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Assessment of Physical and Chemical Quality Standards for Water and Sanitation Disclosure Towards SDG 6: A Study in Wijimulyo, Nanggulan, Kulon Progo Regency

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Abstract Collaboration between academics, educators, students, village civil servants, and the community is needed to implement Sustainable Development Goal (SDG) 6. It is related to clean water and sanitation in the context of training vocational teachers and students to provide it to the community. First, measurements were made of the water quality around the research area. Sixty-three water samples were drawn from each resident's home's water supply. A multi-parameter water quality checker was used to evaluate the samples, and then spatial data processing was used. A temperature of 24.1°C, turbidity of 0.4 NTU, conductivity of 0.4 mS/cm, pH 7.1, salinity of 0.2 ppt, DO of 5.9 mg/l, and TDS value of 267 mg/l were measured. These average results indicate that the water quality satisfies both Indonesian National Standard 3553:2015 and the water quality criteria set by the Minister of Health of the Republic of Indonesia Regulation No. 2 Year 2023. However, the results of tracking every sampling location show that several samples fall short of water quality requirements because of the high mineral content, weather, and other factors. Every school and community organization needs to run scenarios to raise awareness about water quality standards involving the government, non-governmental organizations, and the private sector to implement SDGs 6, such as stakeholder engagement, community enhancement, and policy and regulation.

1. INTRODUCTION

Water, one of the natural elements needed to create and maintain various forms of life on earth, has basic properties, which are colorless, tasteless, and odorless at standard conditions. According to data from the Kementerian Pekerjaan Umum dan Perumahan Rakyat (2007), the minimum requirement for each person is 70 liters of water per day which the average water usage of households in Indonesia is 144 liters per person per day. On an international scale, the WHO (2022) set water quality standards entitled Guidelines for Drinking Water for Drinking Water Fourth Edition. On a national scale, the guidelines for water quality standards are in the form of a Minister of Health Regulation No. 2 of 2023, which contains drinking water and clean water quality standards

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as well as Indonesia's National Standard for Drinking Water.

Almost 29% of the world faces difficulty accessing clean water, with 70% of households in Indonesia consuming contaminated water (National Geographic, 2015; USAID, 2022). Factors include uneven water infrastructure, low economic levels, and high pollution (UNICEF, 2019). Maintaining water quality includes improving infrastructure, sanitation facilities, education, integrated water resource management, water use efficiency, and protecting the water ecosystem. The millennial generation can play a crucial role in achieving these standards.

This study seeks to assess water quality and sanitation standards in order to improve the knowledge, skills, and awareness of Vocational High School students as members of the millennial generation, as well as teachers as change agents in the implementation of SDG 6 in Vocational High School (SMKN 1 Nanggulan). This research object was chosen because this institution has the mandate to promote low-cost smart agriculture with adaptive technology, environment, sustainability, and focus on economic welfare which is convenient with the vision of Kulon Progo becoming an "aerotropolis city" in line with SDG 11 "Sustainable Cities and Communities".

2. METHOD

This research addressed national issues related to waste management, sanitation, and clean water availability for vocational students studying natural and social sciences. It measured groundwater quality in Wijimulyo using physical and chemical characteristics shown in Table 1, adhering to Indonesia National Standard 3553:2015 based on Badan Standardisasi Nasional (2015a). The findings provided information on water quality, aquatic ecosystem balance, and communal sanitation, impacting local industrial uses for drinking water and sanitary water quality.

