters listed in the water designation quality standard (j)

C_i = Concentration of survey water quality parameters

IPj = Pollution Indices for allotment (j)

$(C_i/L_{ij})_M$ = Maximum C_i/L_{ij} value

$(C_i/L_{ij})R$ = Average C_i/L_{ij} valueThe results of the calculation of the pollution indices are then analyzed for the level of pollution to determine the status of water quality and the Decree of the Minister of the Environment Number 115 of 2003 concerning Guidelines for Determining the Status of Water Quality. Evaluation of the water pollution indices value is shown in Exhibit 3.

EXHIBIT 3 the relationship between pollution index values with water quality

Pollution Index Values	Water Quality
0–1.0	Good condition
1.1–5.0	Slightly polluted
5.0–10.0	Moderately polluted
>10.0	Heavily polluted

Source: Decree of the Minister of Environment No. 115 Year 2003.

2.2 | Analysis of water pollution control strategies

The strategy for controlling pollution of the Pucang River waters is analyzed by evaluating the existing pollution control policies by conducting internal and external analysis through SWOT analysis. The strategy resulting from the SWOT analysis can be grouped into 4 (four) categories (Nazarko et al., 2017):

a. Strategy 1 (SO) is the most profitable situation because it has opportunities and strengths (support an aggressive strategy).
b. Strategy 2 (ST) has strength but faces an unfavorable threat (support a diversification strategy).
c. Strategy 3 (WO) means that the system has opportunities but is hampered by internal weaknesses (support a turn-around oriented strategy).
d. Strategy 4 (WT) means that the system faces the most unfavorable situation, with internal threats and weaknesses (support a defensive strategy).

From the grouping of the SWOT analysis, WO is a solution (problem-solving) because it is necessary to reduce weaknesses to take advantage of current opportunities, while WT is to reduce weaknesses to prevent and overcome threats carried out in the form of suggestions and recommendations for the future in the long term.

3 | RESULTS AND DISCUSSION

The results of Pucang River water quality analysis in 2018–2021 compared with Class II water quality criteria as contained in the attachment of Government Regulation Number 22 of 2021, concerning Water Quality Management and Water Pollution Control, are presented in Exhibits 4–14.

3.1 | Temperature

Compared with Class II water quality standards based on Government Regulation Number 22 of 2021, which is a deviation 3 from the natural state, the condition of river water quality in terms of temperature parameters is still within the water quality standard limits according to its designation. Increasing the temperature of the water (Exhibit 4)

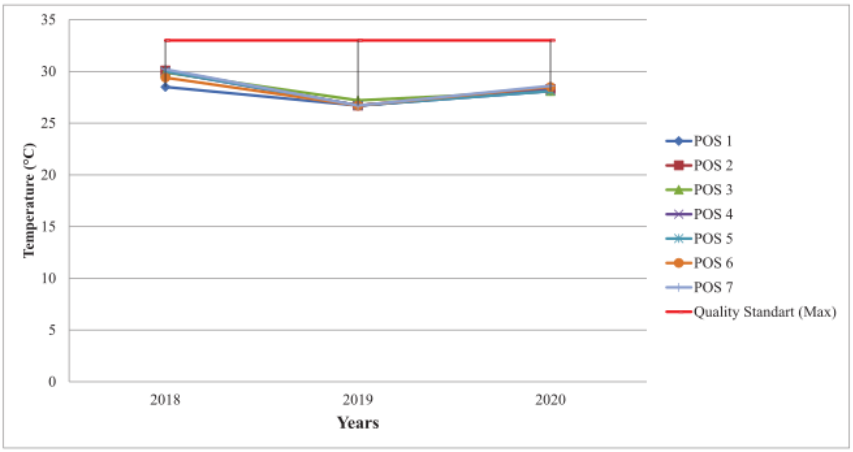

EXHIBIT 4 Parameter test results for 2018–2020 of temperature [Color figure can be viewed at wileyonlinelibrary.com]

