PAPER NAME

Evaluation of the Water Quality Status and Pollution Load Carrying Capacity of Way Umpu River, Way K

AUTHOR

Tugiyono Tugiyono

WORD COUNT

7153 Words

CHARACTER COUNT

32748 Characters

PAGE COUNT

10 Pages

FILE SIZE

2.1MB

SUBMISSION DATE

Aug 1, 2023 9:16 PM GMT+7

REPORT DATE

Aug 1, 2023 9:20 PM GMT+7

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Hindawi
International Journal of Ecology
Volume 2023, Article ID 2689879, 10 pages
https://doi.org/10.1155/2023/2689879

Research Article

Evaluation of the Water Quality Status and Pollution Load Carrying Capacity of Way Umpu River, Way Kanan District, Lampung Province, Indonesia, Based on Land Use

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Received 26 December 2022; Revised 15 June 2023; Accepted 21 June 2023; Published 29 June 2023

Academic Editor: Agoes Soegianto

This research aims to evaluate the water quality status and pollution load-carrying capacity of the Way Umpu River based on land use. This was carried out using the survey method by directly measuring the river water debit, pH, temperature, and dissolved oxygen (DO) on-site, taking the water sample to analyze the parameters of water quality such as total dissolved solid (TDS), total suspended solid (TSS), water color, turbidity, salinity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), fecal coli, total coliform, and plankton in the lab, and monitoring the land use. The results showed that the use of land for illegal mining and the settlement of inhabitants in station-4 (ST-4) caused water pollution. Furthermore, based on Class III water use, the parameters in ST-4 exceeded the standards for TSS, color, and BOD, while other stations such as ST-1, ST-2, ST-3, ST-5, and ST-6 showed clean and good water quality statuses. It was also found that the pollution load-carrying capacity of the Way Umpu River has not yet been exceeded for Class III and the quality of the water may be improved when the river water debit increases. In addition, the plankton community structure on ST-1, ST-2, and ST-3 showed the number of species and individuals, and the diversity index was relatively high compared to ST-4, ST-5, and ST-6. It was concluded that the integrated evaluation was based on water quality status, plankton community structure, and pollution load analyses. The land use for illegal mining will decrease the water quality and the plankton community structure compared to other land uses.

1. Introduction

Water is the most important component in life, and as a result, people tend to reside around riverine areas. Most human civilizations are located near water streams, especially along big rivers. This is because they are important freshwater sources; however, it is the most susceptible to pollution. Moreover, good water quality is essential because it plays a major role in supporting life, food production, energy generation, industry, and environmental support capacities including domestic consumption, agriculture, transportation, tourism, and other required water activities [1, 2].

The river is a meeting point of water coming from various sources such as rainwater and even liquid waste from human activities such as agriculture, transportation, industry, urban, and settlement areas. However, some people think that a river is an ideal place to receive waste from most anthropogenic activities because of its continuous water flow [3]. The condition of water quality of river in Indonesia is generally determined by the land use. As an example, the source of pollution entering the Cikeas River (West Java) was dominated by housing complexes and the Celeungsi River (West Java) was dominated by industrial sector while the Bekasi River (Wes Java) was dominated by shopping centers, hotels, and restaurants [4]. This condition is also widespread in countries with low and middle incomes such as Indonesia, Malaysia, and Myanmar where rapid developments are followed with minimal environmental considerations [2]. Furthermore, the examples of dominant stressors in the lotic system (40% of all water bodies) include hydromorphology degradation, point resource pollution distribution, and water use [5]. They commonly affect the water quality in the downstream and upstream areas as a result of the waste that comes from local activities around their surroundings [6]. In addition, stressors were found in the upstream areas due to the effects of anthropocentric activities such as dam building, urbanization, mining, and forestry as well as chemical fertilizers and pesticides from agriculture [7, 8].

Water is considered polluted due to the presence of some substances or some conditions that prevent it from being used for a particular purpose [9]. Previous research studies have shown that reduced water quality in some areas such as the Celeungsi, Cikeas, and Bekasi River in West Java, Indonesia, has increased in the last century [4], and this is caused by rapid industrialization, urbanization, other developments/processes, and pollution. The level of water pollution is assessed based on physical and chemical parameters that influence the quality of the water body, aquatic habitats, phytoplankton community, and the health of fish [1, 10–12]. Furthermore, the water body is functioned as a habitat for organisms, and responses to the stressors may vary among the producers and consumers. These responses affect the nutritional status of the phytoplankton community, and in the long run, it may affect the survival of biodiversity [7].

The water quality assessment is a complex problem because it involves many factors such as physical, chemical, and biological parameters, and there are difficulties in identifying polluting components accurately, which are also influenced by many factors and processes. Therefore, the knowledge of various causes of pollutants such as sources and impacts of pollution on ecological status is a fundamental prerequisite for effective river management [5].

