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Management of Clean Water Resources at Renzo Edupark, Sukabumi, West Java

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Abstract: This study examines the quality and management of clean water in Renzo Edupark, Cibadak, Sukabumi, a reclaimed area of a former silica sand mining site. Water samples were collected from three points—the main reservoir, the final reservoir, and a dug well—for analysis using parameters of TDS, TSS, pH, BOD, COD, DO, ammonia, Mn, Zn, and Pb, in accordance with Government Regulation of the Republic of Indonesia No. 22 of 2021. Laboratory test results indicated that five parameters—pH, BOD, COD, Mn, and Zn—did not meet the quality standards, with low pH (4–5) indicating acidic conditions, high BOD and COD values, and Mn and Zn concentrations exceeding the threshold limits. These conditions have led to fish mortality and declining water quality. Several improvement methods were proposed, including neutralization using NaOH or quicklime, as well as biological and chemical treatments. The coagulation–flocculation method was found to be the most effective, reducing COD by up to 79% and increasing pH to 8.5 with specific doses of chlorinated lime, quicklime, and alum. This study recommends the application of coagulation–flocculation as a practical and economical solution for revitalizing water quality in the area.

Keyword: water quality, pH, BOD, COD, coagulation–flocculation, Renzo Edupark

INTRODUCTION

The general condition of water resources in Indonesia, based on research conducted by the Water Resources Research and Development Center of the Ministry of Public Works in 2009, shows that Indonesia still possesses substantial water reserves, amounting to 2,530 km³, ranking fifth in the world. However, the distribution of water resources in Indonesia is actually uneven. In the western region, water availability is relatively abundant, while in the eastern and southern regions, it is limited, leading to recurring threats of water crises in several parts of the country (Fitriyah and Maulana, 2018), with concerns that this may become more widespread. This situation is exacerbated by uneven population distribution. For instance, Java Island accounts for only seven percent of Indonesia's land area, yet approximately 65 percent of the country's population resides there, while its water potential is only 4.5 percent of Indonesia's total water resources. The Second World Water Forum held in The Hague in March 2000 had already predicted that Indonesia would be among the countries to face a water crisis by 2025. One of the main causes is poor water management, including inefficient water usage (Baidhowie et al., 2020).

Water needs to be managed properly to ensure its availability in terms of both quantity and quality so that it can benefit human life. Clean and safe water conditions, among others, must be free from contamination by germs or pathogens, free from harmful or toxic chemical substances, tasteless and odorless, suitable for domestic and household needs, and meet the minimum standards set by the WHO or the Ministry of Health of the Republic of Indonesia (Baidhowie et al., 2020). Furthermore, water quality standards are explained in Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management.

The consumption of safe drinking water must, of course, come from clean and secure sources. This issue is a major problem at Renzo Edupark, located in the Cibadak area. Renzo Edupark is the result of a collaboration between PT Holcim Indonesia Tbk and the Faculty of Forestry, Bogor Agricultural University (IPB), in reclaiming a former silica sand mining site owned by Holcim Indonesia in Cibadak, Sukabumi, transforming it into the Holcim Educational Forest (HEF). At Renzo Edupark, it is evident that the water available in the area cannot be used by the surrounding community for daily needs.

Based on observations and measurements carried out, as well as the existing situation and conditions, the water around Renzo Edupark has a low pH. The location's proximity to silica stone mining operations has caused water contamination. Therefore, this study was conducted to determine the substances present in the water that render it unfit for consumption.

METHOD

This study was conducted in the Renzo Edupark area, located on Jl. Nasional III, Sekarwangi, Cibadak District, Sukabumi Regency. Water samples were collected from three different points: the main reservoir (embung utama), the final reservoir (embung akhir), and a dug well. A reservoir (embung) is a micro-scale water storage pond constructed to capture excess rainwater during the rainy season. The stored water is then used as an irrigation source during the dry season or when rainfall becomes scarce. Reservoirs are one of the most suitable water harvesting techniques for all types of agroecosystems (Fikri and Siregar, 2020).