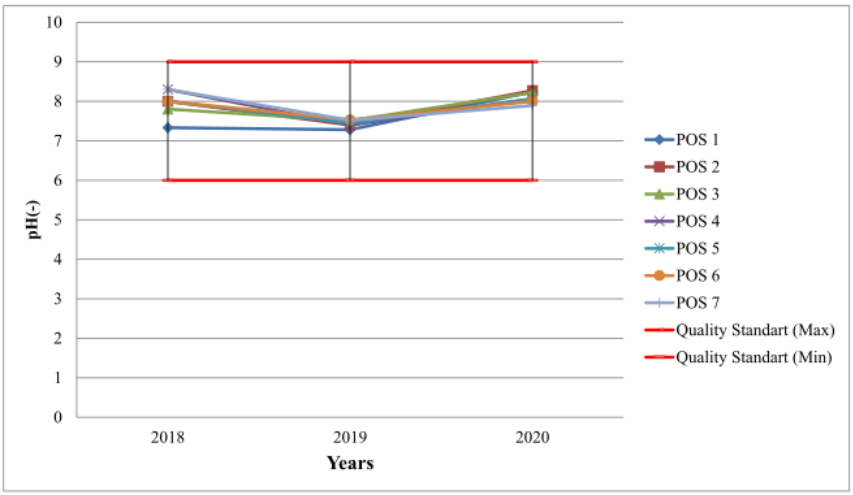

EXHIBIT 5 Parameter test results for 2018–2020 of pH [Color figure can be viewed at wileyonlinelibrary.com]

19ses an increase in viscosity, chemical reactions, evaporation, and volatilization. In addition, it also causes a decrease in the solubility of gases in water and an increase in the rate of metabolism and respiration of aquatic organisms (Ingram et al., 2017). Wastes from industrial activities, agriculture, settlements are directly discharged into the Pucang River, supply of liquid waste with high temperatures will endanger the life of aquatic organisms in the Pucang River. The measurement temperature parameter shows the number reaches 25–28°C, so the wastewater temperature does not have much effect on river water (Dermendzhieva et al., 2018). Temperature parameter is still within the water quality standard threshold based on Government Regulation number 82 of 2001 concerning Water Quality Management and Water Pollution Control. The optimum temperature range for phytoplankton growth in the waters is 20–30°C (Suwoyo et al., 2020). Temperature of the river water is still able to support the growth of phytoplankton.

3.2 | pH (acidity)

Condition of Pucang River water quality, when viewed from the pH acidity parameter, is still within the water quality standard limit according to its designation. Based on the measurement results in Exhibit 5, the pH parameter of liquid waste originating from industrial, residential, agricultural activities shows the number reaches 8.3. The pH of the liquid waste at seven sample locations, the pH parameter indicates a number below nine, this shows that based on the degree of acidity, the waste is classified as alkaline. The pH value of the liquid waste

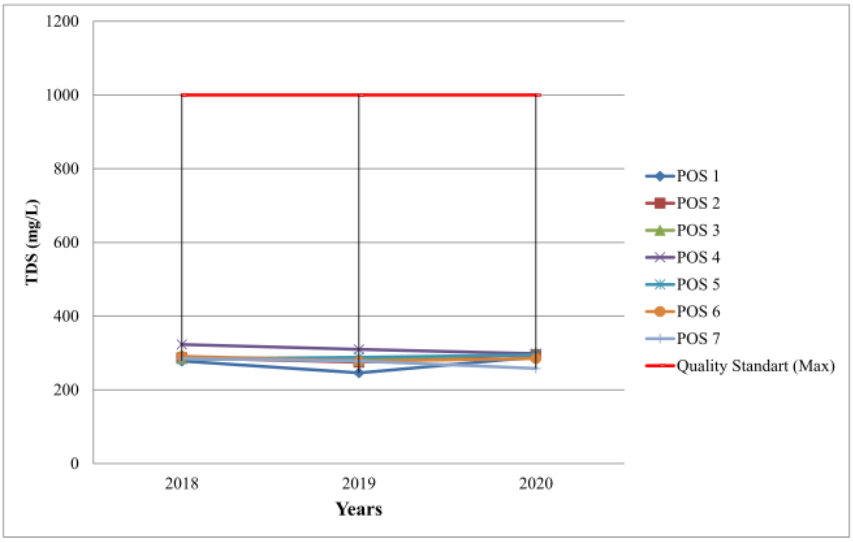

EXHIBIT 6 Parameter test results for 2018–2020 of TDS (Total Dissolved Solid) [Color figure can be viewed at wileyonlinelibrary.com]

that enters the waters of the Pucang River ranges from 7.28 to 8.24. Wastewater from industrial activities, settlements, agriculture, etc. discharged into the seas can potentially change the pH of the water and disrupt the life of aquatic organisms that are sensitive to changes in pH. Water with a pH of 6.7–8.6 supports fish populations because their growth and reproduction are not disturbed (Martin & Currie, 2020). Most aquatic biotas are sensitive to changes in pH and prefer a pH value of around 7–8.5 (Wang et al., 2016).

3.3 | TDS (total dissolved solids)

The TDS parameter at the disposal of liquid waste to the seven sampling locations showed several values that did not meet the quality standards. The TDS value for 2018–2020 on the discharge of liquid waste that enters the waters of the Pucang River ranges from a value of 4.6 to 285 mg/L. In the Class II quality standard, the TDS parameter is 1000 mg/L, and in 2018–2020 it decreased, see Exhibit 6. Suppose the high TDS value in water can be caused by the remnants of inorganic materials and molecules caused by wastewater, such as detergents, water-soluble surfactants, and soap molecules (Sulistiawati et al., 2020). Water with high TDS levels causes scale in household appliances, and the water tastes terrible like metal (Sharma & Bhattacharya, 2017).