The Way Umpu River is one of the main rivers in Way Kanan District, Lampung Province, Indonesia. It has a watershed width of ± 1.179 km^2, a river length of 100 km, and an average width of 90 to 110 meters. The Way Umpu River watershed has several land uses, i.e., for forestry, plantation, agriculture, industry, mining, and inhabitant settlement. Besides its main function as macrodrainage into the Java Sea, it serves as a water source for the public. In the dry season, people depend on it for bathing, washing, and fishing [13–15]. Moreover, a river is an open ecosystem that is susceptible to stressors coming from its surroundings. The chief of Environmental Service in Way Kanan District, Dwi Handoyo Retno, S.E., M.M., stated on 27 January, 2021, that illegal mining in Way Kanan, especially gold, severely polluted the Way Umpu River [14]. The color of the water became brown-yellowish, indicating that the water is not safe to use by the people for many purposes such as washing and bathing. Subsequently, illegal mining also destroys river water flow and mining material waste disposal causes river silting. This illegal activity violates the regulation implemented by the Indonesian government for Mineral and Coal Mining Number 4 in 2009, which has been amended to Law Number 3 in 2020 concerning mineral mining [14, 15]. Therefore, environment parameter monitoring is the highest priority in water resource environmental status evaluation, environment protection and management, and policy implementation. Furthermore, polluted rivers are important challenges that require intervention from various stakeholders [1, 2].

Based on the information above, the objective of this research was to measure the level of pollution by analyzing the river water quality, calculating the pollution load capacity and plankton community structure in the Way Umpu River based on land use.

2. Materials and Methods

2.1. Sampling Location and Sample Collection. The Way Umpu River is geographically located between 04°28′41.4″ south latitude and 104°42′34.9″ east longitude. The research location includes 7 (seven) stations for sample collection representing several land uses such as forestry, plantation, agriculture, mining, and inhabitant settlement. The sampling location is presented in Table 1. Sampling locations to predict the water pollutant carrying load capacity are presented in Table 1 and Figure 1.

The water samples were taken during the wet season (October-April) with the monthly average rainfall data for the last 5 years are 376.83 mm, the data are obtained from the Meteorology, Climatology, and Geophysics Agency of Kota Bumi Lampung, Indonesia. Furthermore, they were collected from 7 stations selected based on the land use in watershed areas. Samples were taken from the right and left banks at each station. The water parameter was measured directly in situ (pH, temperature, and DO) and the other parameters were analyzed in Seameo Biotrop Service Department Environment Laboratory, in Bogor, Indonesia, which is LP-221-IDN nationally accredited. The physical and microbiology parameters include temperature, total dissolved solids (TDS), total suspended solids (TSS), water color, turbidity, fecal, and total coliforms. Furthermore, the chemical parameters include pH, salinity, biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), total phosphate (P), nitrate (NO_3-N), cadmium (Cd), total chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nitrite (NO_2-N), and cyanide (CN).

Water debit is the volume of water that flows per time unit through a river cross-section, and it is expressed in meters cubic per second (m^3/sec). The data were obtained by multiplying the speed measurement using the current meter and river width and a trapezoidal width approach. The width of the river cross-section was also measured with a tape meter [3].

Table 1: Sampling location.

No.	Station	Location	Ordinate	Land use
1	ST-1	Way Kasui Kiri River downstream	4°42′34.94″S 104°28′32.92″E	Inhabitant settlement in Kasui Pasar Village of Kasui subdistrict plantation, and Bukit Punggur forests registered 24
2	ST-2	Upstream of Way Umpu River before receiving water flow from Way Kasui Kiri River	4°42′36.55″S 104°28′35.44″E	Inhabitant settlement in Kasui Pasar Village of Kasui subdistrict plantation, and Bukit Punggur forests registered 24
3	ST-3	Way Umpu River that received water flow from way Kasui Kiri River	4°42′33.89”S 104°28′36.52″E	Inhabitant settlement in Kasui Pasar Village of Kasui subdistrict plantation, and Bukit Punggur forests registered 24
4	ST-4	Ojolali River downstream	4°41′11,67″S 104°29′49.37″E	For gold and manganese mining and inhabitant settlement in Ojolali Village of Umpu Semenguk subdistrict
5	ST-5	Way Umpu River at suspension bridge Ojolali Village	4°41′9.57″S 104°29′49.45″E	Inhabitant settlement in Ojolali Village of Umpu Semenguk subdistrict
6	ST-6	Way Neki River downstream	4°38′45.87″S 104°30′22.44″E	Plantation, mining, and inhabitant settlement in Gunung Katun Village of Baradatu subdistrict
7	ST-7	Downstream of Way Umpu River received water flow from Way Neki River (ST-6) and other rivers above it (ST-1 to ST-5)	4°38′45.53″S 104°30′20.48″ E	This was the area that was used to predict the water pollutant carrying load capacity