Water samples were taken from as many as 67 samples from boreholes that were properly constructed and pollution-free, as well as local government-regulated and supervised water supply systems that respondents

Table 1 . Water sample testing parameter formula

Parameters	Formula	Description	Reference
pH	pH = $-log[H^{+}]$	$[H^{+}]$: ion concentration	(Tarigan, 2019)
TDS	TDS (ppm) = $EC(\mu S$/cm at 25°C) x 0.65	EC: electrical conductivity	(Rusydi, 2018)
	DS(mg/L) = $\frac{(A-B)\ x\ 1000}{volume\ sampel\ (mL)}$	A = weight of dry residue + vaporizer dish (mg) B = weight of empty vaporizer dish (mg)	(Badan Standardisasi Nasional, 2015b)
Temperature	-	-	-
Turbidity	Turbidity = $(2.3\ x\ A)/L$	A = light absorption L = optical length	(Len, 2023)
Salinity	Š = 0.3 + 1.805 $x\ K$	K = chlorinity	(Prakosa et al., 2020)
Dissolved oxygen	Dissolved oxygen (mg/l) = $\frac{V\ x\ N x\ 8000x\ F}{50}$	V = $Na_2S_2O_3$ (ml) N = normality $Na_2S_2O_3$ F = factor (bottle volume divided by bottle volume minus the volume of $MnSO_4$ reagent and alkali iodide azide)	(Badan Standardisasi Nasional, 2004)

Table 2 . Specifications of horiba u-50 multi-parameter water quality checker

Aspects	Sub-aspects	Specifications
Sensor probe	Measurement temperature	-10 to 50°C
	Max. sensor diameter	96 mm
	Probe length	340 mm
	Cable length	Standard: 2 meters
	Mass	1.800 grams
	Measurement depth	Max. 30 meters
Control unit	Dimensions	115 (W) x 66 (D) x 283 (H)
	Mass	800 grams
	LCD	320 x 240
	Data memory	10.000
	Battery	Battery C x 4
	Battery power	70 hours (500 measurements)
	Storage temperature	-10 to 60°C

commonly used. Information related to the water sources and sanitation treatment was carried out through questionnaires and direct observation of the research location. Water sample testing was carried out at the Quality Analysis and Standardization Laboratory, Department of Agro-Industrial Technology, Gadjah Mada University. Water sample quality testing was repeated three times for each parameter using a multi-parameter water quality checker instrument with tool specifications according to Table 2.

3. RESULT AND DISCUSSION

Since 2020, SMKN1 Nanggulan and the UGM research team have collaborated to promote an understanding of environmental sustainability in Kulon Progo. The Wijimulyo region, with high and low summer rainfall, requires high-quality water for industrial activities and sanitation. Municipal waterworks unit Kulon Progo Sentolo supports clean water services in the district. Data samples were collected from thirty main points in Wijimulyo, Nanggulan, Kulon Progo. In this study, each respondent was asked to send location points by sharing the position of the water source taken, covering the adjacent areas of Wijimulyo Village and SMKN Nanggulan, as well as environmental and social similarities, to represent accurate water source conditions (Figure 1).

Table 3 displays the results test, which measures the turbidity, temperature, pH, and DO parameters of the water quality in the Wijimulyo Region. This region has a tremendous normal result for the water's average value and satisfies the requirements for clean water and drinking water quality as set forth by Minister of Health Regulation No. 2 of 2023 and Indonesian National Standard 3553:2015. These standards include a minimum DO value of 4 mg/l, an air temperature of approximately 3°C, pH values between 6.5 and 8.5, and a maximum turbidity of 1.5 NTU. Furthermore, the Ministry of Health Regulation No. 2 of 2023 states that the TDS and conductivity parameters have levels that are quite near the upper limit of the drinking water quality regulations. According to the Ministry of Health Regulation No. 2 of 2023, the water quality standard of TDS is 300 mg/l, and according to the water quality standard from WHO, the maximum conductivity is 0.4 mS/cm (Meride & Ayenew, 2016).