3.4 | TSS (total suspended solid)

Compared to Class II water quality standards based on Government Regulation Number 22 of 2021, namely the 50 mg/L quality standard, the condition of Pucang River water quality when viewed from the TSS parameters in 2018 and 2019 is still within the water quality standard limits according to their designation. In 2020, the TSS parameter at POS 7 exceeded the water quality standard limit, not following its designation. The TSS parameter at the disposal of liquid waste to the seven sampling locations showed several values that did not meet the quality standards (Exhibit 7). The TSS value for 2018–2020 in the discharge of liquid waste that enters the waters of the Pucang River ranges from a value of 3.9 to 139 mg/L. In the Class II quality standard, the TSS parameter is 50 mg/L, in 2018–2020, there is an increase. The total value of suspended solids in the waters is divided into 4 categories, namely TSS value < 25 mg/L, meaning no effect, TSS value 25–80 mg/L means little effect, TSS value 81–400 mg/L means not good, and TSS value > 400 mg/L means not good (Rusydi, 2018).

The increase in TSS parameters comes from solids that cause water turbidity, are not dissolved, and cannot settle, consisting of mud and micro-organisms originating from soil erosion or erosion, generally consisting of phytoplankton, zooplankton, animal waste, plant remains, animal remains, human waste, and industrial waste carried into the water. The impact of TSS on water quality can lead to a decrease in water quality. This condition can cause a disturbance, damage, and danger to humans if used as drinking water, which will impact health (Sen, 2013). Suspended solids in the form of particles carried by the water flow will affect the amount of TSS content inside (Glaser et al., 2020). The impact of TSS on water quality can lead to a decrease in water quality (Revitt et al., 2017). This condition can cause a disturbance, damage, and danger to humans if used as drinking water, which will impact health (Izah et al., 2016).

3.5 | DO (dissolved oxygen)

Condition of Pucang River water quality, when viewed from DO parameters in 2018, is still within the water quality standard limits, while in

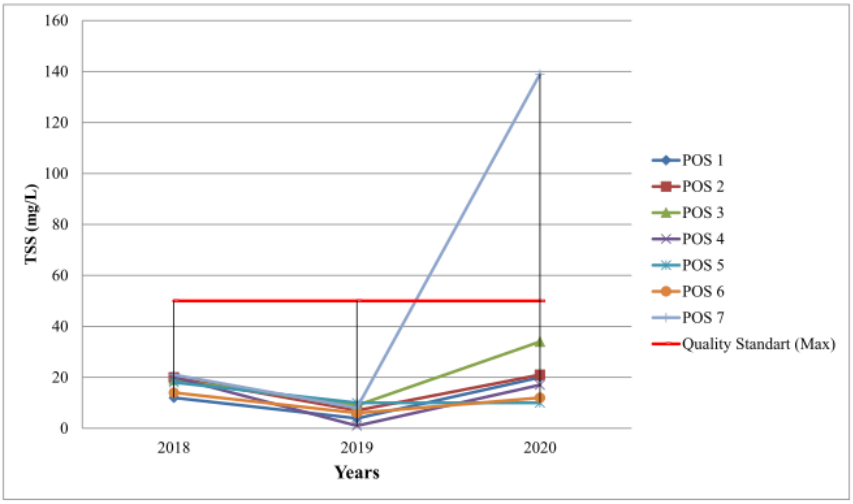

EXHIBIT 7 Parameter test results for 2018–2020 of TSS (Total Suspended Solid) [Color figure can be viewed at wileyonlinelibrary.com]

