# Civil and Environmental Engineering for Resilient, Smart and Sustainable Solutions

Edited by
Tahar Ayadat

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# Civil and Environmental Engineering for Resilient, Smart and Sustainable Solutions

1st International Conference on Civil and Environmental Engineering for Resilient, Smart and Sustainable Solutions,
Civil Engineering Department - College of Engineering, Prince Mohammad Bin Fahd University
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*Editor*
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# Preface

On behalf of the conference committee, I would like to thank all the contributors and participants in the 1st International Conference on Civil and Environmental Engineering for Resilient, Smart and Sustainable Solutions (CEES2024) which had been held at Prince Mohammad Bin Fahd University (PMU) Khobar, Kingdom of Saudi Arabia on 3-5 November, 2024. I was honored to serve as Chairman of this important event. Firstly, I would like to thank the organizing committee for their unrelenting efforts to organize this congress. In the world community, we were all aware of how important research has been in contributing to the body of knowledge and the development of prospects. The conference aims to exchange scientific information and knowledge in the development of recent and future infrastructures that are resilient, smart, and sustainable. The conference provides an excellent environment for government policy makers, practicing professional engineers, researchers, university professors, students, and general public to extend their interests and expertise in addressing and solving the infrastructure issues faced by societies. The success of CEES2024 reflects a collective commitment to advancing civil and environmental engineering practices. As participants departed Al-Khobar, they carried with them not just new knowledge but also a renewed sense of purpose in shaping a sustainable future. Finally, I thank the keynote speakers, presenters and authors for their contributions.

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# Preliminary study of water quality in the Jragung river

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**Keywords:** Pollution Index, Pollution Load Capacity, Water Quality, Jragung River

**Abstract.** The concentration of pollutants in the Jragung River differs in the dry season and the rainy season. The purpose of this study was to analyze the effect of the dry season on the water quality of the Jragung River in the Upper Zone. The method used was grab sample with reference to SNI 698957:2008. Meanwhile, water quality data analysis was carried out using quantitative data analysis. Testing was carried out at the Environmental Engineering Laboratory of Trisakti University. The concentration of pollutants in the Jragung River differs in the dry season and the rainy season. The purpose of this study was to analyze the water quality of the Jragung River in the Upper Zone. The method used was grab sample with reference to SNI 698957:2008. Meanwhile, water quality data analysis was carried out using quantitative data analysis. Testing was carried out at the Environmental Engineering Laboratory of Trisakti University. The results showed that the concentration of detergent in the Jragung River at station 1 was 0.07 mg/L and 0.1 mg/L at station 2, both below the quality standard of 0.2 mg/L set by Government Regulation Number 82 of 2001. The Pollution Index (IP) of 7.77 indicates moderate pollution. The pH of the water ranges from 8.4 to 8.7, still suitable for aquatic life. However, several parameters, including COD, DO, Phenol, Phosphate, Oil and Fat, Sulfide, Lead, Total Coliform, and Fecal Coli, exceed the river water quality standard limits so that the use of water from the Jragung River requires a treatment process to meet the class 1 raw water quality standard.

## 1. Introduction

Climate variability is the change in temperature, rainfall patterns, and precipitation that impacts the social and natural environment [1,2]. Various human activities have caused the average temperature on the earth's surface to increase over the last century [3]. The increase in surface temperature causes increased evaporation from the oceans and land which causes changes in the global average rainfall [4]. Population growth and anthropogenic activities greatly affect water resources as well as water needs which affect the quality of water resources [5]. In the IPCC scenario, the global average air temperature increases between 1.8 and 4.0 °C, causing a tendency for drought in summer, especially in subtropical, low and middle latitudes, and an increase in extreme events in general, conditions that directly affect water quality. dilution or concentration of solutes [6]. Increased temperature in water resources increases the concentration of solutes in water and causes a decrease in dissolved oxygen concentration [7,8]. Extreme rainfall events result in changes in hydrological conditions including runoff and transport of solid materials. Drought events that cause waterlogging can affect water quality because they increase decomposition and release of organic matter into runoff and increased solar radiation can also change water quality [9,10].

