International Journal of Scientific Advances
ISSN: 2708-7972
Volume: 5 | Issue: 6 | Nov – Dec 2024 Available Online: www.ijscia.com
DOI: 10.51542/ijscia.v5i6.102

Water Quality Assessment for Raw Water Utilization from Saguling Dam or Saguling Supply Tributaries

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ABSTRACT
The objective of this study is to evaluate the water quality status of Saguling dam and its tributaries in order to determine optimal locations for raw water intake for water treatment plants (WTP). The assessment is centered on pivotal parameters, including dissolved oxygen (DO), pH, and total dissolved solids (TDS), which were measured in situ at 11 sampling points. The water quality was analyzed using the Pollution Index method, in accordance with the standards set forth by the Indonesian regulatory authorities. The findings indicate that the water quality in the region exhibits a range from compliance with established standards to slight contamination. The quality of water at points such as Cilanang, Cijenuk, Ciminyak, Saguling dam, and Cibitung meets the requisite standards and is thus suitable for intake locations, thereby reducing the necessity for extensive treatment. However, points such as Citarum-BBS, Cihaur, and Cijambu exhibit slight pollution, necessitating careful management to mitigate contamination. Among the locations, the Cibitung River is identified as the most optimal intake site due to its superior water quality. This research underscores the significance of strategic intake site selection and comprehensive water management to guarantee a sustainable and reliable clean water supply while supporting environmental conservation.

Keywords: water quality; drinking water; and Saguling dam.

INTRODUCTION
The demand for water in the Greater Bandung Metropolitan Area, which encompasses Bandung City, Cimahi City, Bandung Regency, West Bandung Regency, and portions of Sumed Regency, persists in rising due to a confluence of factors, including population growth, urbanization, industrial expansion, climate change, and the necessities of the ecosystem. Based on projections, the demand for the Drinking Water Supply System (SPAM) in this region will reach 23.06 m^3/second in 2030 [1]. In order to meet these needs, an increase in production capacity at the existing Water Treatment Plant (WTP) is required, or the construction of a new WTP to support an adequate clean water supply.

One potential solution is the utilization of raw water sources from the Saguling Dam and its supplying tributaries. Saguling Dam, which is one of the three principal reservoirs in the Citarum River basin, exhibits a comparatively lower level of pollution in comparison to other sub-watersheds, including Ci Kapundung and Ci Tarik. Moreover, the reservoir fulfills the functions of flood control, temporary water storage, fish farming with floating net cages (KJA), and a tourism development center that generates substantial economic benefits for the local community and government [2].

The development of the environment surrounding the Saguling Dam has rendered it a pivotal multifunctional resource. Accordingly, enhancing the capacity and efficiency of the Saguling dam-based raw water treatment plant represents a primary objective. A comprehensive examination of the potential and challenges associated with the management of this water source is essential to ensure the long-term sustainability of the water supply, while simultaneously addressing the needs of the community and promoting environmental sustainability.

RESEARCH METHODOLOGY
Study Area
The present study focuses on the Saguling Dam and its supplementary tributaries. A total of 11 points are distributed throughout the study area and are to be evaluated with regard to their suitability for water quality and the potential feasibility of utilizing them as water intake locations for raw water designation. The precise locations of all sampling points are illustrated in Figure 1 below.

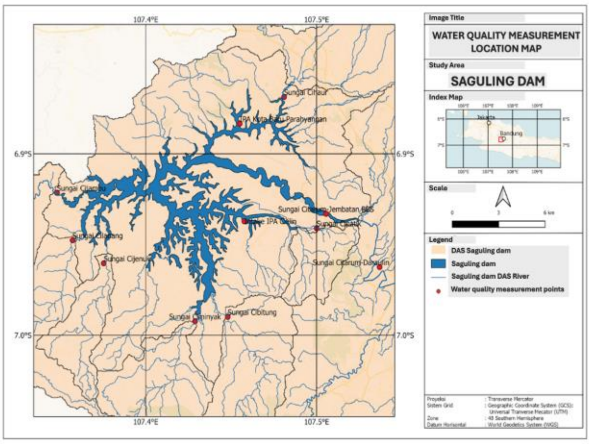

FIGURE 1: Study Area.

Water Quality Measurement

The present study encompasses an investigation of the following parameters: dissolved oxygen (DO), total dissolved solids (TDS), and pH. Measurements are conducted directly in the field, or other terms, in situ measurements are taken. Surface water quality testing was conducted in accordance with the Standard Methods for the Examination of Water and Wastewater 23rd Edition 2017, published by the American Public Health Association (APHA). This involved the use of instrumentation, including pH meters, DO meters, and TDS meters.