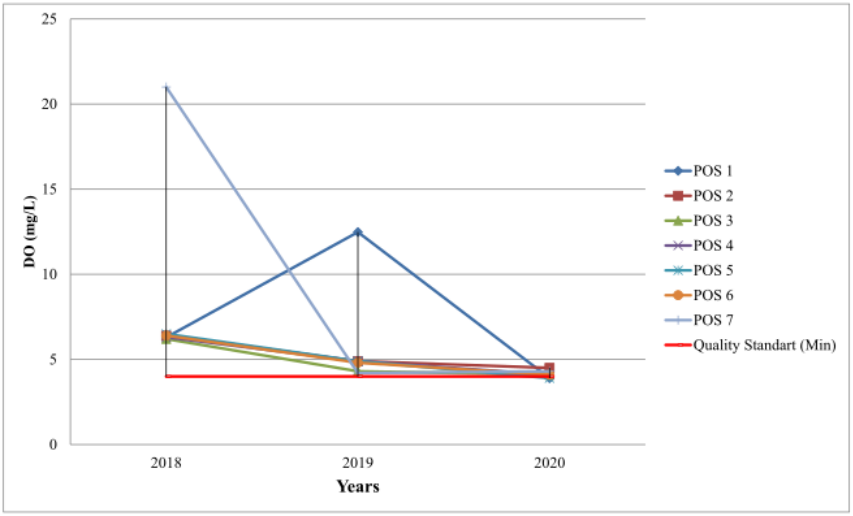

EXHIBIT 8 Parameter test results for 2018–2020 of DO (Dissolved Oxygen) [Color figure can be viewed at wileyonlinelibrary.com]

2018–2020 is above the quality standard according to its designation. The DO parameter at liquid waste disposal to the seven sampling locations showed several values that did not meet the quality standards, see Exhibit 8. The DO value for 2018–2020 on the discharge of liquid waste that enters the waters of the Pucang River ranges from a value of 3.9–21.7 mg/L. In the Class II quality standard, the DO parameter is 4 mg/L, in 2018–2020 it significantly increased. Liquid wastewater that affects DO parameters, among others, from industrial activities, settlements, agriculture, etc., which is discharged into waters can potentially change DO parameters in water and disrupt the life of aquatic organisms (Edokpayi, 2017). The minimum dissolved oxygen concentration for biota life should not be less than 6 ppm (Shirokova & Al-Nussairi, 2020). River water with a DO parameter value of 4.7–6.5 can still be used for recreational facilities, freshwater fish cultivation, animal husbandry, and agriculture (Naubi et al., 2016).

3.6 | COD (chemical oxygen demand)

COD parameters at the disposal of liquid waste to the seven sampling locations showed several values that did not meet the quality standards. The COD value for 2018–2020 in the discharge of liquid waste that enters the waters of the Pucang River ranges from a value of 8.53 to 74.83 mg/L. In the Class II quality standard, the COD parameter

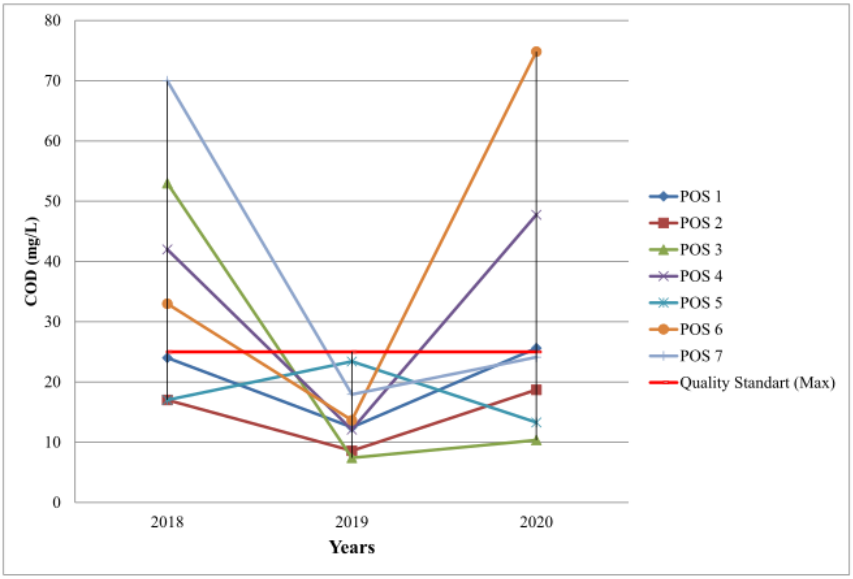

EXHIBIT 9 Parameter test results for 2018–2020 of COD (Chemical Oxygen Demand) [Color figure can be viewed at wileyonlinelibrary.com]

is 25 mg/L, in 2018–2020 it increased (Exhibit 9). A high concentration of COD indicates the greater level of pollution that occurs in the waters (Koda et al., 2017). COD values in unpolluted waters are usually less than 25 mg/L (Khan et al., 2016) and indicate the activity of microorganisms in degrading organic compounds. The interests of fishery cultivation and agriculture do not desire condition. Based on the measurement results, high COD values at sampling points 4, 6, and 7 (>20 mg/L) indicated polluted waters. Waters with high COD values are undesirable for agriculture and fisheries (Anyanwu & Umeham, 2020).