In Indonesia, water quality is affected by climate change through fluctuations in temperature and rainfall. Research shows that maximum temperatures increase significantly in the pre-monsoon season every year and a significant increase is seen in August [11, 17]. Current water resource conditions indicate that climate change poses a greater danger than previously thought, namely affecting the water cycle and having serious impacts on life and sustainable development [12]. Increasing water pollution reflects future trends and predicts potential variations in water quality amidst the ongoing threat of climate change. This shows that high local temperatures and frequent/intensive rainfall against climate change will increase the discharge of suspended solids and the addition of nutrients to water bodies [13].

The quality of water sources needs to be maintained from pollutants that can interfere with living things. In each of its uses, water has its own quality standards for each different activity or according to its intended use. The use of water must pay attention to quality standards because water quality will affect human health [14]. Water that has poor quality will contain pollutants, which can be bacteria, viruses and/or parasites [15]. The classification of water quality is determined by: into four classes, namely Class 1, water that can be used as raw drinking water, and other uses that require the same water quality as its use; Class 2: water that is used for water tourism infrastructure and facilities, freshwater fish farming, etc. and livestock, plant irrigation, and/or other uses that require the same water quality as its use; Class 3: water that can be used for freshwater fish farming, livestock, water for plant irrigation, and/or other uses that require the same water quality as its use; requires the same water quality as its use and Class 4: water that can be used to irrigate plants, and/or other uses that require the same water quality as its use [16]. To determine the level of pollution of a body of water, it is necessary to conduct a study of the level of pollution of the water. river flow, you can use water quality checks in terms of chemistry, physics and biology. River quality monitoring must be carried out within a certain period of time. By calculating the Pollution Index (IP) (Decree of the Minister of State for the Environment No. 15 of 2003) the level of pollution relative to water quality standards can be known.
This study discusses the condition of surface water quality in the Jragung River, which will be used for raw water needs, irrigation and hydropower

## 2. Method

### 2.1 Sampling Procedures

The methodology of sampling water quality in this activity is based on the procedure of the Indonesian National Standard (SNI) 6989.57:2008 about Water and Wastewater section 57: Surface Water Sampling Method. The location of river water sample collection is determined based on the following river water discharge:

a. River with discharge of less than 5 $m^3$/second, samples are taken at one point in the middle of the river at a depth of 0.5 times the depth of the surface or taken with an integrated sampler so that samples of water from the surface to the bottom evenly mixed.
b. River with a discharge between 5 $m^3$/second – 150 $m^3$/second, samples are taken at two points each a distance of 1/3 and 2/3 of the width of the river at a depth of 0.5 times the depth of the surface or taken with an integrated sampler so that samples of water from the surface to the bottom are evenly mixed and then mixed.
c. Rivers with a discharge of more that 150 $m^3$/second, samples are taken at a minimum of six points at a distance of ¼, ½, and ¾ of the width of the river at a depth of 0.2 and 0.8 times the

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depth of the surface or taken with an integrated sampler so that samples of the water from the surface to the bottom are evenly mixed.

Sampling time can be done in dry season and wet season with the regulations, mentioned in SNI 6989.57:2008 about The Surface Water Sampling Method [18]. The sample parameters used refer to Government Regulation of the Republic of Indonesia No. 22 Year 2021 [19], about the Implementation of Environmental Protection and Management for Raw Water Needs (Table 1).

*Table 1. Classification of surface water area functions based on Government Regulation of the Republic of Indonesia No. 22 Year 2021*

