Freshwater Quality Analysis Based on RRA and Thailand River Protocol in Wonorejo River, Surabaya and Dlundung River, Mojokerto, East Java

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Abstract. Freshwater rivers are one of Indonesia's most important water courses, traversing diverse landscapes from mountainous to coastal areas, and playing vital role in providing clean drinking water sources, and maintaining rich and diverse biodiversity across aquatic ecosystems. However, nowadays these rivers are increasingly threatened by various factors, such as increasing pollution, massive deforestation, and climate change, which have significant impacts on environmental sustainability and health. In this context, biomonitoring can be an effective tool to evaluate the health of aquatic ecosystems by utilizing the presence of living organisms in these waters as biological indicators. The method used in this study is to evaluate through scoring invertebrates found in freshwaters rivers. The evaluator determines the relevant parameters, classifies the categories of environmental conditions, defines the area to be evaluated, and assiggns a score to each parameter analyzed with the result being a Water Quality Index (WQI). This scoring result obtained from Dlundung showed score of 79, where 12 diverse animal types were found and resulted WQI of 6.5, which moderately clean category. Whereas, the Wonorejo showed score only 11 and 3 type of animals were found, and had WQI of 3.67, indicating the water in the river was classified as dirty.

1 Introduction

Rivers have an important role as the main water resource that supports various human needs, ranging from drinking water supply, irrigation, to ecosystem functions. Indonesia, with more than 5,590 rivers spread throughout the region, has great potential in freshwater utilization. However, at present, many rivers in Indonesia are experiencing serious pollution. Data from the Ministry of Environment and Forestry (KLHK) shows that around 75% of rivers in Indonesia are polluted by domestic, industrial and agricultural waste. The condition of the

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decline in river water quality has a direct impact on the provision of clean water for daily needs, including drinking water [1]. Polluted river water contains hazardous materials, such as nitrates, phosphates, heavy metals, and pathogenic microorganisms, which can result in various health problems, including diarrheal diseases, cholera, and heavy metal poisoning. This problem has intensified the demand for safe drinking water, especially in rural and urban areas with minimal water treatment infrastructure. Therefore, systematic measures are needed to identify and resolve river pollution, one of which is through water quality monitoring [2].

Monitoring river water quality is the process of observing and measuring physical, chemical, and biological parameters to assess the level of pollution and its impact on the environment and public health. This monitoring aims to obtain water quality and pollutant sources, which form the basis for decision making in water resources management [3]. Some monitoring methods that are often used are Rapid River Assessment (RRA) and Thailand Protocol. RRA is a method used to assess the condition of river ecosystems quickly and effectively. Important aspects in the RRA protocol are water temperature, water pH, dissolved oxygen levels, visible water morphology such as odor, color, number of fungal and algal species, and dominance of benthic macroinvertebrate species [4]. Meanwhile, the Thailand Protocol is a protocol designed to assess river water quality as a whole, including measurements of water quality parameters such as dissolved oxygen levels, temperature, the number of animal species found so that it will produce water quality by scoring [5]. Monitoring from upstream to downstream is important to get a complete picture of the distribution of pollution, as human activities along the river course affect water quality in different ways [6].

The main objective of river water quality monitoring is to support sustainable water resources monitoring and ensure the availability of clean and safe water for the public. In addition, this monitoring is to provide data-based policy recommendations to stakeholders, restore damaged aquatic ecosystems, and increase public awareness about the importance of keeping rivers clean. With an integrated approach, it is expected that mitigation efforts will be carried out effectively, so that rivers in Indonesia remain a sustainable source of life. For this reason, in this study, river monitoring was carried out in the upstream and downstream rivers in East Java to identify the water quality of these rivers.

2 Methods

The method used in this study includes several important steps to ensure that the data obtained is accurate and representative of the river conditions. These stages include:

2.1 Determination of Sampling Location

Determination of sampling points is carried out at locations that represent polluted and unpolluted areas, so as to provide a comprehensive overview of variations in water quality along the river. Sampling is carried out in shallow water with the target being sediment that houses macroinvertebrates.