3.7 | BOD (biochemical oxygen demand)

Compared with the results of monitoring the water quality of the Pucang River, the condition of water quality in 2018–2020 has exceeded the water quality standard according to its designation. The BOD parameter at the disposal of liquid waste to the seven sampling locations showed several values that did not meet the quality standards (Exhibit 10). The BOD value for 2018–2020 on the discharge of liquid waste that enters the waters of the Pucang River ranges from a value of 2.3 to 21.7 mg/L. The greater the concentration of BOD indicates that the water has been polluted, the concentration of BOD based on the Class II quality standard has a low level of pollution and can be categorized as good waters having BOD levels ranging from 0 to 3 mg/L. In comparison, waters that have a BOD concentration of more than 3 mg/L are considered contaminated. Liquid wastewater that affects BOD parameters, among others, from industrial activities, settlements, agriculture, etc., which is discharged into waters can potentially change BOD parameters in water and interfere with the life of aquatic organisms. The biochemical oxygen level (BOD) is classified as high and does not belong to the category of good waters (BOD levels 1–10 ppm) (Gupta & Dey, 2013).

3.8 | NO_2 (Nitrite)

NO_2 parameter at the disposal of liquid waste to the seven sampling locations showed several values that did not meet the quality standards. The value of NO_2 in 2018–2020 in the discharge of liquid waste that enters the waters of the Pucang River ranges from a value of 0.004 to 2.3088 mg/L. In the Class II quality standard, the NO_2 parameter is 0.06 mg/L, in 2018–2020 it decreased, see Exhibit 11. Water's nitrite content is relatively small and more petite than nitrate because it immediately oxidizes nitrate (Schullehner et al., 2017). Sources of nitrite come from industrial waste and domestic waste. Natural waters contain about 0.001 mg/L of nitrite and should not exceed 0.06 mg/L. Based on the distribution of nitrate concentration in the Pucang River, it ranged from 0.004 to 2.3088 mg/L, indicating that the river water was not in its natural condition compared to the water quality criteria for Class II of 0.06 mg/L. The water quality of the Pucang River for the Nitrite parameter does not meet the requirements.

3.9 | NO_3 (Nitrate)

The largest nitrate (NO_3) parameter in 2018 was at POS 2 of 2.89 mg/L; in 2019, the largest was POS 1 of 2.46 mg/L; in 2020, POS 5 of 19.6 mg/L. In 2018–2020 the NO_3 parameter that exceeds the quality standard was in 2020. According to the requirements of Class II water quality standards based on Government Regulation Number 22 of 2021, the value of the nitrate parameter is 10 mg/L. So, compared

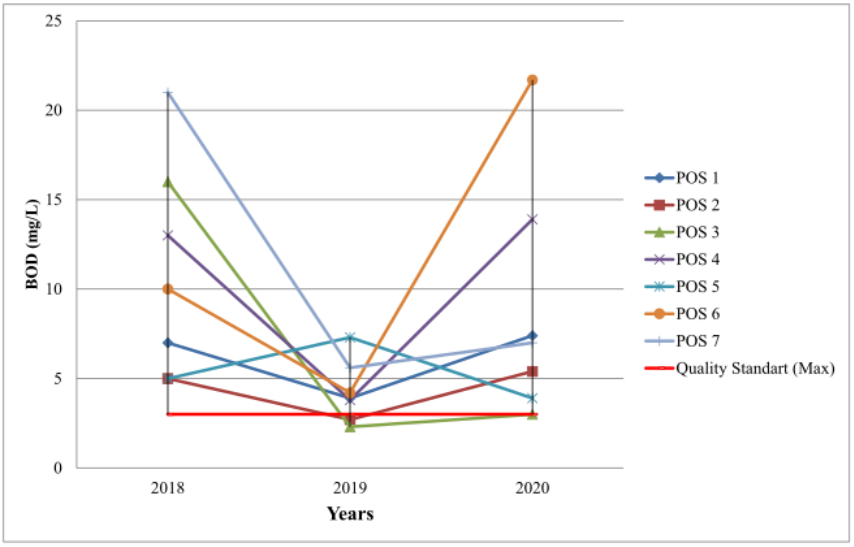

EXHIBIT 10 Parameter test results for 2018–2020 of BOD (Biochemical Oxygen Demand) [Color figure can be viewed at wileyonlinelibrary.com]