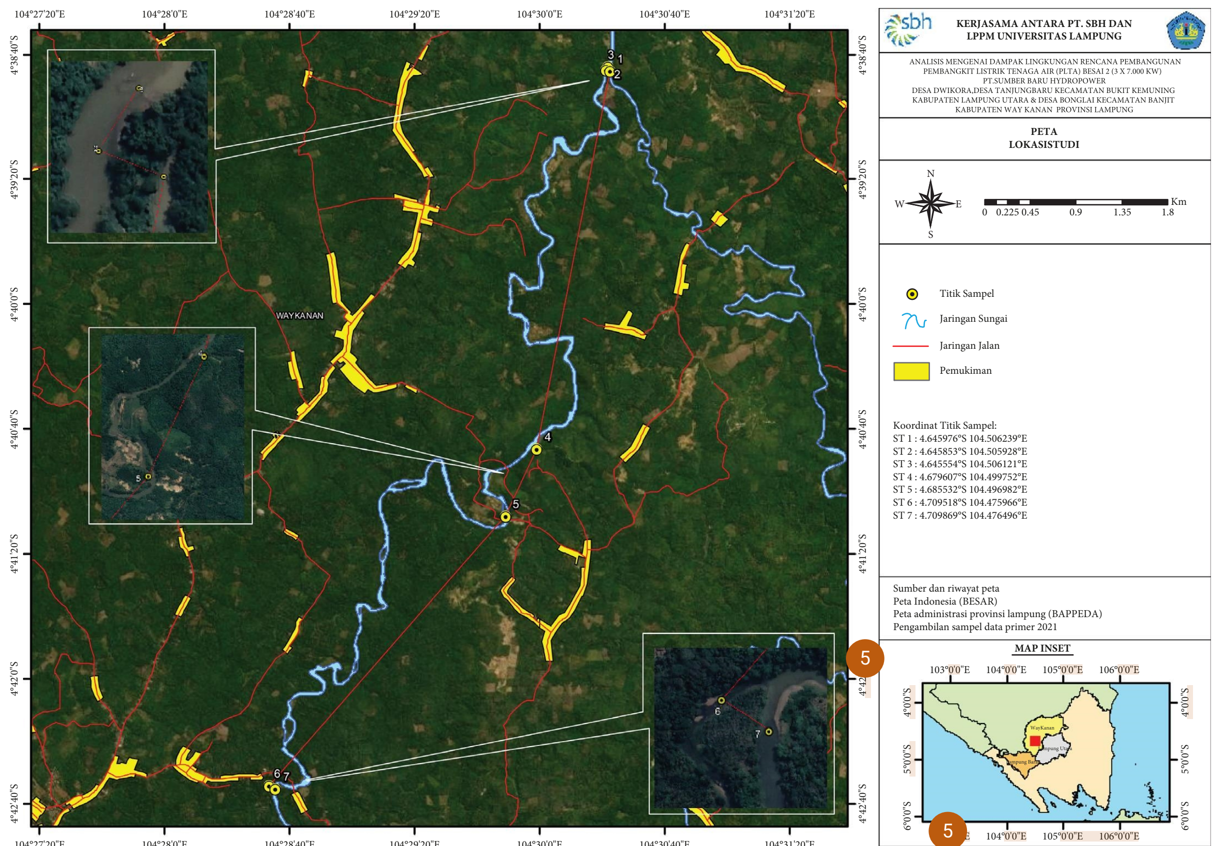

Figure 1: Map sampling location. *Note*. PI < 1.0: clean, 1 < PI < 2: mild pollution, 2 < PI < 3: moderate pollution, 3 < PI < 5: polluted, and PI > 5: extremely pollution categories [16]. The results obtained are based on the calculation of the pollution load capacity according to KepmenLH no. 110 of 2003 [17].

The 50 L water of the plankton sample was taken quantitatively and compositely using a bucket and filtered with a 50 μm plankton net. Plankton samples were taken from the right and left banks at each station. Furthermore, the collected sample was poured into a 30 mL plastic container and fixated with 5 drops of a 4% formalin solution [18]. The sample was then observed in an Ecological Laboratory in the Biology Department of the Faculty of Mathematics and Natural Sciences at the University of Lampung, Indonesia.

2.2. Data Analysis. The Nemerow index (PI) was used to evaluate water quality with the maximum and average scores of a single factor index affecting the composite index[16]. PI has been used widely to evaluate water bodies and is determined based on the ratio of environment standard parameters for specific purposes with parameter scores from various measurement results [19]. Subsequently, the standard scores for this research were purposed for Class III, which makes up the categories of water used for freshwater fish culture, animal husbandry, crop irrigation, and for other purposes based on the Local Regulation of Lampung Province (2012) [20]. The PI equation is presented in the following equation [16]:

$$\mathbf{PI} = \frac{\sqrt{(\mathbf{Ci/Sij})\mathbf{max}^2 + (\mathbf{Ci/Sij})\mathbf{ever}^2}}{\mathbf{2}}, \quad (1)$$

where **PI** = Nemerow Index, Ci = measured concentration from evaluation factor class *i*, and Sij = standard concentration of evaluation factor for water purpose class *j*.