| Classification standard value items | Unit | Class I | Class II | Class III | Class IV |
|---|---|---|---|---|---|
| **PHYSICAL ANALYSIS** | | | | | |
| Total Dissolved Solid (TDS) | mg/L | 1000 | 1000 | 1000 | 1000 |
| Total Suspended Solid (TSS) | mg/L | 40 | 50 | 100 | 400 |
| Temperature | ºC | 6-9 | 6-9 | 6-9 | 6-9 |
| **CHEMICAL ANALYSIS** | | | | | |
| Ammonia (NH3-N) | mg/L | 0.1 | 0.2 | 0.5 | - |
| Iron (Fe) | mg/L | 0.3 | - | - | - |
| COD | mg/L | 10 | 25 | 40 | 80 |
| Detergent (MBAS) | mg/L | 0.2 | 0.2 | 0.2 | - |
| DO | mg/L | 6 | 4 | 3 | 1 |
| Phenol | mg/L | 0.002 | 0.005 | 0.01 | 0.02 |
| Phosphate (PO4) | mg/L | 0.2 | 0.2 | 1.0 | - |
| Cadmium (Cd) | mg/L | 0.01 | 0.01 | .0.01 | 0.01 |
| Chloride (CL-) | mg/L | 300 | 300 | 300 | 600 |
| Chromium Val. 6 (Cr6+) | mg/L | 0.05 | 0.05 | 0.05 | 1 |
| Manganese (Mn) | mg/L | 0.1 | - | - | - |
| Oil and Grease | mg/L | 1 | 1 | 1 | 10 |
| Nitrate as N (NO3-N) | mg/L | 10 | 10 | 20 | 20 |
| Nitrite as N (NO2-N) | mg/L | 0.06 | 0.06 | 0.06 | - |
| pH | - | 6-9 | 6-9 | 6-9 | 6-9 |
| Zinc (Zn) | mg/L | 0.05 | 0.05 | 0.05 | 2 |
| Sulfate (SO4) | mg/L | 300 | 300 | 300 | 400 |
| Sulfide | mg/L | 0.002 | 0.002 | 0.002 | - |
| Copper (Cu) | mg/L | 0.02 | 0.02 | 0.02 | 0.2 |
| Lead (Pb) | mg/L | 0.03 | 0.03 | 0.03 | 0.5 |
| **MICROBIOLOGICAL ANALYSIS** | | | | | |
| Total Coliform | MPN/ 100 ml | 1000 | 5000 | 10000 | 10000 |
| Total Fecal Coli | MPN/ 100 ml | 100 | 1000 | 2000 | 2000 |

## 2.2 Pollution Index (PI)

Pollution Index is used to determine the level of pollution relative to the parameters of water quality allowed [20]. The Pollution Index (PI) is designated for an allotment, then it can be developed for some designation for all parts of a body water or part of a river. The Pollution Index includes a wide range of independent and meaningful quality parameter groups.

The water quality index is important for resolving multi-parameter water analysis into single digit scores. One of the methods to determine the water quality index is river water pollution indices method (Pij) according to Law of Ministry of Environmental No. 115 year 2003.

Water pollution index is utilized to evaluate water body quality and compare it with the river quality standard. Water quality can be decreasing caused by contaminant substances in the water body. In order to monitor the amount of contaminant substances, water pollution index can be applied.

Each Ci/Lij value indicates the relative contamination caused by the air quality parameter. This ratio has no units. The Ci/Lij value = 1.0 is a critical value because this value is expected to be met for a water quality standard. If Ci/Lij > 1.0 for a parameter, then the concentration of this parameter must be reduced or set aside if the water body is used for the designation (j). If this parameter is a meaningful parameter for the designation, then absolute treatment must be carried out for that air. In the IP model, various air quality parameters are used, so in its use, the average value of all Ci/Lij values is needed as a measure of pollution, but this value will not be meaningful if one of the Ci/Lij values is greater than 1. So this index must include the maximum Ci/Lij value.

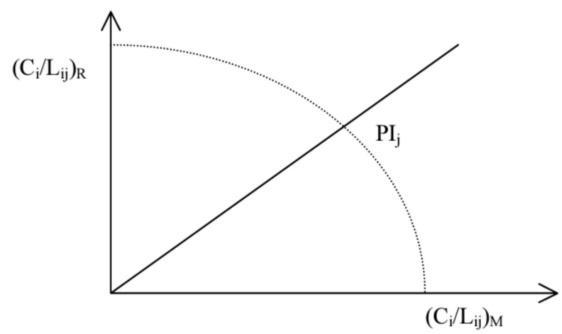


*Figure 1. Index Statement for a Designation (j) [20]*

If (Ci/Lij)R is the coordinate and (Ci/Lij)M is the abscissa, then PIj is the intersection point of (Ci/Lij)R and (Ci/Lij)M in the plane bounded by the two axes. The waters will be increasingly polluted for a designation (j) if the value of (Ci/Lij)R and or (Ci/Lij)M is greater than 1.0. If the maximum value of Ci/Lij and/or the average value of Ci/Lij are greater, then the level of pollution in an air body will also be greater. So the length of the line from the origin to the point Pij is proposed as a meaningful factor to express the level of pollution.