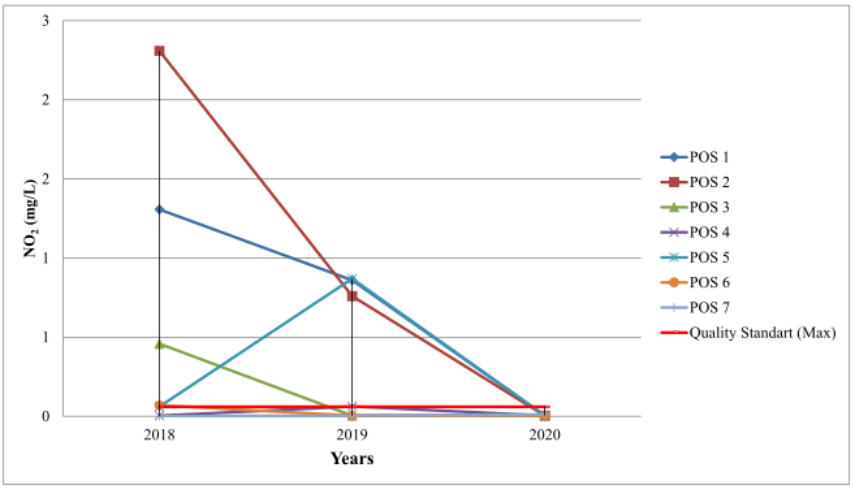

EXHIBIT 11 Parameter test results for 2018–2020 of NO_2 (Nitrite) [Color figure can be viewed at wileyonlinelibrary.com]

to Pucang River water quality in 2018 and 2019, it is still within the water quality standard limits according to its designation. In 2020 it exceeded the water quality standard limits according to its designation (Exhibit 12).

The NO_3 parameter at the disposal of liquid waste to the seven sampling locations showed several values that did not meet the quality standards. The value of NO_3 in 2018–2020 in the discharge of liquid waste that enters the waters of the Pucang River ranges from a value of 0.15 to 19.6 mg/L. In the Class II quality standard, the NO_3 parameter is 10 mg/L, in 2018–2020 it increased. It was stated that the impact of agricultural activities would result in runoff, nitrate, and phosphate sediments. Nitrate-nitrogen levels in natural waters are rarely more than 0.1 mg/L (Schullehner et al., 2017). Suppose the value of the nitrate content is compared with the Class II river water quality criteria in accordance with Government Regulation Number 22 of 2021. In that case, the nitrate content in Pucang River water cannot be used according to its designation.

3.10 | Oil and grease

Analysis of oil and grease in Pucang River water shows the amount of oil and grease in 2018 from monitoring points 1–7, the results are the same at 300 pg/L, in 2019 the most significant monitoring point 4

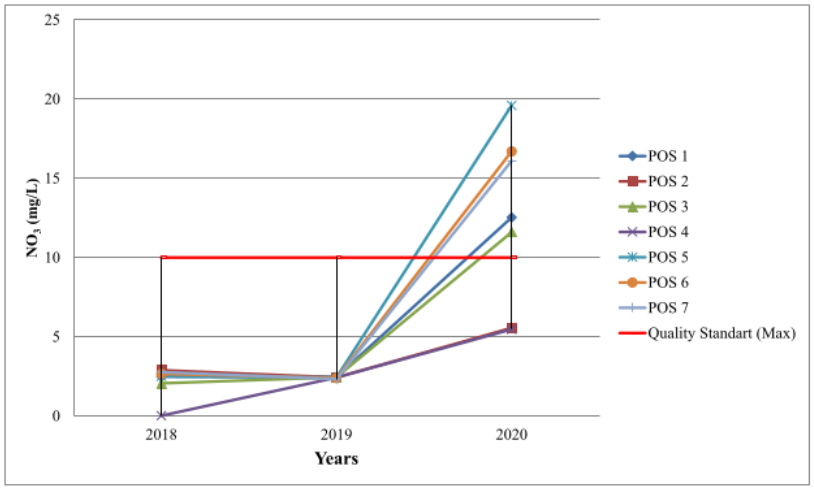

EXHIBIT 12 Parameter test results for 2018–2020 of NO_3 (Nitrate) [Color figure can be viewed at wileyonlinelibrary.com]

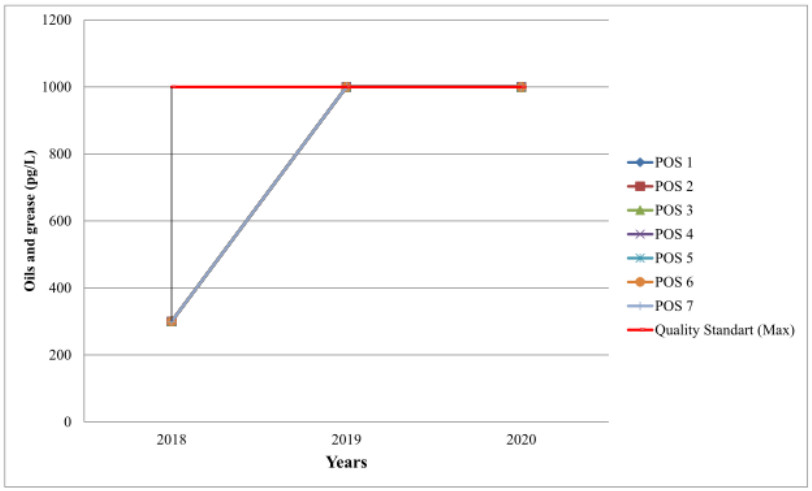

EXHIBIT 13 Parameter test results for 2018–2020 of oils and grease [Color figure can be viewed at wileyonlinelibrary.com]