2.2 Biotic Sampling

Biotics sampling is carried out to analyze organisms in the river such as benthos, microinvertebrates, and fish, as biological indicators of the quality of the aquatic environment. Biotic sampling methods are carried out using Kick Net. Kick Net is a sampling

method used in shallow waters, and has a swift current [7]. The position of kick net in biotic sampling can be seen in **Fig.1.**

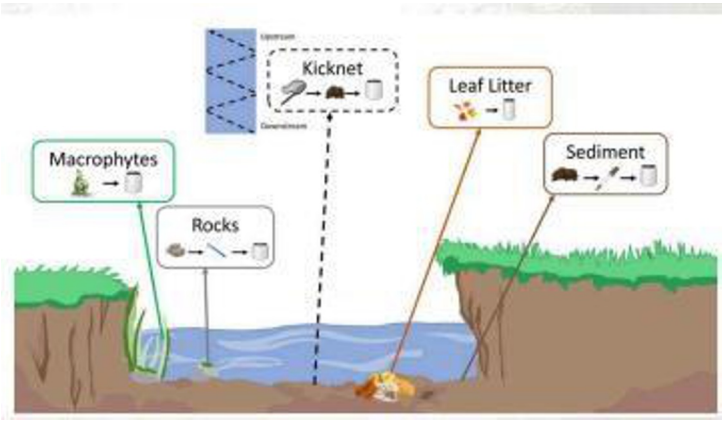

Fig. 1 Position of kick net in biotic sampling [7]

2.3 Abiotic Sampling

Sampling of abiotic samples such as water and other physico-chemical parameters, such as temperature, pH, dissolved oxygen (DO) levels, and concentrations of heavy metals and other hazardous chemicals.

2.4 Sample Preservation

Samples taken are preserved using appropriate methods, such as refrigeration or the addition of alcohol or chloroform, to maintain sample quality before analysis in the laboratory.

2.5 Observation and Identification

Observations were made directly to take notes on the environmental conditions at the sampling sites, while identification of biotic organisms and abiotic parameters was carried out using relevant tools and methods in the laboratory.

2.6 Analysis used RRA and Thailand Protocol

The RRA protocol is identified with several parameters namely Non-natural turbidity, suspended solids, non-natural color, foam, odor, aste dumping, Ferro sulphide reduction (water velocity reduction - water velocity, 0.25 - 0. 75 m/s), lower surface of stone (% cover of black dots), uppers & lower surface of stones, Sewage fungi & bacteria (visible to the naked eyes), stones with algae vegetation (peryphyton in thin layers), % of thick, significant layers of algae, filamentous green algae, dominance of tolerance with value 1 - 10, baetidae different types, chiranomidae (with red color), Heptageniidae (Rhithrogena spp.), periidae, placetidae (with red color). After obtaining biotic and abiotic parameter data, scoring is then carried out with a score value of 0 very dirty water category, 1 - 2.9 very dirty water category, 3 - 4.9 dirty water category, 5 - 5.9 average category, 6 - 7.9 clean water category, and 8 - 10 categorized as very clean water. Based on this score, it can be concluded whether the condition of the river is polluted or not. As for Thailand Giudes water quality is by collecting macroinvertebrate samples, identification, classification of bioindicator animals, assessment of water quality based on bioindicator animals, determination of water quality whether polluted or not. This method uses bioindicators to assess water quality, which is a common method in river water environment monitoring. Although the use of this method originated

in Thailand, the basic principles can still be applied in various places by adjusting to the existing species.

3 Results and Discussion

The analysis results obtained from observations made in the Wonorejo and Dlundung rivers are as follows

3.1 Rapid River Assesment (RRA) Protocol

RRA protocol is a method used to assess the condition of river ecosystems quickly and effectively. Important aspects in the RRA protocol are water temperature, water pH, dissolved oxygen levels, visible water morphology such as odor, color, number of fungal and algal species and dominance of benthic macroinvertebrate species [8]. In this study, observations were made of the Wonorejo Mangrove River in Surabaya and the Dlundung Pacet River using the RRA protocol method. The RRA protocol method sampling result can be seen in Table 1.

Table 1. RRA Protocol Method sampling results

Location	Temperature (ºC)	pH	DO (mg/L)	Colour	Odors
Wonorejo	30.8	15	0.1	Cloudy brown	Soil odor
Dlundung	24	7.5	7.3	Clear	Odorless

River water with a pH value of around 6.5 - 7.5 is normal water that meets the requirements for an ecosystem in these waters [9]. The maximum temperature allowed to indicate a clean river water is 30 ºC [10]. River water that is not clear and smells bad is an early indicator of poor environmental conditions [11]. A water body can be said to be good and has a low level of pollution if its dissolved oxygen (DO) level is more than 5 mg/L [9]. So based on the results obtained, it can be concluded that by using the RRA method based on the water quality index, it can be seen that the Wonorejo Mangrove River can be categorized as polluted and the Dlundung Pacet River is categorized as still clean and fulfills water quality standards.