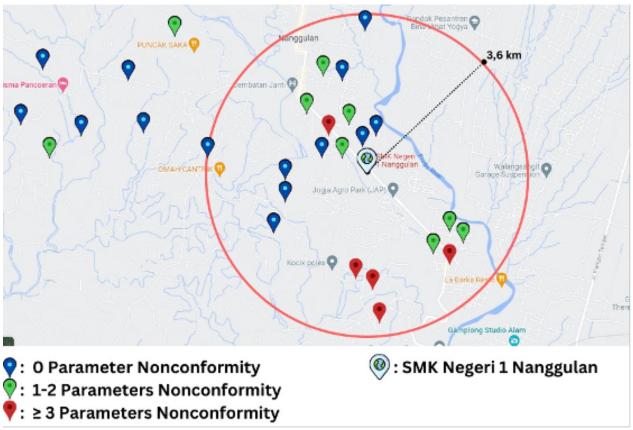

Figure 1 . Water sampling point of Wijimulyo area

The result of water quality in the Wijimulyo Region in terms of turbidity, temperature, pH, and DO parameters are measured in the triple test, which is shown in Table 3, had a great normal result water in average value and meets clean water and drinking water quality standards concerning quality standards Minister of Health Regulation No. 2 of 2023 and Indonesian National Standard 3553:2015 that water quality standard of temperatures approximately 3°C of air temperature, pH values in the range of 6.5 - 8.5, turbidity maximum 1.5 NTU, and minimum DO value of 4 mg/l.

In addition, TDS and conductivity parameters have values that are quite close to the threshold of the maximum value of drinking water quality standards. According to the Ministry of Health Regulation No. 2 of 2023, the water quality standard of TDS is 300 mg/l, and according to the water quality standard from WHO, the maximum conductivity is 0.4 mS/cm (Meride & Ayenew, 2016). The salinity parameter reached the proper value at the 0.2 ppt drinking water quality criterion (Rudianto & Pasaribu, 2021). The following table provides an explanation of each water quality parameter that was examined.

3.1 Total Dissolved Solids (TDS)

Total Dissolved Solid (TDS) is a small, dissolved solid in the form of organic ions, compounds, and colloids in water (Zamora et al., 2015). Based on Table 3, the average

Table 3 . Physical and chemical water quality in Wijimulyo, Nanggulan, Kulon Progo Regency

No	Parameter	Mean ± sd	Min - Max	Med	Quality Standard		Unit
					Clean Water	Drinking Water	
A.	**Physical**						
1.	TDS	267 ± 43	179 - 389	263	< 300	< 300	mg/l
2.	Turbidity	0.4 ± 0.3	0.0 - 1.0	0.3	< 3	< 1.5	NTU
3.	Temperature	24.1 ± 1.0	23 - 26	23.7	± 3 air temperature	± 3 air temperature	°C
4.	Electrical conductivity	0.4 ± 0.16	0.03 - 0.95	0.36	0.02 - 0.5	≤ 0.4	mS/cm
B.	**Chemical**						
1.	pH	7.1 ± 0.4	6.2 - 7.8	7.2	6.5 - 8.5	6.5 - 8.5	-
2.	Salinity	0.2 ± 0.1	0.1 - 0.5	0.2	≤ 0.5	≤ 0.2	ppt
3.	DO	5.9 ± 0.8	3.9 - 7.7	5.8	≥ 4	≥ 4	mg/l

result of 267 ± 43 mg/l was obtained with a range of 179 - 389 mg/l. This average value is quite close to the threshold of clean water and drinking water quality standards according to the Minister of Health Regulation No. 2 of 2023, which is a maximum of 300 mg/l, as shown in Figure 2. Some twenty-seven percent (27.5%) of TDS numbers passed the quality standards for clean and drinking water.