The correlation between PI value and water classification includes PI < 1.0: clean, 1 < PI < 2: mild pollution, 2 < PI < 3: moderate pollution, 3 < PI < 5: polluted, and PI > 5: extremely polluted categories [16, 21]. The differences between each station were evaluated with the method of analysis of variance (ANOVA). Values were considered significant at $p < 0.05$ level.

The analysis for load capacity based on Minister Environment Decree of Indonesia Number 110 years 2003 [17] was carried out in Station 7, in the downstream area of the Way Umpu River which receives water flow from some tributaries, namely, the Way Kasui Kiri River where its water flowed through the registered 24 forests of Bukit Punggur and plantation (ST-1) and ST-2 Upstream Way Umpu, the Way Ojolali River (ST-4), where the water flowed through inhabitant settlement, manganese, and gold mining, and the Way Neki River (ST-6), where its water flowed through gold mining and inhabitant settlement.

The load capacity was estimated using the mass balance method (equation (2)) based on the Regulation of the Indonesian Ministry of Environment Decree No. 110 for the year 2003 [17].

$$\mathbf{CR} = \frac{\sum \mathbf{CiQi}}{\sum \mathbf{Qi}} = \frac{\sum \mathbf{Mi}}{\sum \mathbf{Qi}}, \tag{2}$$

with CR = average concentration of composite flow (mg/L or °C), Ci = constituent concentration of flow-i (mg/L or °C), Qi = debit of flow-i (m^3/s), and Mi = constituent mass of flow-i (kg^3/s).

Plankton community structure was determined based on plankton density and expressed as the numbers of individual plankton per liter. Abundance Index (individual per liter or dm^3). Plankton abundance estimation is based on the following equation:

$$N = \frac{(ax1000)b}{L}, \tag{3}$$

with N = number of plankters per liter of river water, a = average of plankter number counted from 1 cc of filtered water, b = volume of filtered sample water (mL), and L = volume of filtered river water (L) [18].

The diversity (H) and evenness of plankton were determined based on the Shannon–Wiener diversity and evenness index [22]. Furthermore, based on the H score, the water condition was evaluated as follows: $H < 1.0$: heavy pollution, $1 < H < 3$: moderate pollution, and $H > 3$: clean according to Mason [23].

3. Results and Discussion

The results of the physical, chemical, and biological parameter analysis are presented in Table 1 the measurement results for all water quality parameters at all stations were below the quality standard for Class III, except for Station 4, where its TSS, color, and BOD exceed the standard. The estimation result of the water PI score for all stations showed the water quality status was clean and in good condition (PI < 1). However, ST-4 showed moderate water polluted quality status (PI = 2.05) which exceeded the standard for Class III water use. The PI scores are presented in Figure 2. Based on the results of the analysis of variance (ANOVA) at Station 4 the PI value was significantly different with a p value <0.05 compared to the other 6 stations (ST-1, ST-2, ST-3, ST-5, ST-6, and ST-7), while between the 6 stations each PI value was not significantly different $p > 0.05$.

The results from the analysis of the pollution load capacity of Way Umpu River using the mass balance method for all parameters are shown in ST-7. These results were compared with the standards for Class III water use according to the Local Regulation of Lampung Province [20], as shown in Table 2.

Table 3 shows that the load capacity of Way Umpu River at ST-7 for all parameters did not exceed the standard for Class III water purpose according to this Local Regulation of Lampung Province [20]. This means that at ST-7 the pollution load capacity for all designation parameters for Class III has not exceeded the quality standard, so Way Umpu still has a capacity for all parameters [17].

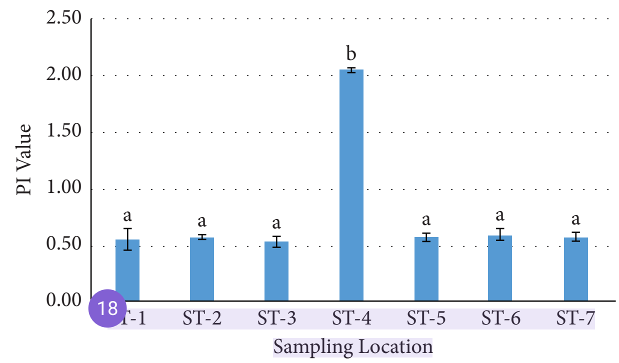

Figure 2: Evaluation of river water quality based on PI score.