If Lij states the concentration of water quality parameters listed in the Quality Standards for a Water Allocation (j) and Ci states the concentration of water quality parameters (i) obtained from the results of water sample analysis at a sample collection location from a river channel, then PIj is the Pollution Index for the allocation (j), which is a function of Ci/Lij. The value of Pij can be determined by:

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

Where:

| | |
|---|---|
| PIj | : pollution index |
| Lij | : Concentration of water quality standard j, for parameter i |
| Cij | : Concentration of parameter i |
| (Ci/Lij)R | : value, Ci/Lij average |
| (Ci/Lij)M | : value, Ci/Lij maximum |

*Table 2. Standard of surface water quality classification (The Ministry of Environment No. 115 of 2003)*

| **Pollution Index (PI)** | **Water quality level** |
|---|---|
| $0 \leq PI \leq 1.0$ | Meet water quality standards |
| $1.0 \leq PI \leq 5.0$ | Lightly polluted |
| $5.0 \leq PI \leq 10.0$ | Moderately polluted |
| $PI > 10$ | Heavily polluted |

## 3. Case Study

### 3.1 Study Area

This research was carried out in the Jragung Watershed, which is one of the largest rivers in Demak Regency, Central Java Province, located in the middle part of the Jragung Watershed. The Jragung River is a river that has the function of controlling floods, meeting irrigation water needs, raw water supplies, and so on. The Jragung River is located + 20 km east of Semarang City, Karangawen District, Demak Regency, Central Java Province, with an area of 135.22 km. Meanwhile, the main river in the Jragung watershed is Kali Jragung, which has a river length of 72.44 km.

Geographical Location The Jragung watershed is located in the northern part of Central Java which crosses 4 (four) districts, namely Demak district (65,145.98 ha), Semarang (25,932.55 ha), Grobogan (25,654.64 ha) and Semarang City (1,304.48 ha). And the coordinate position of the study is between 7°09'26.0"S -110°31'01.0"E and 7°11'21.3"S 110°29'49.3"E. The location map showing the Jragung Watershed and monitoring sites (sections) is described in Figure 2.

*Figure 2. Study area*

The Jragung watershed has a morphological structure consisting of low hills with high folding and fault intensity in the west which gradually weakens to the east. The geological formation mainly consists of mudstone, marl and sandstone with a thickness of more than 2000 meters. This plain has a slope of 0º-2º at an elevation of 50 meters, composed of carbonate sandstone and marl. This area, including Borangan and Kedungklapa, is used for settlements and plantations. These hills are oriented west-east with a slope of 30º-60º at an elevation of 97-160 meters, consisting of carbonaceous sandstone and marl, and influenced by folds and faults. This area is used for settlements, plantations and rice fields.

Based on the results of field observations, the geological survey area is divided into 4 rock units, sorted from oldest to youngest, namely the interbedded carbonate sandstone unit and the Banyak Napal, Kalibeng marl unit. Based on comparisons with regional stratigraphy, the relationship between the two units is menjari. The naming of these rock units is based on megascopic observations, namely based on their characteristics or physical characteristics such as rock structure, rock texture and composition. The geological structures that develop, namely folds and faults, the process of forming these geological structures are the result of plate tectonics at work.