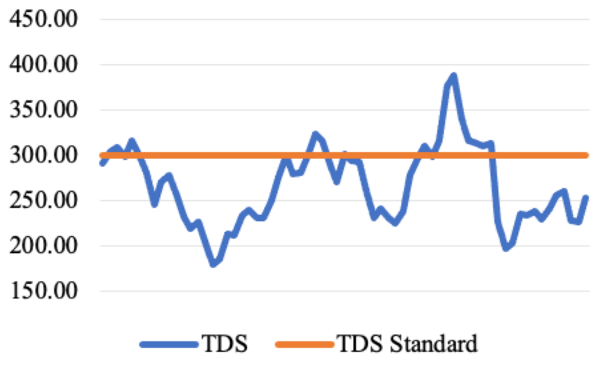

Figure 2 . TDS water in Wijimulyo

Based on the distance from Vocational High School (SMKN 1 Nanggulan), it is known that the highest TDS, which is at a distance of > 20 km from Vocational High School (SMKN 1 Nanggulan) with a value of 317 ± 130 has passed the established water quality standards. If TDS levels in water exceed 300 mg/l, it can affect the health of human kidney organs that consume it because of the high solids content in water. Increased TDS in normal water assets can be a sign of a natural issue, such as industrial or agricultural pollution. TDS monitoring can help mitigate pollution and preserve water sources for human consumption and aquatic ecosystems related to the osmosis ability of aquatic animals and plants (Boyd, 2019).

3.2 Turbidity

The indicator of quality measurement is based on the level of transparency and clarity of water. Factors affecting turbidity are the content of fine mineral particles in water, high bacterial concentration, and high number of water aeration bubbles (Gray, 2008). Test results were obtained based on Table 3 that the average turbidity value was 0.4 ± 0.3 NTU with a range of numbers 0 - 1 NTU shown in Figure 3.

According to the Regulation of the Minister of Health No. 2 of 2023 and Indonesian National Standard 3553:2015, the standard turbidity parameters for clean water is a maximum of 3 NTU, and for drinking water, a maximum of 1.5 NTU. Therefore, the average result still meets clean and drinking water quality standards. Water sources are at a distance of 0 - 10 km from Vocational High School, and the turbidity results in a range of 0 - 1 NTU. High turbidity numbers can be characterized by dark watercolor and affect the taste of water because organic compounds pollute water. If humans consume water with a high turbidity rate, they are at high risk of disease in the digestive system and can form deposits in water flow pipes (Omar & Jafri, 2013). Monitoring water turbidity parameters helps society in mitigating erosion and ensuring water assets (Legono, 2022).

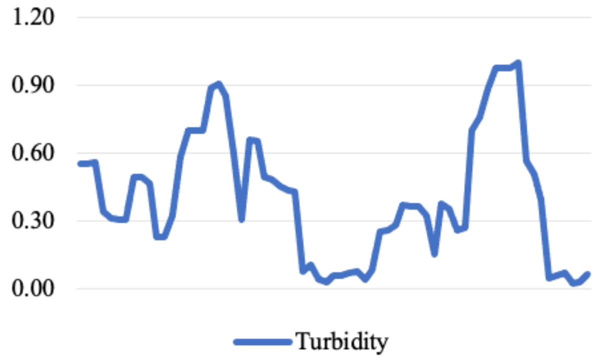

Figure 3 . Water turbidity in Wijimulyo

3.3 Temperature

Temperature is a measure or degree of heat for an object or system (Boyd, 2019). Through laboratory testing, the result was that the temperature of all water samples met the quality standards of clean water and drinking water, which is approximately 3°C of the surrounding air temperature by the Minister of Health Regulation No. 2 of 2023. According to Table 3, the overall water sample temperature has an average value of 23 ± 26°C, and there are no extreme values where the range of values is between 23 - 26°C. Temperature fluctuations affect salinity levels and total dissolved solids in tidal coastal areas. (Khairunnas & Gusman, 2018).

3.4 Conductivity

Conductivity is the ability of water to conduct electricity (Letterman, 1999). Conductivity parameters are closely related to water salinity level, which is classified into five categories, from low salinity to extreme salinity. Conductivity values for low water salinity of 0 - 0.25 mS/cm; medium water salinity 0.25 - 0.75 mS/cm; high water salinity 0.75 - 2.25 mS/cm; very high water salinity 2.25 - 4 mS/cm; extreme salinity > 4 mS/cm (Ravikumar et al., 2013). The results in Wijimulyo Area are according to Table 3, which is an average of 0.4 ± 0.16 mS/cm with a value range of 0.03 – 0.95 mS/cm shown in Figure 4. The average value includes water with moderate salinity and has approached the upper threshold of clean water and drinking water quality standards for conductivity parameters, and according to the WHO, the standard for electrical conductivity parameter in drinking water is 0.4 mS/cm (Meride & Ayenew, 2016).