Data Analysis

The assessment of water quality in Saguling Dam and its supplementary tributaries requires the evaluation of its suitability based on water quality measurements that align with the standards set forth in Government Regulation Number 22 of 2021, Class I. Subsequently, the water quality status was determined based on the Pollution Index method outlined in Minister of State for the Environment Decree No. 115 of 2003, which provides guidelines for determining the water quality status. The Pollution Index value for each sampling point can be calculated using the following equation:

$$IP_j = \sqrt{\frac{\left(\frac{C_i}{L_{ij}}\right)^2_M + \left(\frac{C_i}{L_{ij}}\right)^2_R}{2}}$$

Note :

$(C_i/L_{ij})_M$ = The highest C_i/L_{ij} value among all monitoring parameters.

$(C_i/L_{ij})_R$ = Average C_i/L_{ij} values from all monitoring parameters.

IP_j = Pollution Index value for allocation/ purpose (j).

The determination of water quality status can be determined based on the obtained Pollution Index values calculated using the equation above, and the classification of water quality status is provided in the following Table 1.

TABLE 1: Classification of Water Quality Status Based on the Pollution Index (IP) Method.

Pollution Index	Interpretation
0 -1.0	Comply quality standards
1.1 – 5.0	Lightly polluted
5.1 – 10.0	Moderately polluted
>10	Highly polluted

RESULT AND DISCUSSION

Analysis of Water Quality

• *pH*

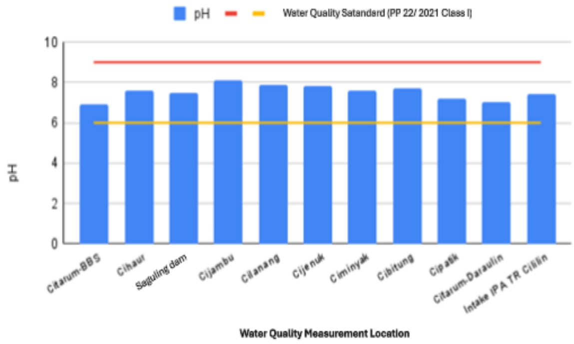

FIGURE 2: pH Concentration Profile in Saguling Dam and Saguling Supply Tributaries.

As illustrated in Figure 2, the pH parameters at all sampling points are within the quality standard range of 6-9, indicating that the acidity or alkalinity of the water remains within acceptable limits. It is of great importance to maintain a stable pH within the appropriate range in order to prevent corrosion or excessive alkalinity in the raw water, which could otherwise damage the water distribution system and affect consumer health. The pH parameter indicates the concentration of hydrogen ions dissolved in water, which reflects the equilibrium between acids and bases [3].

The pH value of water can serve as an indicator of balance, influencing the availability of essential chemical elements and nutrients for the growth of aquatic vegetation. Furthermore, the pH value of water plays a significant role in the survival of aquatic fauna, including fish and other organisms that inhabit these ecosystems. The typical pH range for water is 6.5 to 7.5, which is conducive to the survival of living organisms [4]. A pH value below the normal range indicates an acidic condition, whereas a pH value above the normal range indicates an alkaline condition. The pH value of water is primarily influenced by the presence of carbon dioxide in the aquatic ecosystem.

- *Dissolved Oxygen (DO)*

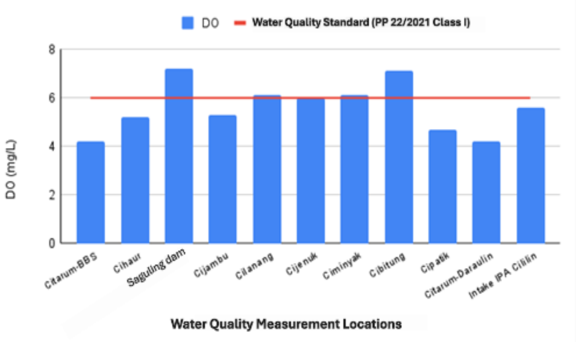

FIGURE 3: Dissolved Oxygen Concentration Profile in Saguling Dam and Saguling Supply Tributaries.

As illustrated in Figure 3, the water quality data for the DO parameter, as measured in the field, indicates that only the sampling points at Saguling dam (7.2 mg/L), Cibitung (7.1 mg/L), and Cijambu (6.1 mg/L) meet the quality standards. Other sampling points exhibited dissolved oxygen (DO) values that were below the standard, suggesting the potential for a dissolved oxygen deficit resulting from elevated microbial activity.

Low dissolved oxygen levels have the potential to impair the quality of raw water, as they can negatively impact aquatic life and indicate the presence of organic matter contamination. Dissolved oxygen (DO) serves as a crucial indicator of water quality, as it is involved in the oxidation and reduction of organic and inorganic materials [5]. A higher DO value indicates a lower level of pollution [6]. The concentration of dissolved oxygen in water is subject to a number of influences, including the movement of water masses, mixing processes, the activities of photosynthesis and respiration, and the input of waste materials into water bodies [7].