Furthermore, the analysis of the plankton community structure consisting of the values of density, diversity, dominance, and evenness of plankton is presented in Table 4. Based on Table 4, it was found that the structure of the plankton community n land use in the form of forests, plantations, and settlements (ST-1, ST-2, and ST-3) which shows the number of species, individuals, and the diversity index were relatively high compared to the areas those were in the form of mining and settlements (ST-4, ST-5, ST-6, and ST-7). The plankton diversity index indicated that all locations belong to moderate community stability or moderate polluted water quality ($1 < H < 3$) [17]. In addition, the structure of the plankton community based on the evenness index showed that planktons were evenly distributed ($0.41 < E < 0.60$ and $0.61 < E < 0.80$) with low dominance ($0 < D \leq 0.5$) at each station [22]. There are several species of plankton used as indicators of pollution, namely, *Anabaena* sp., *Closterium* sp., *Euglena* sp., *Microsystis* sp., and *Nitzchia* sp. [7]. The existence of *Euglena* sp., *Nitzchia* sp., *Navicula*, and *Synedra* is an indication of pollution by organic matter originating from organic waste, agricultural runoffs, and anthropogenic inputs [7].

The Ojolali River flow at ST-4 receives waste from illegal gold mining activities that resulted in polluted water conditions, especially in TSS, BOD, and color parameters which are 235 ± 2.8 mg/L, 9.7 ± 0.2 mg/L, and 181 ± 7.1 Pt-Co, respectively. Gold mining is performed by striping soil using a diesel machine-driven soil suction with a big-size hose to suck and dispose of soil in big capacity. Furthermore, this method requires thousands of liters of water and disposes of thousands of cubic of soil daily (Figure 3), which blocks the water flow of rivers surrounding the mining area [24]. Besides that, illegal gold mining affects the quality of the river by turning it into brown-yellowish muddy water. This condition prevents people from relying on the Way Umpu River as a fresh water source, washing, bathing, and fishing, especially during the dry season [14, 15].

TSS consists of organic materials such as the debris part of an organism and inorganic materials in the form of fine

Table 2: Water quality measurement results.

No.	Parameters	Unit	Standard Class III	Sampling location						
				ST-1	ST-2	ST-3	ST-4	ST-5	ST-6	ST-7*
1	Air Temp	°C	—	27 ± 0	29 ± 0	27 ± 0	29 ± 0	29 ± 0	27 ± 0	28.5 ± 0
2	Water Temp	°C	—	27.9 ± 0.1	27.6 ± 0.1	27.9 ± 0.3	29.2 ± 0.3	28.1 ± 0.1	27.9 ± 0.1	27.7 ± 0.1
3	TDS	mg/L	1,000	28 ± 1.4	24.5 ± 1.1	28.6 ± 1.2	42.1 ± 1.2	24 ± 2.8	31.2 ± 0.2	26.0 ± 0.6
4	TSS	mg/L	100	7.4 ± 0.4	12 ± 1.0	11.2 ± 0.8	235 ± 2.8	11.2 ± 1.6	1 0.8 ± 0.4	12.0 ± 0.7
5	Color	Pt-Co	100	38.7 ± 2.8	40.5 ± 1.7	56.7 ± 1.5	181 ± 7.1	36.9 ± 2.1	42.3 ± 2.8	41.0 ± 1.3
6	Turbidity	NTU	—	4.9 ± 0.6	5.8 ± 0.1	6.8 ± 0	70.6 ± 6.4	6.3 ± 0.1	9.4 ± 0.4	6.4 ± 0.2
7	pH	—	6–9	7.8 ± 0.1	7.4 ± 0.1	7.8 ± 0.08	6.7 ± 0.3	7.5 ± 0.2	7.7 ± 0.2	7.6 ± 0.1
8	Salinity	$^{o}/_{o}$o	—	0	0	0	0	0	0	0 ± 0
9	BOD	mg/L	6	2 ± 0.3	2.2 ± 0.3	3.6 ± 0.07	9.7 ± 0,2	2.4 ± 0.3	2.0 ± 0.1	2.2 ± 0.2
10	COD	mg/L	40	1.9 ± 0.1	4.4 ± 0.4	7.9 ± 0.3	22.4 ± 1.6	5.0 ± 0.1	4.1 ± 0.2	4.0 ± 0.4
11	DO	mg/L	3	3.9 ± 0.6	3.8 ± 0.1	4.1 ± 0.003	3.9 ± 0.6	3.8 ± 0.2	3.7 ± 0.3	3.8 ± 0.2
12	P (PO_4^-)	mg/L	1	0.4 ± 0.01	0.5 ± 0.04	0.6 ± 0.003	0.3 ± 0.02	0.4 ± 006	0.4 ± 0.04	0.4 ± 0.1
13	N(NO_3^-)	mg/L	20	0.5 ± 0.01	0.7 ± 0.06	0.7 ± 0.0004	1.7 ± 0.04	0.8 ± 0.03	1.5 ± 0.4	0.7 ± 0.01
14	Cd	mg/L	0.01	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0
15	Cr	mg/L	0.05	0.0003 ± 0	0.0003 ± 0	0.0003 ± 0	0.0003 ± 0	0.0003 ± 0	0.0003 ± 0	0.0003 ± 0
16	Cu	mg/L	0.02	0.002 ± 0.001	0.003 ± 0.001	0.004 ± 0.0001	0.002 ± 0.0003	0.001 ± 0.0004	0.002 ± 0.001	0.003 ± 0.0009
17	Pb	mg/L	0.03	0.001 ± 0.001	0.001 ± 0.0001	0.0009 ± 0.00004	0.001 ± 0.0001	0.0007 ± 0.0001	0.0008 ± 0.001	0.001 ± 0.000[illegible]
18	Hg	mg/L	0.002	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0
19	N (NO_2^-)	mg/L	0.06	0.002 ± 0.002	0.003 ± 0.001	0.002 ± 0.0001	0.008 ± 0.001	0.002 ± 0.001	0.007 ± 0.003	0.003 ± 0.0003
20	Cn	mg/L	0.02	0.01 ± 0	0.01 ± 0	0.01 ± 0	0.01 ± 0	0.01 ± 0	0.01 ± 0	0.01 ± 0
22	Fecal coliform	MPN/100 mL	2,000	7.2 ± 0.3	9.4 ± 1.0	7.2 ± 0.1	11 ± 1.4	7.4 ± 1.4	7.2 ± 0.3	8.8 ± 0.6
23	Total coliform	MPN/100 mL	10,000	7.2 ± 0.3	9.4 ± 1.0	11 ± 1.4	11 ± 1.4	7.4 ± 1.4	7.2 ± 0.2	8.8 ± 0.7