was 0.951 pg/L, in 2020 from post monitoring points 1–7 the result is the same at 100 pg/L. When viewed from 2018–2020, the oil and grease parameters do not exceed the quality standard limit, which in the Class II river water quality criteria is 1000 pg/L (Exhibit 13), so that the Pucang River water can still be used for recreational facilities, freshwater fish cultivation, animal husbandry, and agriculture.

Parameters of oil and grease in liquid waste disposal to seven sampling locations showed several values that did not meet the quality standards. The value of oil and grease in 2018–2020 in the discharge of liquid waste that enters the waters of the Pucang River ranges from a value of 0.054–1000 pg/L. In the Class II quality standard, the oil and grease parameters are 1000 pg/L, in 2018–2020 there is an increase. Oils and grease are organic materials that are permanent and difficult to break down by bacteria (Usman et al., 2020). This waste makes an attachment to the water's surface to form a film with an oil content of 5800 mg/L. The specific gravity is smaller than water, so the oil is in the form of a thin layer on the water's surface and covers the surface, which results in limited oxygen entering the water. This oil forms sludge and settles in others, which is difficult to decompose (Usman et al., 2020).

3.11 | Total coliform

Coliform bacteria are one indicator of the presence of domestic waste contaminants in the waters. Analysis of total Coliform bacteria in Pucang River water showed that the most extensive total coliform in 2018 was POS 2 of 281 MPN/100 ml, in 2019 from POS 1–7 the results were the same at 0.014 MPN/100 ml, in 2020, the largest was POS 5 and 7 of 920 MPN/100 ml (Exhibit 14). The group of coliform bacteria is one indicator of domestic waste contaminants in the waters

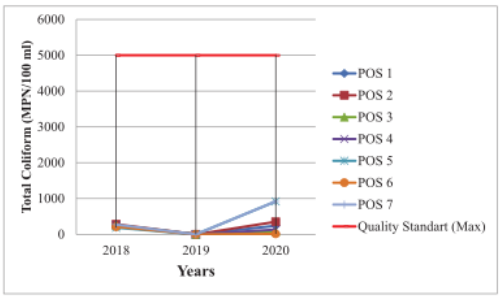

EXHIBIT 14 Parameter test results for 2018–2020 of total coliform [Color figure can be viewed at wileyonlinelibrary.com]

(Aram et al., 2021). Coliform bacteria can transmit several diseases through water, especially stomach diseases such as typhoid, cholera, and dysentery. Total coliform is a group of bacteria used as an indicator of dirt pollution and unfavorable conditions for water (Cabral, 2010). Pathogenic microorganisms that enter from various sources such as settlements, agriculture, and livestock easily pollute the aquatic environment. Bacteria commonly used as indicators of contamination of a water body are bacteria classified as total coliforms and usually live in human and animal feces (Wen et al., 2020).

3.12 | Water pollution quality status (pollution indices)

Calculation of the level of pollution can be done by using the pollution indices method as in the Decree of the Minister of State for the Environment Number 115 of 2003 concerning guidelines for determining the status of water quality. The results of calculating the water quality status of the Pucang River in 2018–2020 using the Pollution indices method are presented in Exhibit 15.

Overall, the water quality status results using the pollution indices method show that the water quality of the Pucang River from upstream to downstream has decreased in water quality status, which is indicated by the increasing value of the pollution indices. The status of water quality in 2018 shows "lightly polluted-moderately polluted," in 2019 it shows "moderately polluted-heavily polluted," while in 2020, it shows " moderately polluted-heavily polluted.

Overall, the water quality status results using the pollution indices method show that the water quality of the Pucang River from upstream to downstream has decreased in water quality status, which is indicated by the increasing value of the pollution indices. The status of water quality in 2018 shows "lightly polluted-moderately polluted," in 2019 it shows "medium-severe pollution," while in 2020, it shows "medium-highly polluted.

Pollution indices are used to determine the level of pollution relative to allowable water quality parameters (Kamboj & Kamboj, 2019). This indices relates to significant pollutant compounds for a designation and can be developed for several uses for all parts of a water body or part of a river. In this study, the calculation of the pollution indices is based on the sampling point and the parameters determined, namely temperature, pH, TDS, TSS, DO, BOD, COD, NO_2, NO_3, oil, and grease, total coliform. The water quality standard used is based on Government Regulation Number 22 of 2021 concerning Water Quality Management and Water Pollution Control.