Based on the test results, it is known that 20.3% of water samples have high conductivity numbers and are not by clean water and drinking water quality standards. At a distance of 0-10 km from Vocational High School (SMKN 1 Nanggulan), the highest conductivity at 0.95 mS/cm was followed by a distance of 11-20 km at 0.62 mS/cm and a distance of > 20 km at 0.84 mS/cm. Water conductivity figures that exceed quality standards are not suitable for consumption because they can result in human health issues, especially kidney stone disease, due to the deposition process of mineral ions in water.

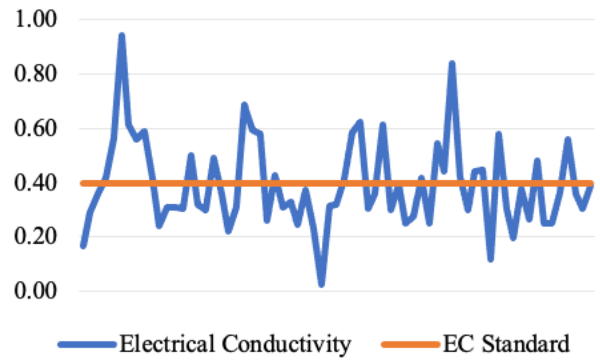

Figure 4 . Electrical conductivity water in Wijimulyo

3.5 pH

pH, or degree of acidity, is a chemical parameter expressing the acidity level in a solution. The pH value shows the concentration of H (hydrogen) ions released in a liquid (Tarigan, 2019). The test results that have been carried out in the laboratory show that the pH degree number is in the range of 6.2 - 7.8 with an average pH of 7.1 ± 0.4, as shown in Figure 5.

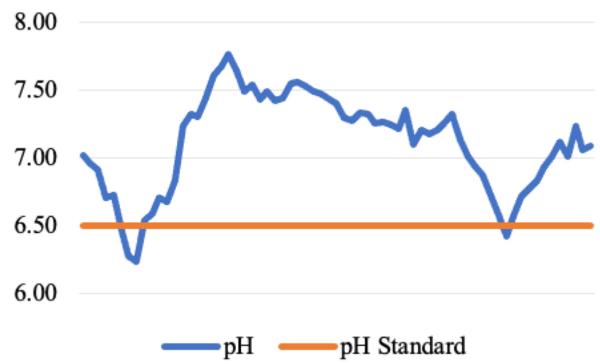

Figure 5 . Water pH in Wijimulyo

According to the Regulation of the Minister of Health No. 2 of 2023, the pH quality standards for clean and drinking water are 6.5 - 8.5. Based on the test results obtained, 17.4% of samples with pH numbers were less than the established clean water and drinking water quality standards, or it could be said that the water samples were in acidic conditions.

From the test results, it is also known that water sample data at a distance of 0 - 10 km from Vocational High School is data with a pH number outside the highest number of quality standards, with a range of values of 6.2 - 7.8. The pH number can be quite extreme because of its low acid value. If used by humans as sanitary water, it can irritate the eyes and skin, while drinking water can be toxic to the human body system. In addition, water with extreme pH (very low or very high) can damage aquatic organisms and affect the growth of plankton, fish, and other aquatic life (Hardiyana et al., 2020).

3.6 Salinity

Essentially, the level of saltiness in water can reflect the degree to which clean water is undermined by contamination and can give clues as to whether the water is secure for utilization or day-by-day utilization. The saltiness of water increments when there's an expansion of salt or other broken-down substances in the water. This may happen due to mechanical contamination, agrarian squandering, or sanitation issues (Prakosa et al., 2020). Based on Table 3, the results of testing water salinity parameters were obtained: an average of 0.2 ± 0.1 ppt with a range of 0.1 - 0.5 ppt shown in Figure 6. Clean water and drinking water quality standards for salinity parameters, according to Rudianto & