RESEARCH ARTICLE

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The Water Chemistry Quality of the Ex-sand Mining Sites in Gantar District, West Java, for Freshwater Fish Cultivation

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ABSTRACT

Sand mining activities in Gantar District, Indramayu Regency, West Java, have changed water morphology and quality. Many ex-sand mining areas have left large ponds that have not been utilized optimally by the community around the mining area. The research aims to analyze the suitability of water quality in the ex-sand mining area for freshwater fish cultivation. Observations in three water ponds in Bantarwaru Village, Gantar District, in August 2022. Water quality measurements in situ and the laboratory. Water quality parameters observed in situ measured temperature, water depth, brightness, dissolved oxygen (DO), and pH. Laboratory measurements included TSS, TDS, BOD, COD, and chemical elements such as total phosphate, nitrate, nitrite, ammonia, sulfate, and iron. The data obtained were analyzed descriptively by making comparisons with the standard water quality based on standards of Government Regulation Number 22 of 2021 concerning Management of Water Quality and Control of Water Pollution. To find out how suitable the suitability for freshwater fish farming is. Suitability analysis using the weighting and scoring method. The scoring results for ex-sand mining ponds for freshwater fish farming are 81–91% and classified as moderately to highly suitable. This score is good for freshwater fish cultivation.

Keywords: cultivation, ex-sand mining, freshwater fish, Gantar, ponds

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I. Introduction

In the 2000s, the Gantar District, Indramayu Regency area, was a large enough vegetable-producing area. However, with increasing infrastructure development around Indramayu, Subang, and Sumedang Regency, either in the form of the construction of the Cipali Toll Road and the Cisumdawu Toll Road or the PLTU in Indramayu power plant, as well as the construction of the Sadawarna Dam and Jatigede Dam in Subang and Sumedang Regencies; has caused a change in the pattern of society in Gantar District and its surroundings; from an agrarian society to a mining society (in this case, sand miners). To meet the material needs of sand, gravel, and earth fill for these infrastructure activities, the materials from productive land around the Gantar sub-district. With the money from the sale of wide land/sand, many community landowners sell land or lease land to illegal or official sand miners (having mining permits from the Mining Office of West Java Province).

The open pit mining method carries out sand mining, which can change the earth's surface. Because of this, mining activities are often associated with environmental damage [1]–[3]. Although this statement is not always true, the fact that many mining activities positively impact the community and environment around the mining area can be recognized [4]–[6]. However, on the other hand, sharp changes can occur in the quality of the environment at the mining site, the quality of human life in the mining area, and making the natural surroundings better organized, with complete infrastructure. Because mining activities can be attractive, many residents move closer to the mining location. Even though sand mining activities can have a positive impact on the community and local revenue (PAD) [7], mining activities often cause environmental damage, resulting in a decrease in ecological quality, such as changing soil physical properties, reducing land fertility, damage to land in the river channel and riparian areas, physical and chemical damage to the soil and erosion hazards; which in turn will threaten and endanger the survival of local humans [8]. The impacts include, among others, the physical, chemical, and biological conditions of the soil becoming worse; for example, the soil layer is not profiled, compaction occurs, a shortage of essential nutrients, low pH, contamination by heavy metals on ex-mining land, and a decrease in the population of soil microbes [9]–[11].

The end of several mining activities from various companies in Gantar District has left several ponds, both large and small, with depths ranging from 5 to 10 m; in Bantarwaru Village in the Western part of District Gantar, there are three ponds, consisting of Pond-1 (ST-1) measuring 35 m × 18 m × 10 m; Pond-2 (ST-2) with dimensions of 15 m × 10 m × 8 m; and Ponds-3 (ST-3) with a size of 11 m × 8 m × 5 m. These water ponds can be utilized as a reservoir source to be used by the surrounding community as a source of clean

water, freshwater fish farming, and irrigation. However, at this time, the community does not utilize this potential. These water ponds are pools of water formed from sand mining activities that leave basins filled with water. The pond's bedrock and the pool's walls are composed of volcanic material in the form of tuff rocks ranging from coarse to fine. At the same time, the pond's water source comes from groundwater and rainwater from time to time. During the summer, this pool of water never dries up.

The purpose of research on water quality in ponds, formerly sand mining, was to determine the quality of water in water ponds and the condition of the water contained in water ponds related to the feasibility or suitability of habitat for fisheries for freshwater fish cultivation.

II. Materials and Method

A. Study Area

The coordinate of the studied area is part of Gantar District, Indrmayu Regency at 107°53' 9.9456" East and 107°53' 12.3468" East longitudes and -06°33' 29.3832" South and -06°33' 29.8464" South latitudes.