Standard: water body for Class III purposes according to Local Regulation of Lampung Province [20]. ST-7∗: The results obtained are based on the calculation of the pollution load capacity according to Kepmen LH No. 110 of 2003 [17].

Table 3: Analysis of load capacity of Way Umpu downstream.

No.	Parameter/river	Unit	Sampling location					Standard Class III
			ST-1	ST-2	ST-4	ST-6	ST-7*	
1	River discharge	(m^3/sec)	12.4	61.2	0.3	10.7	84.5	
2	Water Temp	°C	27.9 ± 0.1	27.6 ± 0.1	29.2 ± 0.3	27.9 ± 0.1	27.7 ± 0.1	—
3	TDS	mg/L	28 ± 1.4	24.5 ± 1.1	42.1 ± 1.2	31.2 ± 0.2	26.0 ± 0.6	1,000
4	TSS	mg/L	7.4 ± 0.4	12 ± 1.0	235 ± 2.8	1 0.8 ± 0.4	12.0 ± 0.7	100
5	Color	Pt-Co	38.7 ± 2.8	40.5 ± 1.7	181 ± 7.1	42.3 ± 2.8	41.0 ± 1.3	100
6	Turbidity	NTU	4.9 ± 0.6	5.8 ± 0.1	70.6 ± 6.4	9.4 ± 0.4	6.4 ± 0.2	—
7	pH	—	7.8 ± 0.1	7.4 ± 0.1	6.7 ± 0.3	7.7 ± 0.2	7.6 ± 0.1	6–9
8	Salinity	‰	0	0	0	0	0 ± 0	—
9	BOD	mg/L	2 ± 0.3	2.2 ± 0.3	9.7 ± 0,2	2.0 ± 0.1	2.2 ± 0.2	6
10	COD	mg/L	1.9 ± 0.1	4.4 ± 0.4	22.4 ± 1.6	4.1 ± 0.2	4.0 ± 0.4	40
11	DO	mg/L	3.9 ± 0.6	3.8 ± 0.1	3.9 ± 0.6	3.7 ± 0.3	3.8 ± 0.2	3
12	P ($PO4^-$)	mg/L	0.4 ± 0.01	0.5 ± 0.04	0.3 ± 0.02	0.4 ± 0.04	0.4 ± 0.1	1
13	N ($NO3^-$)	mg/L	0.5 ± 0.01	0.7 ± 0.06	1.7 ± 0.04	1.5 ± 0.4	0.7 ± 0.01	20
14	Cd	mg/L	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.01
15	Cr	mg/L	0.0003 ± 0	0.0003 ± 0	0.0003 ± 0	0.0003 ± 0	0.0003 ± 0	0.01
16	Cu	mg/L	0.002 ± 0.001	0.003 ± 0.001	0.002 ± 0.0003	0.002 ± 0.001	0.003 ± 0.0009	0.02
17	Pb	mg/L	0.001 ± 0.001	0.001 ± 0.0001	0.001 ± 0.0001	0.0008 ± 0.001	0.001 ± 0.0002	0.03
18	Hg	mg/L	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.0002 ± 0	0.002
19	N ($NO2^-$)	mg/L	0.002 ± 0.002	0.003 ± 0.001	0.008 ± 0.001	0.007 ± 0.003	0.003 ± 0.0003	0.06
20	Cn	mg/L	0.01 ± 0	0.01 ± 0	0.01 ± 0	0.01 ± 0	0.01 ± 0	0.02
21	Fecal coliform	MPN/100 mL	7.2 ± 0.3	9.4 ± 1.0	11 ± 1.4	7.2 ± 0.3	8.8 ± 0.6	2,000
22	Total coliform	MPN/100 mL	7.2 ± 0.3	9.4 ± 1.0	11 ± 1.4	7.2 ± 0.2	8.8 ± 0.7	10,000