Based on the results of biotic and abiotic sampling observations in the Dlundung river, no RRA method parameters were found such as non-natural turbidity and suspended solids, unnatural colors, foam, odors, sewage, ferro-sulhide reduction (water velocity, 0.25 - 0.75 m/s), upper and lower surfaces of stones, fungi and bacteria from sewage, significant layers of algae, filamentous green algae. However, the dlundung river has other parameter values such as stones with algal vegetation (periphyton in thin layers) in categories I (2) and II (2), species richness of benthic macroinvertebrates is in category I (2) with 16-19 species, dominance of sensitive benthic macroinvertebrate organisms in categories I (2), II (3), and III (1). Meanwhile, in Wonorejo River Surabaya, RRA parameters such as non-natural turbidity and suspended solids, unnatural color, sewage discharge, and water odor were found. The sampling result of water quality index determination can be seen in Table 2.

Table 2. Sampling results of water quality index determination

Location	Temperature (°C)	DO (mg/L)	Animal Species	Water Quality Index
Wonorejo	30.8	0.1	2 spesies	3.6
Dlundung	24	7.3	12 spesies	6.5

Based on the results of the above analysis, it can be concluded that the Dlundung River, Mojokerto with a water quality index value of 6.5 is an area with clean water, while the Wonorejo River area, Surabaya with a water quality index value of 3.6 is an area with dirty water. The results of observations with the RRA protocol method in the Dlundung River Pacet, Mojokerto are included in the quality class I which is a good quality which indicates that the river is free from pollution so that many species are able to survive in the Dlundung River, Pacet, Mojokerto, while in the Wonorejo Mangrove River is included in the quality class V which is a poor quality which indicates that the river is polluted which causes limited species that are able to survive in the Wonorejo Mangrove River. Water quality in Surabaya's mangrove ecosystem is poorly polluted due to pollution and human activities. Pollution comes from industrial waste, ponds, and urbanization which results in a decrease in water quality in coastal areas [12].

The first sampling location is in the upper reaches of the river, which is the starting point of water flow. The upstream serves as a soil and water conservation area. Damage in the upper reaches can adversely affect all parts of the river, including the middle and lower reaches. Increased human activity upstream can reduce water quality [13]. The upper reaches of a river are basically areas filled with forests and dense, shady vegetation. This region functions as a water catchment area and provides a source of life for humans [14]. While the second location is the downstream of the river which refers to the part of the river that is close to the estuary or the place where the river empties into the sea, lake, or large river [15].

3.2 A Guide to Freshwater Invertebrates of Ponds & Streams In Thailand

Method to assess water quality originating from Thailand by observing aquatic macroinvertebrates, which can describe water quality in a body of water. TSS or Total Suspended Solid is the amount of floating or suspended solids in the water, the higher the TSS, the worse and more polluted the water quality. The result of macroinvertebrates found in Dlundung river can be seen in Tabel 3.

Table 3. Results of macroinvertebrates found in Dlundung, Mojokerto

Documention	Famili	TSS	Habitats
	Euphaeidae	8	Healthy ecosystems, good water conditions [16].
	Euphaeidae	8	Healthy ecosystems, good water conditions [16].
	Perlidae	8	Sensitive water conditions, predators, good ecosystem, healthy and good water conditions [17].
	Heptageniidae	6/8	Collector group, eats small particles in water, needs good oxygen, fast water flow, good water conditions [16].
	Chloropertilidae	9	Living in cold temperatures, like oxygen, clean water [18]
	Rhycophilidae	8	Vulnerable to toxins and sensitive to environmental changes [19]
	Hydropsychidae	5	Collector group, eater of small particles in water [20]

	Athericidae	10	Medium quality water indicators [21]
	Poecilidae	8	Good aquatic environmental conditions [22]
	Tipulidae	6	Sensitive to pollution [19]
	Poecilidae	7	Good aquatic environmental conditions [23]
	Palaemonidae	4	Watery or gravelly substrate, good ecosystem [24]

The sampling results in Wonorejo only contained two types of animals, namely river crabs and snails with doors. River crabs have several species where some of them have resistance to various water conditions, because river crabs themselves have the ability to regulate salt and water levels in the body (Osmore Regulation), crabs have efficient excretory organs, namely hepatopancreatic antennae (absorbing harmful substances), molting periodically helps crabs remove toxins and contaminants attached to the shell. Meanwhile, some river snail species are resistant to water pollution that occurs in their environment. For example, Physa acuta and Thiara cancellata are resistant to domestic waste, industrial waste, pesticides and chemical fertilizers. Thus it can be concluded that in dlundung waters there are still many indicator species which indicate that the river is in very good condition, while Wonorejo river is a polluted river because there are only two species of animals that can live in the river.