We conducted Water quality observations from October 2020 to September 2021. Three water samples from three water pond stations represent the characteristics of the location of the ex-sand-mined area. Use the Global Positioning System (GPS) to locate these stations' coordinates. In the northern part of Bantarwaru Village at 06° 33' 29.3832"and 105° 46' 25" E., Station 1 (ST-1) is a relatively wide and fairly old sand excavation area. In the middle of Bantarwaru Village) at 5° 31' 30" S, and 105° 46' 17" E., Station 2 (ST-2), is identified. Station 3 (ST-3) in the eastern part of Bantarwaru Village has 5° 33' 06" S and 105° 46' 29" E coordinates. These locations are the most extensive ex-mining location (Fig. 1).

Fig. 1. Sampling sites of ponds in Gantar District (black color).

B. Sampling

In this study, observations and measurements of research of water samples from three ponds were conducted directly on-site (in situ) and in the laboratory. In situ, the measure of water quality's physical parameters consists of temperature and clarity. In contrast, chemical parameters consist of dissolved oxygen (DO) using a DO Meter, Dissolved Oxygen Tester, and pH using a pH Meter. In the IPB University laboratory, the physical parameters of water quality consist of four parameters measured, namely: Total Suspended Solid (TSS), Total Dissolved Solid (TDS), odor, and color, while the chemical parameters consist of 29 parameters, namely *Biological Oxygen Demand (*BOD), *Dissolved Oxygen / Oxygen Demand (*DO), *Chemical Oxygen Demand (COD)* and metal and non-metal chemical elements. The chemical parameter measurement method uses the APHA standard, 23rd Edition, 2017, except for ammonium (NH_3) measurements use a UV-Vis Spectrophotometer.

C. Data Analysis

A comparative analysis uses water's physical and chemical quality in a pool of water by comparing the measured water quality with the quality standard for aquaculture based on the quality standard of the Republic of Indonesia Government Regulation No. 22 of 2021 concerning Management of Water Quality and Control of Water Pollution, with the division of classes I-IV, namely:

- Class I: water designated as drinking water and other uses that require the same water quality as that use;
- Class II: water for water recreation facilities and infrastructure, freshwater fish cultivation, animal husbandry, and water for irrigating plants;
- Class III: water for cultivating freshwater fish, livestock, rinsing plants, and other uses that require the same water quality as that user.
- Class IV: water used to irrigate plants.

The weighting and scoring methods were to identify water quality suitability for freshwater fish farming; therefore, the 14 parameters were measured [12]–[14]. In determining the suitability level of utilization, a suitability value of each parameter assigned by; i.e., a value of 5 is very appropriate, a value of 3 is sufficient, and a value of 1 is inappropriate.

The three groups' suitability level of pool water quality on the suitability score, Group I, with a suitability value of 85-100 v%, is classified as highly suitable. This group has no constraints for the development of freshwater fish culture. Group II, with a suitability value of 75-84 %, is classified as moderately suitable. This group has a few constraints: a minor treatment for developing freshwater fish cultivation. Group III, with a suitability value of 55-74 %, is classified as marginally suitable. This group has a big obstacle: significant treatment for the water suitable for freshwater fish cultivation.

III. Result and Discussion

Water's physical and chemical properties reflect the water's quality and the environment. Water is a medium for life and aquatic bodies. Specific measurements of water quality are needed to determine its designation. Water quality characteristics differ for various purposes; for example, the purposes of freshwater fish farming will differ from those for agriculture or households.

A. Physical Parameters of Water Quality

The measurement of the physical parameters of water quality at the location of water ponds at ex-sand mining, either *in situ* or in the laboratory, is shown in Table I.

In situ measurements of the physical parameters of the water sample are temperature and clarity level. The measurement results are shown in Table I, indicating that the mean water

temperature in the water ponds of the ex-sand mining areas ranged from ST-1, ST-2, and ST-3, 29.5 ºC, 29 ºC, and 29.6 ºC, respectively. Based on Government Regulations 22 of 2021, the water quality is Class II and Class III. The temperature conditions have exceeded the quality standard for fish cultivation. Some researchers also agree with the temperature range; freshwater fish growth conditions will be optimal at the temperature range between 24–32 ºC [15]–[17].

The results of measuring the clarity level of the waters in the ex-sand mining ponds in all observation stations showed a range between 5.7–10.9 m, with the mean clarity level at ST-3 is 1.9 m; ST-1: 6.4 m and ST-2: 7.8 m; and ST-3: 8.8 m. Hastari *et al.* [17] argue that a clarity level greater than 5 m with a water pond depth ranging from 10–40 meters is ideal for developing freshwater fish. A low level of clarity will disrupt photosynthesis and the development of phytoplankton, so fish growth is not optimal. Each station's average clarity level is between 6.4 m and 8.8 m; the water can support the development of freshwater cultivation.