Note. Standard according to reference Local Regulation of Lampung Province [20]. ST-7* = prediction result of pollution carrying load capacity of each water quality parameter [17].

sands and mud. Previous research studies show that a high level of TSS in Semporo Strait (Papua, Indonesia) is caused by factors such as erosion, land use, shifting, agriculture, inhabitant settlement, and sand mining [25].

The Ojolali River flow at ST-4 receives waste from illegal gold mining activities that resulted in polluted water conditions, especially in TSS, BOD, and color parameters where the values are higher the standard, thus also much higher compared to other stations. Gold mining is performed by striping soil using a diesel machine-driven soil suction with a big-size hose to suck and dispose of soil in big capacity. Furthermore, this method requires thousands of liters of water and disposes of thousands of cubic of soil daily (Figure 3), which blocks the water flow of rivers surrounding the mining area. Besides that, illegal gold mining affects the quality of the river by turning it into brown-yellowish muddy water. This condition prevents people from relying on the Way Umpu River for fresh water sources, washing, bathing, and fishing, especially during the dry season.

Subsequently, water bodies are said to be polluted when the TSS level is more than 50 mg/L [26] and our result indicated that the TSS in ST-4 is 235 ± 2.8 mg/L. The same result was found in the Brantas River of Samaan district (East Java, Indonesia), Batang Kuranji River (Padang of West Sumatra, Indonesia) with TSS levels of 70 mL/L [3] and 165 mg/L to 734 mg/L [27]. The high TSS levels are also reportedly caused by land erosion, surface water flow from agriculture area, and industrial waste [28] as well as sand and stone mining [27]. Although TSS is a nontoxic pollutant material, its excessive level prevents sun ray penetration, affecting phytoplankton, or covers water plants [29, 30]. Furthermore, it obstructs the gills of fishes and other aquatic habitats, thereby causing asphyxiation [29].

BOD describes the organic matter that may be decomposed biologically (biodegradable) and the decomposition result of dead plants and animals from industrial waste or domestic waste disposal. Moreover, water bodies are believed to be polluted when the BOD level is more than 2 mg/L. The high BOD level in Station 4 was due to domestic waste flow from the inhabitant settlements in Ojolali Village and the degradation of leaves along the river sides. Furthermore, the following results on BOD levels were obtained by some researchers, namely, 1.60 to 18.36 mg/L, 5.7 to 53 mg/L, and 8.46 to 18.48 mg/L BOD levels in Batang Kuranji in Padang of West Sumatra, Indonesia [27]. The same condition was also found in developed countries such as the Tobol River and basin in Chelyabinsk, Russia, where there is continuous waste disposal from the city, industrial factories, agribusiness, and flood water [31].

TSS comes from suspended materials such as mud, sand, organic and inorganic materials, plankton, and other microscopic organisms that cause water pollution and muddiness [30]. It was also found that the TSS from soil particle deposits into the sediment and dissolves when river water debit increases. This was proved by the reduced concentration and color in the river downstream of ST-5. The analysis of pollutant carrying load capacity in ST-7 (Table 2) for TSS and color parameters showed that they were below the standard of Class III water use.

Furthermore, the BOD levels in downstream river areas in ST-5 and ST-7 were low due to decomposed organic materials, changes in the physical and chemical water quality

Table 4: Plankton community structure analysis.