- *Total Dissolved Solid (TDS)*

FIGURE 4: Total Dissolved Solids Concentration Profile in Saguling Dam and Saguling Supply Tributaries.

As illustrated in Figure 4, the TDS parameter demonstrated that all sampling points remained below the maximum threshold of 1000 mg/L, indicating that the concentration of dissolved solids remained within safe limits. High TDS values have the potential to impact the taste and clarity of water, as well as human health.

Conversely, very low values at the Cibitung (19 mg/L) and Cilanang (35 mg/L) sampling points may indicate the presence of purer water or minimal dissolved mineral content. The total dissolved solid (TDS) parameter represents the content of dissolved materials with a diameter of 10^{-6} mm, as well as colloids with a diameter between 10^{-6} and 10^{-3} mm. These materials consist of chemical compounds and other materials that cannot be filtered using filter paper with a pore diameter of 0.45 μm [7].

The elevated TDS value also suggests the presence of dissolved sediment and elevated water turbidity [8]. Furthermore, the TDS concentration in water can influence the transparency and color of the water. The presence of elevated TDS concentrations in water can result in turbidity, which impedes the penetration of sunlight and disrupts the photosynthetic process. As posited by Effendi [7], the concentration of TDS in waters is influenced by a number of factors, including the process of rock weathering, runoff from the soil, and anthropogenic influences such as domestic and industrial waste. Additionally, Fardiaz [9] posits that the utilization of substances such as soap, detergents, and water-soluble surfactants in household and industrial activities can contribute to an elevation in the concentration of TDS in water.

Analysis of Water Quality Status

The evaluation of surface water quality is based on the assessment of a number of physical and chemical parameters. The primary objective is to ascertain the extent to which the quality of the water under review aligns with the standards set forth for specific purposes.

TABLE 2: Recapitulation of Pollution Index Values in Saguling Dam Water and Saguling Supply Tributaries.

Sampling Point	IP Value	Water Quality Status
Citarum-BBS	1.55	Lightly Polluted
Cihaur	1.14	Lightly Polluted
Saguling Dam	0.81	Meets quality Standards
Cijambu	1.15	Lightly Polluted
Cilanang	0.72	Meets quality Standards
Cijenuk	0.76	Meets quality Standards
Ciminyak	0.73	Meets quality Standards
Cibitung	0.48	Meets quality Standards
Cipatik	1.50	Lightly Polluted
Citarum-Daraulin	1.51	Lightly Polluted
Intake IPA TR Cililin	1.35	Lightly Polluted

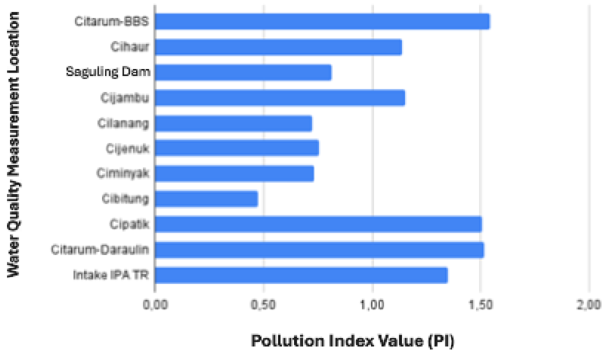

FIGURE 5: Recapitulation of Pollution Index Illustration in Saguling Dam and Saguling Supply Tributaries.

As illustrated in Table 2 and Figure 5, the water quality status and Pollution Index (PI) in the Saguling dam and Saguling tributaries demonstrate fluctuations in water quality that can be assessed through chemical and physical parameters.

Points with "Meets Quality Standards" status, including Cilanang, Cijenuk, Ciminyak, Saguling dam, and Cibitung, demonstrate favorable water quality and are deemed suitable for utilization as water intake locations for Water Treatment Plants (WTP), thereby reducing the necessity for costly supplementary treatment. In contrast, points with "Lightly Polluted" status, including Citarum-BBS, Cihau, Cijambu, Cipatik, Citarum-Daraulin, and PDAM Tirta Raharja Cillilin Water Treatment Plant Intake, necessitate more rigorous pollution management to mitigate the impact on water quality.

It is therefore imperative that a careful approach be taken in determining the optimal location for IPA intake, coupled with the implementation of a comprehensive management strategy, in order to guarantee the resilience of the clean water supply and to maintain environmental sustainability in the surrounding area. The analysis indicates that Cibitung River is one of the optimal locations for the IPA intake.

CONCLUSIONS

The analysis revealed that the water quality status in Saguling dam and its tributaries ranges from meeting quality standards to exhibiting slight pollution, as indicated by the parameters of dissolved oxygen, pH, and total dissolved solids. It can be concluded that the optimal location for the intake of raw water for utilization is in the Saguling Supply tributary, specifically in the Cibitung River.

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