*Figure 3. Conditions of the study location*

*Tabel 3. Jragung water quality testing result*

| Classification standard value items | Unit | Upstream | Middle stream | Class I |
|---|---|---|---|---|
| **PHYSICAL ANALYSIS** | | | | |
| Total Dissolved Solid (TDS) | mg/L | 293 | 293 | 1000 |
| Total Suspended Solid (TSS) | mg/L | 13 | 13 | 40 |
| Temperature | ºC | 34 | 32 | 6-9 |
| **CHEMICAL ANALYSIS** | | | | |
| Ammonia (NH3-N) | mg/L | 0.07 | 0.07 | 0.1 |
| Iron (Fe) | mg/L | 0.16 | 0.16 | 0.3 |
| COD | mg/L | 12.7 | 12.7 | 10 |
| Detergent (MBAS) | mg/L | 0.07 | 0.07 | 0.2 |
| DO | mg/L | 6.6 | 6.6 | 6 |
| Phenol | mg/L | 0.1 | 0.1 | 0.002 |
| Phosphate (PO4) | mg/L | 0.34 | 0.34 | 0.2 |
| Cadmium (Cd) | mg/L | 0.008 | 0.008 | 0.01 |
| Chloride (CL-) | mg/L | 41 | 41 | 300 |
| Chromium Val. 6 (Cr6+) | mg/L | 0.03 | 0.03 | 0.05 |
| Manganese (Mn) | mg/L | 0.04 | 0.04 | 0.1 |
| Oil and Grease | mg/L | 1.03 | 1.03 | 1 |
| Nitrate as N (NO3-N) | mg/L | 1 | 1 | 10 |
| Nitrite as N (NO2-N) | mg/L | 0.04 | 0.04 | 0.06 |
| pH | - | 8.7 | 8.4 | 6-9 |
| Zinc (Zn) | mg/L | 0.005 | 0.03 | 0.05 |
| Sulfate (SO4) | mg/L | 33.5 | 33.5 | 300 |
| Sulfide | mg/L | 0.04 | 0.04 | 0.002 |
| Copper (Cu) | mg/L | 0.01 | 0.01 | 0.02 |
| Lead (Pb) | mg/L | 0.083 | 0.083 | 0.03 |
| **MICROBIOLOGICAL ANALYSIS** | | | | |
| Total Coliform | MPN/ 100 ml | 9200 | 9200 | 1000 |
| Total Fecal Coli | MPN/ 100 ml | 9200 | 9200 | 100 |

Based on the results of the raw water quality, it reveals that the parameters like COD, DO, Phenol, Phosphate (PO4), Oil and Grease, Sulfide, Plumb (Pb), Total Coliform and Total Fecal Coli are exceeding the permissible limit of the applicable national regulation Class-I.

Uncontrolled, unplanned, rapid and extensive growth of urbanisation and industrial activities generate large amounts of solid and liquid waste. Disposal of untreated solid waste, stormwater

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and agricultural waste along with municipal and industrial wastewater, into the river is the main cause of physical, chemicals and microbial contamination of river water. Sources of these wastes include industrial production, sewage, domestic waste, municipal waste, shopping markets, restaurants, agricultural waste, etc. In most developing countries, about half of total human waste is discharged into the rivers and other water bodies without proper treatment.

### 3.2 Water Quality

The calculation of the surface water pollution index in this study used data from laboratory results, where the samples used were 2 sampling points. Laboratory data can be seen in Table 3, and then the average was carried out on the lab data to produce the Ci value. Li in this analysis is the value of the quality standard for each parameter so that the concentration value for each parameter is calculated as Ci/Li.

The pollution index is obtained from the average value of the number of tested parameter concentrations and the maximum value from the division of the concentration value by the quality standard, so that the calculation can be seen in the table below (table 4).