3.3 Pollution Control Strategy

Water monitoring is a systematic process of collecting data on water quality in a given environment, which aims to monitor changes in physical, chemical, and biological parameters of water and identify potential problems or pollution that may affect human and ecosystem health. Parameters measured for water quality biomonitoring include BOD, COD,

TDS, TSS, DO as well as other physical parameters and chemical parameters. Generally, water quality measurements are carried out periodically by local agencies, or using KLHK development tools in the form of Onlimo, which will immediately provide automatic measurement results that are directly inputted into local DLH data. Where this data includes physical and chemical measurements of water in field data only. However, the use of Onlimo is mostly upstream, not downstream. Therefore, it is important to monitor the waters of the downstream area to be able to find out how high the pollution occurs in the water from upstream to downstream.

Pollution control strategies can be carried out by the Government as well as local community support in the following ways government establishes regulations and policies related to industrial and domestic waste, the government conducts a system of supervision, monitoring, and management of waste discharged into rivers, for example by improving and increasing the use of Onlimo, restoring and rehabilitating damaged river conditions by improving aquatic habitats, the government educates the public and campaigns for environmental awareness that can be done through social media platforms,the community plays an active role in maintaining environmental cleanliness and reducing chemicals that can cause pollution, the community reports and disseminates information about environmental cleanliness, adoption of Internet of Things (IoT) and connected technologies for real-time monitoring and data analysis in monitoring [25], students can conduct a research project on measuring water conditions with physical and chemical parameters to be monitored for environmental conditions, as well as technological innovations and projects for such as making water filters regarding waste treatment.

4 Conclusion

Based on the results that have been obtained, it can be concluded that the results of the RRA protocol analysis obtained river conditions in the upstream part, namely the Dlundung river, is an area with clean water conditions with a DO value of 7.3 mg/L. Meanwhile, the downstream part, Wonorejo river, is an area with polluted water conditions with a DO value of 3.1 mg/L. For the analysis of the results based on the Thailand River Protocol, the river conditions in the upstream part, namely the Dlundung river, is an area with clean water with a water quality index value of 6.5. Meanwhile, the downstream part, Wonorejo river, is an area with very dirty water with a water quality index value of 2.5. Waters in the upstream area of the river tend to have good water conditions characterized by good water parameter measurement results, but in the downstream area of the river, the water is classified as very bad from various indicator measurements. Therefore, it is important to be able to maintain, manage, and restore the condition of river water, and observe the exact condition of upstream and downstream water so that further preventive steps can be taken in maintaining river water quality.