3.13 | Water pollution control strategy

Water pollution control strategy is formulated based on the results of water quality analysis, pollution load levels, literature studies, and in-depth interviews with authorized agencies to obtain information about efforts to control river water pollution so that internal and external factors can be identified in controlling river water pollution. A control strategy is formulated based on analyzing each of the SWOT

EXHIBIT 15 Results of calculation of Pucang river water quality status in 2018–2020 (Pollution Indices)

Sampling Point	Pollution Indices (Year)		
	2018	2019	2020
POS 1	4.24 (Slightly polluted)	8.88 (Moderately polluted)	4.84 (Slightly polluted)
POS 2	6.09 (Moderately polluted)	9.96 (Moderately polluted)	4.13 (Slightly polluted)
POS 3	3.71 (Slightly polluted)	10.10 (Heavily polluted)	7.24 (Moderately polluted)
POS 4	5.73 (Moderately polluted)	9.25 (Moderately polluted)	5.71 (Moderately polluted)
POS 5	5.29 (Slightly polluted)	10.11 Heavily polluted)	9.16 (Moderately polluted)
POS 6	4.40 (Slightly polluted)	9.99 (Moderately polluted)	10.07 (Heavily polluted)
POS 7	3.77 (Slightly polluted)	10.11 (Heavily polluted)	2.30 (Slightly polluted)

EXHIBIT 16 Water Pollution Control Strategies

Strengths	1. The existence of a water pollution control policy concerning Government Regulation Number 22 of 2021 is supported by the role of the community in knowing the elements and methods of wastewater treatment. 2. The establishment of quality standards for river water pollution refers to Government Regulation Number 22 of 2021. 3. There is a stipulation of requirements for the disposal of wastewater to surface water sources.
Weakness	1. The water quality does not meet the water Class II criteria. 2. In the upstream to downstream areas, several parameters exceed the Class II quality standard. 3. The status of river's water quality is moderate to heavily polluted. 4. Supervision in monitoring river water is not yet periodic.
Opportunities	1. River water can be used for drinking water, agricultural waters, and daily needs. 2. There is an industry that has a role in having a liquid waste treatment plant (WWTP). 3. The existence of the industry already has environmental documents
Threats	1. There is an industry that disposes of waste that does not meet quality standards. 2. At locations around the Pucang River, there are still people who throw garbage in the river.

analysis indicators (Strength, Weakness, Opportunity, Threats) faced to control water pollution in the Pucang River. The process of determining water pollution control strategies using a SWOT analysis that can be applied can be seen in Exhibit 16.

Water pollution control is an effort to prevent and control water pollution and restore water quality to ensure that water is following water quality standards or its designation and can be helpful in a sustainable manner. Likewise, the policy of controlling pollution of the Pucang River waters in Sidoarjo Regency is expected to prevent water pollution so that the quality of Pucang River water can be maintained and valuable according to its designation.

SWOT analysis indicators are used to identify strengths, weaknesses, opportunities, and threats faced to control pollution of the Pucang River waters. The current pollution control policies are not able to prevent pollution and water quality degradation. Weak internal factors and the many threats from external factors make policies not appropriately implemented. Therefore, it is necessary to prioritize new approaches to prevent water pollution and decrease water quality. The system is expected to change river water to be applied according to its designation and be sustainable. Some of these policies include:

a. Improve inventory and identification of water pollutant sources
b. Improving Waste Management
c. Setting Pollution Load Capacity
d. Increasing Community Knowledge and Participation in Waste Management
e. Growing supervision for Wastewater Disposal
f. Improving river water quality monitoring

4 | CONCLUSION

The condition of the water quality of the Pucang River, Sidoarjo Regency in 2018–2020 for the concentration of pH, TSS, DO, COD, BOD, NO_3, oil and grease, and total coliform at all monitoring points from upstream to downstream have exceeded the Class II water quality criteria based on Regulation Government Number 22 of 2021. The quality status of Pucang River water pollution in 2018–2020 has decreased in quality. In 2018 the rate with the status of mild to moderate polluted conditions, in 2019, the quality with the status of middle to heavily polluted conditions, then in 2020, the quality with the status of the light, moderate, and heavily polluted conditions. The quality standard in Government Regulation number 22 of 2021 for Class II, Pucang River can still be used in its designation. Based on the SWOT analysis results, the recommendation strategy for controlling water pollution in the Pucang River, Sidoarjo Regency, is a progressive strategy with aggressive water pollution control efforts. Therefore, it is necessary to regularly monitor the quality of water in the Pucang River, which aims to compare the condition of the Pucang River from time to time.

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DATA AVAILABILITY STATEMENT

The data supporting this study findings are available from the corresponding author upon reasonable request.

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