*Table 4. Pollution Index Result*

| Classification standard value items | Ci | Lix | Ci/Lix | (Ci/Lix)New | (Ci/Lix)M | (Ci/Lix)R | Pij | Result |
|---|---|---|---|---|---|---|---|---|
| **PHYSICAL ANALYSIS** | | | | | | | | |
| Total Dissolved Solid (TDS) | 293 | 1000 | 0.29 | 0.29 | | | | |
| Total Suspended Solid (TSS) | 13 | 40 | 0.33 | 0.325 | | | | |
| Temperature | 34 | 24-30 | -2.33 | -2.33 | | | | |
| **CHEMICAL ANALYSIS** | | | | | | | | |
| Ammonia (NH3-N) | 0.07 | 0.1 | 0.7 | 0.7 | | | | |
| Iron (Fe) | 0.16 | 0.3 | 0.53 | 0.53 | | | | |
| COD | 12.7 | 10 | 1.27 | 1.52 | | | | |
| Detergent (MBAS) | 0.07 | 0.2 | 0.35 | 0.35 | | | | |
| DO | 6.6 | 6 | 1.10 | 1.21 | | | | |
| Phenol | 0.1 | 0.002 | 50 | 9.49 | | | | |
| Phosphate (PO4) | 0.34 | 0.2 | 1.7 | 2.15 | | | | |
| Cadmium (Cd) | 0.008 | 0.01 | 0.8 | 0.8 | | | | |
| Chloride (CL-) | 41 | 300 | 0.14 | 0.137 | 10.819 | 1.88 | 7.77 | Moderately polluted |
| Chromium Val. 6 (Cr6+) | 0.03 | 0.05 | 0.6 | 0.6 | | | | |
| Manganese (Mn) | 0.04 | 0.1 | 0.4 | 0.4 | | | | |
| Oil and Grease | 1.03 | 1 | 1.03 | 1.064 | | | | |
| Nitrate as N (NO3-N) | 1 | 10 | 0.1 | 0.1 | | | | |
| Nitrite as N (NO2-N) | 0.04 | 0.06 | 0.60 | 0.660 | | | | |
| pH | 8.7 | 6.0-9.0 | -0.80 | -0.80 | | | | |
| Zinc (Zn) | 0.005 | 0.05 | 0.1 | 0.1 | | | | |
| Sulfate (SO4) | 33.5 | 300 | 0.112 | 0.112 | | | | |
| Sulfide | 0.04 | 0.002 | 20 | 7.505 | | | | |
| Copper (Cu) | 0.01 | 0.02 | 0.5 | 0.5 | | | | |
| Lead (Pb) | 0.083 | 0.03 | 2.767 | 3.210 | | | | |
| **MICROBIOLOGICAL ANALYSIS** | | | | | | | | |
| Total Coliform | 9200 | 1000 | 9.20 | 5.819 | | | | |
| Total Fecal Coli | 9200 | 100 | 92 | 10.819 | | | | |

Based on the analysis results presented in Table 4 above, the water quality level with a value of 5.0 - 10.0 is included in the waters that are experiencing moderate pollution. The IP value in this study is 7.77. Therefore, it can be said that the waters of the Jragung River are experiencing moderate pollution based on the Pollution Index value.

### 3.3 Detergent Analysis-MBAS

Detergent analysis is used to determine the detergent content in the waters; this is because the Jragung River is used by local residents to support their activities. Based on the laboratory results, the detergent parameters for both points are 0.07 mg/L located in the upstream and 0.1 mg/L in the middle of the river. The concentration in the middle of the river is greater because it is right near the drainage channel, which contains some plastic waste. The results of the study showed that the concentration of detergent in the upstream part of the Jragung River, according to Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control, the detergent quality standard in the waters is 200 ug/L, or equivalent to 0.2 mg/L. It can be said that the detergent content value in the Jragung River waters is still very low.Evaluation of Water Quality with Trends Considered

## Conclusions

The concentration of detergent in the Jragung River Waters at station 1 is 0.07 mg/L, and at station 2 it is 0.1 mg/L. Based on Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control, the detergent quality standard in waters is 200 ug/L or equivalent to 0.2 mg/L, so it can be said that the detergent content value in the Jragung River waters is still very low. The Pollution Index (IP) value in the Jragung River Waters ranges from 7.77, which is included in moderate pollution.

Water quality based on water parameters such as pH, which ranges from 8.4 to 8.7, is still in the good range for aquatic biota. The parameters that have values exceeding the quality standard limits for raw water in rivers include COD, DO, Phenol, Phosphate, Oil and Grease, Sulfide, Lead, Total Coliform, and Total Fecal Coli.

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# Keyword Index