No.	Species	Sampling location (individual/L)						
		ST-1	ST-2	ST-3	ST-4	ST-5	ST-6	ST-7
1	*Amoeba* sp.	7,800 ± 848	600 ± 848	3,000 ± 848	38,400 ± 4,242	12,600 ± 3,394	1,200 ± 0	1,200 ± 848
2	*Anabaena* sp.*	6,600 ± 1697	600 ± 0	13,800 ± 3,394	600 ± 0	0	600 ± 0	600 ± 0
3	*Arcella* sp.	0	0	0	4,200 ± 1,697	0	0	0
4	*Asterionella spp.*	0	0	600 ± 0	0	0	0	0
5	*Bacillaria spp.*	0	0	600 ± 0	0	0	0	0
6	*Botryococcus spp.*	600 ± 0	0	600 ± 848	600 ± 848	33,000 ± 3,394	33,600 ± 2,545	33,600 ± 3,394
7	*Closterium* sp.*	37,200 ± 2,546	0	10,800 ± 1,697	0	600 ± 0	600 ± 848	600 ± 0
8	*Eudorina* sp.	0	0	1,200 ± 0	0	0	0	0
9	*Euglena spp.* *	0	16,800 ± 1,697	2,400 ± 1,697	38,400 ± 3,394	19,800 ± 1,697	6,600 ± 1,697	6,600 ± 1,697
10	*Frontania* sp	0	600 ± 0	0	0	0	0	0
11	*Gomphosphaeria* sp.	0	3,600 ± 848	1,200 ± 0	0	0	600 ± 0	600 ± 848
12	*Gyrosigma* sp.	600 ± 0	0	0	0	0	0	0
13	*Heteronema spp.*	0	0	6	0	0	0	0
14	*Lyngbya* sp.	0	600 ± 848	0	0	0	0	0
15	*Microsystis* sp.*	15,600 ± 3,394	10,200 ± 848	2,400 ± 848	10,800 ± 2,545	12,600 ± 1,697	4,800 ± 848	4,800 ± 1,697
16	*Netrium spp.*	600 ± 0	0	0	0	0	0	0
17	*Nitzchia* sp.*	21,000 ± 3,394	4,800 ± 0	0	6,600 ± 1,697	1,800 ± 848	600 ± 0	600 ± 0
18	*Oocyatis* sp.	600 ± 0	0	0	0	0	0	0
19	*Phacus* sp.	600 ± 848	0	0	0	0	0	0
20	*Rhabdonella* sp.	0	0	0	0	0	0	0
21	*Stauroneis* sp.	0	0	0	0	0	0	0
22	*Thallasiothrix* sp.	1200 ± 0	0	0	0	0	0	0
	No. of species	11 ± 0.7	8 ± 1.4	11 ± 0.7	7 ± 0.7	6 ± 0	8 ± 0.7	8 ± 0.7
	No. of Individual/L	92,411 ± 4,243	37,808 ± 3,394	37,211 ± 2,545	99,607 ± 12,727	80,406 ± 4,242	48,608 ± 2,545	48,600 ± 5,091
	Diversity index (*H*)	1.6 ± 0.7	1.5 ± 0.2	1.8 ± 0.3	1.4 ± 0.05	1.4 ± 0.01	1.1 ± 0.04	1.0 ± 0.07
	Dominance index (*D*)	0.3 ± 0.03	0.3 ± 0.01	0.2 ± 0.07	0.3 ± 0.02	0.3 ± 0.02	0.4 ± 0	0.5 ± 0.004
	Evenness index (*E*)	0.7 ± 0.3	0.7 ± 0.01	0.7 ± 0.07	0.7 ± 0.1	0.8 ± 0.004	0.5 ± 0.003	0.5 ± 0.01

Note. Species with asterisks are pollution indicator based on references [1, 7].

(a) (b)

Figure 3: (a) Illegal gold mining activity and (b) brown-yellowish water river color after receiving mining waste.

parameters, and the plankton community structure. This was indicated by increased numbers of species and individuals and the plankton diversity index in ST-5 and ST-7. This is in line with the research by Ma [32], which states that human activities play important roles in catchment area disturbance worldwide in terms of the physical and chemical parameters of rivers. Therefore, most aquatic species are under big threat because of human influences.

4. Conclusions

The results of this work clearly indicate that anthropogenic activities in aquatic ecosystems can be evaluated using water quality parameters and plankton community structure. The finding for the ST-4 area, which is used for illegal mining and residential areas, indicates that this specific location moderately polluted conditions as demonstrated by TSS, color, and BOD which exceed Class III water use standards. On the other hand, the river in the area of plantation and forestry was found to meet the water quality standard. The pollution load-carrying capacity of the downstream Way Umpu River (ST-7) is still in the range of standard for Class III water use. The condition of the plankton community structure in each study location was found to be evenly distributed ($0.41 < E < 0.60$ and $0.61 < E < 0.80$) with low dominance ($0 < D \leq 0.5$) and a moderate diversity index ($1 < H < 3$). It should be noted that several species of plankton as an indicator of organic pollution was observed.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

The authors express their sincere gratitude to the Research and Public Service Institution of Lampung University for proving research funds through the professorship grant scheme (Hibah professorship) with grant number: 1674/UN26.21/PN/2021. The authors also express their sincere gratitude to the Head of Environment Service in Way Kanan District of Lampung Province for his help during this research.

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