This study, referring to Annex VI of Government Regulation of the Republic of Indonesia No. 22 of 2021, employed a descriptive survey method to provide an overview of water quality at the source (in-situ) and to conduct water quality testing (ex-situ) at the PT Unilab Perdana laboratory in South Jakarta. The obtained data were analyzed qualitatively in a descriptive manner, where laboratory test results were compared with the water quality standards specified in Government Regulation of the Republic of Indonesia No. 22 of 2021 concerning environmental protection and management. The parameters used in the laboratory tests included Total Dissolved Solids (TDS), Total Suspended Solids (TSS), pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), ammonia, manganese (Mn), zinc (Zn), and lead (Pb).

Renzo Edupark has both a main reservoir and a final reservoir. The main reservoir functions as the primary water collection point before the water is channeled into the final reservoir. Water from the main reservoir flows through pipes installed for this purpose toward the final reservoir. Sampling at the main reservoir was conducted once by placing a 5-liter jerry can into the pipe that channels water from the main reservoir.

RESULT AND DISCUSSION

Laboratory testing to determine the water content of the two water storage reservoirs and the dug well at Renzo Edupark was carried out at PT Unilab Perdana, South Jakarta. The results showed that, of the parameters tested, five did not meet the water quality standards specified in Annex VI of Government Regulation of the Republic of Indonesia No. 22 of 2021 concerning the implementation of environmental protection and management.

During the sampling process, water taken from the pipe flow appeared slightly brownish in color. The laboratory test results for water from the main reservoir are presented in Table 1.

Table 1. Laboratory Test Results for Water from the Main Reservoir

NO	PARAMETER	UNIT	QUALITY STANDARD	RESULT
A	**Physical**			
1	Total Dissolved Solids (TDS)	Mg/L	1.000	257
2	Total Suspended Solids (TSS)	Mg/L	40	<2
B	**Chemical**			
1	Acidity Level (pH)	-	6-9	4
2	Biochemical Oxygen Demand (BOD)	Mg/L	2	5
3	Chemical Oxygen Demand (COD)	Mg/L	10	25
4	Dissolved Oxygen (DO)	Mg/L	6	4,0
5	Ammonia	Mg/L	0,1	<0,03
6	Dissolved Manganese (Mn)	Mg/L	0,1	9
7	Dissolved Zinc (Zn)	Mg/L	0,05	0,2
8	Dissolved Lead (Pb)	Mg/L	0,03	<0,009

In the main reservoir, water is collected from a spring source before being supplied to several downstream reservoirs. Based on the analysis results in Table 1 above, the parameters measured were as follows: pH of 4, Biochemical Oxygen Demand (BOD) of 5 mg/L, Chemical Oxygen Demand (COD) of 25 mg/L, Dissolved Manganese (Mn) of 9 mg/L, and Dissolved Zinc (Zn) of 0.2 mg/L. These results indicate that the water in the main reservoir does not meet the surface water quality standards stipulated in Annex VI of Government Regulation of the Republic of Indonesia No. 22 of 2021.

The final reservoir serves as the last collection point for water that flows from the main reservoir through pipelines to several other reservoirs. Water sampling in the final reservoir was conducted once by collecting water directly from the reservoir using a 5-liter jerry can. On Friday, January 21, 2022, during the sampling process, all the fish in the final reservoir were found dead, whereas on Wednesday, January 19, 2022, some fish were still alive. The water in the final reservoir also appeared green in color. The laboratory test results for water from the final reservoir are presented in Table 2.

Table 2. Laboratory Test Results for Water from the Final Reservoir

NO	PARAMETER	UNIT	QUALITY STANDARD	RESULT
A	**Physical**			
1	Total Dissolved Solids (TDS)	Mg/L	1.000	194
2	Total Suspended Solids (TSS)	Mg/L	40	5
B	**Chemical**			
1	Acidity Level (pH)	-	6-9	4
2	Biochemical Oxygen Demand (BOD)	Mg/L	2	5
3	Chemical Oxygen Demand (COD)	Mg/L	10	23
4	Dissolved Oxygen (DO)	Mg/L	6	4,2
5	Ammonia	Mg/L	0,1	<0,03
6	Dissolved Manganese (Mn)	Mg/L	0,1	6
7	Dissolved Zinc (Zn)	Mg/L	0,05	0,2
8	Dissolved Lead (Pb)	Mg/L	0,03	<0,009

Based on the analysis results in Table 2, the parameters obtained were pH of 4, Biochemical Oxygen Demand (BOD) of 5 mg/L, Chemical Oxygen Demand (COD) of 23 mg/L, Dissolved Manganese (Mn) of 6 mg/L, and Dissolved Zinc (Zn) of 0.2 mg/L. It can therefore be concluded that the water in the final reservoir does not meet the surface water quality standards as stipulated in Annex VI of Government Regulation of the Republic of Indonesia No. 22 of 2021.