The measurement of total suspended solids, commonly known as TSS, shows the highest value at ST-3 (17.2 mg/L) and the lowest value at ST-1 (8.4 mg/L). Other physical water quality of Total Dissolved Solids (TDS) ranged between 124 to 274 mg/L (Table I), while the average value of TDS from ST-1, ST-2, and ST-3 is 178.33 mg/L. The average TSS and TDS in each research location are still below under the conditions set by the water quality standards of the Government Regulation of the Republic of Indonesia No. 82 the year 2001 (class II); 81mg/l for TSS, and 1000 mg/L for TDS, so the ex-sand mining pool is suitable for fish.

B. Chemical Parameters of Water Quality

Table II presents the chemical parameters of water quality from ex-sand mining.

The acidity (pH) degree is essential in determining water quality for freshwater fish farming. The pH value describes the amount or activity of hydrogen in water. Low pH values in fish farming can cause the solubility of metals in the water to increase and are toxic to aquatic organisms. In contrast, high pH values can increase the concentration of ammonia in water, which is also harmful to marine organisms. The proper pH for fish growth ranges from 6.5–8.5 [17], [18]. The pH value measured in the ex-mining pond shows normal conditions - alkaline at ST-1 and ST-2, while in ST-3, it tends to be more acidic (Table II). Thus, ST-1 and ST-2 water ponds are suitable for freshwater fish farming. Meanwhile, the ST-3 water pond needs to increase the pH value to be a freshwater fish farming pond. To raise the pH level to 7 (neutral pH), add limestone or crushed stone, aerate the tank water with an air pump to remove excess carbon dioxide that forms in low pH water, or use an alkaline buffer to neutralize acids and make it a more neutral pH.

The range of dissolved oxygen for good fish farming is more excellent than four mg/L [20]. The concentration range of dissolved oxygen in water used for sand mining in the Gantar District is 6.96–8.28 mg/L, classified as suitable for freshwater fish farming activities.

Biological Oxygen Demand (BOD) concentration in ponds suitable for use as freshwater fish farming ponds is 5.20–5.90 mg/L [21]. Likewise, the concentration of Chemical Oxygen Demand (COD) is still within the threshold of suitability for using freshwater fish farming, i.e., 50 mg/L [22]; the COD in ponds characterized by a range of COD values between 25.76 mg/L–29.52 mg/L.

One of the nutrients needed and influences the growth and development of living aquatic organisms is phosphate (PO_4), which is used as an indicator to determine water fertility [23]. Based on PP No. 22 of 2021, quality standards are at 0.2–1 mg/L for freshwater fish farming. Based on the criteria for the fertility of the waters mentioned above, ex-sand mining water ponds have a high fertility level (eutrophic) because they have a phosphate value between 0.043 mg/l to 0.071 mg/L [24].

The average ammonia concentration (NH_3) measured at ST-1: 0.23 mg/L; ST-2: 0.28 mg/L, and ST-3: 0.30 mg/L. Ammonia levels greater than 0.2 mg/L in water ponds will be toxic to several types of fish [25]. With measured ammonia concentrations at each pond water are in the upper limits based on Government Regulation 22 of 2021 concerning the quality standard of NH3 0.1–0.2 mg/L); ex-sand mining ponds need treatments for cultivating freshwater fish.

TABLE I: PHYSICAL CHARACTERISTICS OF WATER QUALITY IN WATER PONDS EX-SAND MINING

No	Parameters	ST-1		ST-2		ST-3	
		Range	Mean	Range	Mean	Range	Mean
1	Temperature (^{0}C)	28.4–32.8	29.5	29.1–33.4	29.9	29.3–30.1	29.6
2	Clarity (m)	5.7–7.8	6.4	6.8–8.3	7.8	6.9–10.2	8.8
3	TSS (mg/L)	8.4–9.2	7.7	8.5–11.2	9.9	12.8–17.2	15.4
4	TDS (mg/L)	126 - 146	136.0	124–164	146.0	240–275	253.0

TABLE II: CHEMICAL CHARACTERISTICS OF WATER QUALITY IN WATER PONDS EX-SAND MINING

No	Parameters	ST-1		ST-2		ST-3	
		Range	Mean	Range	Mean	Range	Mean
1	pH	6.8–7.6	7.1	7.1–7.4	7.3	5.1–5.9	5.5
2	DO (mg/L)	6.96–8.14	7.50	7.22–8.12	7.82	7.42–8.28	7.93
3	BOD (mg/L)	5.20–5.76	5.44	5.60–5.90	5.75	5.42–5.87	5.48
4	COD (mg/L)	25.76–26.72	25.71	28.53–29.52	28.44	26.18–26.75	24.94
5	PO_4 (mg/L)	0.025–0.071	0.051	0.016–0.043	0.032	0.052–0.081	0.067
6	NO_3 – N(mg/L)	0.12–0.98	0.56	0.61–0.98	0.78	0.94–1.14	1.02
7	NO_2 -N (mg/L)	0.012–0.035	0.024	0.002–0.065	0.046	0.005–0.045	0.028
8	NH_3-N (mg/L)	0.081–0.092	0.09	0.039–0.96	0.29	0.075–0.182	0.13
9	SO_4 (mg/L)	32-14–50.45	46.06	44.87–52.40	49.29	49.30–66.76	59.33
10	Fe (mg/L)	0.050–0.47	0.22	0.054–0.076	0.34	0.052–0.11	0.27

TABLE III: ASSESSMENT OF THE SUITABILITY OF WATER PONDS EX-SAND MINING

Parameters	Mean Value			Scoring	Weight	Total Scoring		
	ST-1	ST-2	ST-3			ST-1	ST-2	ST-3
Temperature (^{0}C)	29.5	29.9	29.6	5	5	25	25	25
Clarity (m)	6.4	7.8	8.8	5	5	25	25	25
TSS				5	5	25	25	25
TDS (mg/L)				5	5	25	25	25
pH				5 3	10	50	50	30
DO (mg/L)				5	15	75	75	75
BOD (mg/L)				5	10	30	30	30
COD (mg/L)				5	10	50	50	50
PO_4 (mg/L)	0.051	0.032	0.067	5	5	25	25	25
NO_3 -N (mg/L)	0.56	0.78		5	10	50	50	
			1.02	3				30
NO_2 -N (mg/L)	0.024	0.046	0.028	3	5	15	15	15
NH_3-N (mg/L)	0.12	0.16	0.13	3	10	30	30	30
SO_4 (mg/L)	46.06	49.29	59.33	5	5	25	25	25
Fe (mg/L)	0.22	0.34	0.27	5	5	25	25	25
				Total Score		455	435	405
				Suitability Score (%)		91	87	81

The nitrite (NO_2) average concentrations in the ex-sand mining ponds are all in the upper the maximum quality standard threshold determined by Government Regulation 22, 2021, i.e., 0.06 mg/L for nitrite (Table II), Measured average nitrate (NO_3) concentration at ST-1: 1.06 mg/L, ST-2: 1.09 mg/L, and ST-3: 1.02 mg/L; indicates that the condition of the pond water is less fertile to moderate for freshwater fish farming [26]. Setiadi *et al.* [26] recommend that a good nitrate concentration for aquaculture is <1.0 mg/L.

The concentration of sulfate (SO_4) detected at ST-1 was 50.45 mg/L, at ST-2: 52.40 mg/L, and at ST-3: 49.30 mg/L. This sulfate concentration is still far below the threshold specified by Government Regulation 22, 2021, i.e., 300 mg/L. The concentration of Fe at all sampling points in the ex-sand mining ponds shows low concentrations, i.e., below 0.050 mg/L. This condition makes it possible to use water ponds formerly sand mining for freshwater fish farming. It is still far below the quality standard required in Government Regulation 22, 2021, i.e., <0.3 mg/L.

C. Water Quality Suitability for Cultivating Freshwater Fish

Determining the suitability of the waters is done using a modified weighting and scoring method—the expert judgment method to determining the weight and scoring of water quality suitability parameters. The parameters refer to the standard data of Government Regulation 22, 2021, and other scholars [28]–[31]. A total of 14 parameters used as a reference in this study were temperature, water clarity, dissolved oxygen (DO), pH, Phosphate (PO_4-P), Nitrate (NO_3-N), Nitrite (NO_2-N), and Sulfate (SO_4), iron (Fe). Table III shows the score for the assessment of the former sand mining area for cultivation. The results of the suitability analysis with weighting and the scoring method show a suitability score of 91% for ST-1, 87 % for ST-2, and ST-3: 81%.

Thus, based on the suitability score, the ex-sand mining water quality at Gantar is grouped into moderately suitable at ponds ST-3 with a score of 81% and highly suitable ST-2 and ST-1 with 87 % and 91 %, respectively.

IV. CONCLUSION

Referring to the measurement results of 14 ex-sand mining quality parameters area in the Gantar Region is still feasible. It meets the threshold value of water quality standards stipulated by Government Regulation No. 22 of 2021 freshwater fish culture as moderately suitable (ST-3), highly suitable ST-1 and ST-2. Even though all the ex-sand mining water quality conditions are very suitable for freshwater fish development; however, some parameters require treatment, such as pH, nitrate, nitrite, and ammonia, to improve water quality to make it suitable for freshwater fish culture activities.

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CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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