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References

1. Kementerian Lingkungan Hidup dan Kehutanan (KLHK). (2020). *Laporan Status Lingkungan Hidup Indonesia*.
2. Eko, Erna Rahayu, Hutwan Syarifuddin, and Jalius Jalius. "Analisis Kualitas Air Sungai Batanghari Berkelanjutan di Kota Jambi." *Jurnal Pembangunan Berkelanjutan* 1.2 (2018): 123-141.
3. Hamuna, Baigo, Rosye Hefmi Tanjung, and Hendra MAury. "Kajian kualitas air laut dan indeks pencemaran berdasarkan parameter fisika-kimia di perairan Distrik Depapre, Jayapura." (2018).
4. Parsons, Melissa, Martin Thoms, and Richard Norris. "Australian river assessment system: AusRivAS physical assessment protocol." *Monitoring river health initiative technical report* 22 (2002).
5. Boonsoong, Boonsatien, et al. "An implementation plan for using biological indicators to improve assessment of water quality in Thailand." *Environmental monitoring and assessment* 165 (2010): 205-215.
6. Suprayogi, Slamet, L. Setyawan Purnama, and Darmakusuma Darmanto. *Pengelolaan Daerah Aliran Sungai*. UGM PRESS, 2024.
7. Maitland, Victoria Carley, et al. "Freshwater diatom biomonitoring through benthic kick-net metabarcoding." *PLoS One* 15.11 (2020): e0242143.
8. Parsons, Melissa, Martin Thoms, and Richard Norris. "Australian river assessment system: AusRivAS physical assessment protocol." *Monitoring river health initiative technical report* 22 (2002).
9. Prasetya, Ferry Budi, Yeyek IhdalUmam, and Ratno Budiyanto. "Analisis Parameter Pencemaran Air dalam Penentuan Kualitas Sungai Brantas." *EVOLUSI: JOURNAL OF MATHEMATICS AND SCIENCES* 7.1 (2023): 8-13.
10. Kirana, Kartika Hajar, et al. "Identifikasi kualitas air sungai Citarum Hulu melalui analisa parameter hidrologi dan kandungan logam berat (studi kasus: Sungai Citarum sektor 7)." *Wahana Fisika* 4.2 (2019): 120-128.
11. Astuti, Beti Cahyaning. "Kualitas air sumur Desa Bantaran Sungai Bengawan Solo berdasarkan aspek kemasyarakatan dan standar menteri kesehatan." *Jurnal Matematika Sains dan Teknologi* 16.1 (2015): 18-25.
12. Putra, Beny Satrya Eka, and Novirina Hendrasarie. "The effect of mangrove density to estuary water quality based on physic-chemist parameters at Wonorejo, Surabaya." *Jurnal Pendidikan dan Konseling (JPDK)* 5.1 (2023): 1308-1318.
13. Nalang, Amanda TC, et al. "Struktur dan Komposisi Fitoplankton di Bagian Hulu Sungai Saluesem, Minahasa, Sulawesi Utara." *Jurnal Ilmiah Sains* (2015): 105-110.
14. Fitri, Rini. "Karakteristik DAS Ciliwung Hulu Provinsi Jawa Barat." *Naturalis: Jurnal Penelitian Pengelolaan Sumber Daya Alam dan Lingkungan* 9.1 (2020).
15. Pratiwi, Nandika Aisya, Harianto Harianto, and Arief Daryanto. "Peran agroindustri hulu dan hilir dalam perekonomian dan distribusi pendapatan di Indonesia." *Jurnal Manajemen & Agribisnis* 14.2 (2017): 127-127.
16. Soegianto, Ir Agoes. *Ekologi perairan tawar*. Airlangga University Press, 2019.

17. Khairuddin, Muhammad Yamin, and Abdul Syukur. "Analisis kualitas air Kali Ancar dengan menggunakan bioindikator makroinvertebrata." *Jurnal Biologi Tropis* (2016).
18. Anzani, Yunita Magrima, Majariana Krisanti, and Yusli Wardiatno. "The diversity and density of Plecoptera in the headwaters of Cisadane River, West Java, Indonesia." *Journal of Biodiversity and Environmental Sciences* 9.1 (2016): 126-132.
19. Ratnasari, Desy, Ibnu Fajar Muhammad Thoifur, and Nurul Avidhah Elhany. "Uji Kualitas Air Sungai Di Desa Sumberkolak Kecamatan Panarukan Kabupaten Situbondo." *Uji Kualitas Air Sungai Di Desa Sumberkolak Kecamatan Panarukan Kabupaten Situbondo* (2023): 1-7.
20. Sulistiyowati, Eka, Dien F. Awaliyah, and Shofwatul Uyun. "Penilaian Kesehatan Sungai Menggunakan Metode Biotik dan Fisik di Sungai Boyong, Sleman, Yogyakarta." *Jurnal Kesehatan Lingkungan Indonesia* 23.2 (2024): 162-169.
21. Basset, Alberto, Franca Sangiorgio, and Maurizio Pinna. "Monitoring with benthic macroinvertebrates: advantages and disadvantages of body size descriptors." *Aquatic Conservation: Marine and Freshwater Ecosystems* 14.S1 (2004): S43-S58.
22. Naigaga, I., et al. "Fish as bioindicators in aquatic environmental pollution assessment: A case study in Lake Victoria wetlands, Uganda." *Physics and Chemistry of the Earth, parts A/B/C* 36.14-15 (2011): 918-928.
23. De Andrade, Vanessa Moraes, et al. "Fish as bioindicators to assess the effects of pollution in two southern Brazilian rivers using the Comet assay and micronucleus test." *Environmental and molecular mutagenesis* 44.5 (2004): 459-468.
24. Anger, Klaus. "Neotropical Macrobrachium (Caridea: Palaemonidae): on the biology, origin, and radiation of freshwater-invading shrimp." *Journal of Crustacean Biology* 33.2 (2013): 151-183.
25. Chowdury, Mohammad Salah Uddin, et al. "IoT based real-time river water quality monitoring system." *Procedia computer science* 155 (2019): 161-168.