A dug well is water obtained directly from the ground by drilling to a certain depth. The dug well water in Renzo Edupark is still considered to not meet the quality standards because the soil used for the dug well comes from seepage of silica stone mining residues. Water sampling from the dug well was conducted once by opening the water pipe flow and filling a 5-liter jerry can. The water taken from the dug well was brownish in color and slightly turbid. The laboratory test results for dug well water are presented in Table 3.

Table 3. Laboratory Test Results for Dug Well Water

NO	PARAMETER	UNIT	QUALITY STANDARD	RESULT
A	**Physical**			
1	Total Dissolved Solids (TDS)	Mg/L	1.000	266
2	Total Suspended Solids (TSS)	Mg/L	40	120
B	**Chemical**			
1	Acidity Level (pH)	-	6-9	5
2	Biochemical Oxygen Demand (BOD)	Mg/L	2	45
3	Chemical Oxygen Demand (COD)	Mg/L	10	140
4	Dissolved Oxygen (DO)	Mg/L	6	0,5
5	Ammonia	Mg/L	0,1	<0,03
6	Dissolved Manganese (Mn)	Mg/L	0,1	2
7	Dissolved Zinc (Zn)	Mg/L	0,05	0,06
8	Dissolved Lead (Pb)	Mg/L	0,03	<0,009

Based on the analysis results above, the parameters obtained for the dug well water were pH of 5, Biochemical Oxygen Demand (BOD) of 45 mg/L, Chemical Oxygen Demand (COD) of 140 mg/L, Dissolved Manganese (Mn) of 2 mg/L, and Dissolved Zinc (Zn) of 0.06 mg/L. It can be concluded that the dug well water does not meet the surface water quality standards as stipulated in Annex VI of Government Regulation of the Republic of Indonesia No. 22 of 2021.

The results of testing water samples from the main reservoir, the final reservoir, and the dug well at Renzo Edupark indicate that the water has low pH levels, which caused high fish mortality in the reservoirs. The pH values at all three sampling points ranged from 4 to 5, indicating acidic water conditions. This low pH is caused by high concentrations of carbon dioxide in the water, which leads to acidity. One method to neutralize acidic pH is by adding chemicals to the acid mine water. This chemical addition must be carried out carefully to achieve the desired quality standard. A chemical that can be used to increase the pH of acid mine water is sodium hydroxide (NaOH) solution, which is a strong base. In a study conducted by Irwan Ferdian, the addition of 0.6 mL NaOH increased water pH from 4.28 to 7.63. In addition to NaOH, quicklime (CaO) can also be used to raise the pH of acid mine water (Irwan Ferdian, 2020). Quicklime not only neutralizes acidic pH but also reduces iron and manganese content. The solubility of Fe (iron) in acid mine water is affected by pH—at low pH, metal solubility is high, whereas at neutral pH, solubility decreases. Neutralization by adding CaO or NaOH is therefore an effective treatment, with quicklime being the more economical option.

Samples from the main reservoir, the final reservoir, and the dug well also showed BOD levels exceeding the specified quality standard. BOD is an important indicator of water quality, as high BOD indicates low dissolved oxygen in the water. Elevated BOD levels can cause fish mortality due to oxygen depletion (anoxia). High BOD concentrations reduce fish populations in aquatic environments, and therefore biological treatment is required to restore water quality so that it can support the growth, development, and survival of aquatic biota (Daroni and Arisandi, 2020). BOD measures the amount of dissolved oxygen required by microorganisms to decompose organic matter under aerobic conditions.

The COD content in the main reservoir, the final reservoir, and the dug well also exceeded the quality standards. Factors influencing high COD include dissolved oxygen, organic substances, and other pollutant sources. COD can be reduced through microbiological processes. According to Alerts, COD represents the amount of dissolved oxygen required by oxidizing agents to oxidize various organic compounds. High COD levels can reduce the ability of a water body to maintain ecosystem balance. Various methods are available for treating wastewater, one of which is the use of powdered coconut shell activated carbon. Hartanto explains that activated carbon is an amorphous carbon material consisting of flat carbon atom plates bonded covalently in a hexagonal lattice, with one carbon atom at each corner (Mefiana, 2021).

The manganese (Mn) content in the main reservoir, the final reservoir, and the dug well also exceeded the clean water quality standard. Referring to wastewater treatment results, appropriate treatment methods include neutralization and coagulation. A study by Irwan Ferdian (2021), titled "Analysis of Acid Mine Water Treatment Success Based on pH, TSS, Fe, and Mn Parameters at KPL AL 01 PT Bukit Asam, Tbk", used active treatment methods including the addition of quicklime (CaO), sodium hydroxide (NaOH), and Kuriflok. NaOH was applied via a gravity flow system through water pipelines, while quicklime was manually added to the water channel. This treatment reduced Mn concentration from 1.3 mg/L to 0.6 mg/L, showing significant reduction after pH was neutralized. The solubility of Mn is high at low pH and decreases as pH approaches neutral. This method could be applied in Renzo Edupark by constructing a tank into which water from the final reservoir and dug well is directed via gravity flow. Care must be taken in chemical dosing to ensure the resulting water quality meets the standards.

Zinc (Zn) levels also exceeded the clean water quality standard. Zinc is found in industries such as alloy production, ceramics, cosmetics, pigments, and rubber manufacturing. Although Zn toxicity is generally low and zinc is essential for metabolic processes, high concentrations can be toxic. In water, Zn can cause astringency and symptoms such as diarrhea and vomiting. It can also make water appear opalescent, and when boiled, form sediment similar to sand. One method for reducing Zn levels is the electrochemical process. A study by Atikah (2021), "Removal of Metals from Songket Weaving Wastewater Using Electrochemical Methods", describes a continuous process using direct electrical current to drive electrochemical reactions—specifically redox reactions—between electrodes, one of which is metal. In the laboratory-scale batch experiment, 1 liter of wastewater was treated with 0.5 A current and 12 V voltage for 20–60 minutes using aluminum plate electrodes of various sizes (24, 32, and 40 cm^2) placed 5 cm apart. The reaction produced gas, foam, and $Al(OH)_3$ flocs, which adsorbed Zn and Fe and subsequently settled. With 60 minutes of treatment and 40 cm^2 electrode plates, Zn concentration was reduced from 1.02 mg/L to 0.02 mg/L, a 98.04% reduction. While effective, applying this method to Renzo Edupark would be difficult due to the large scale, requiring large aluminum plates and high electrical input.

Coagulation–flocculation is another wastewater treatment method. However, it is less effective if the solution contains suspended particles forming colloids, and must be performed in stages. This method is chosen for its simplicity, ease of application, relatively low cost, and ability to meet quality standards. In a study by Rusydi et al. (2017), the initial water had alkaline pH and COD above the standard. Adding bleaching powder (calcium hypochlorite) reduced COD concentration, and further addition of quicklime (CaO) reduced COD to its lowest level at a dose of 0.5 g, though it increased pH. Alum was then used as a coagulant to bind pollutants and metals into flocs for sedimentation. Alum also helped reduce pH, with a dose of 1 g being used (Rusydi, Suherman, and Sumawijaya, 2017).

CONCLUSION

In this study, it can be concluded that the method that can be used to improve the water condition in the Renzo Edupark reservoirs is the coagulation–flocculation process. Using this process can reduce COD levels by up to 79% and increase pH to 8.5, with dosages of 2 g bleaching powder (calcium hypochlorite), 0.3 g quicklime (CaO), and 1 g alum for every 500 ml of water sample. The coagulation–flocculation process can be effectively applied and is considered capable of improving the water quality in the Renzo Edupark reservoirs.

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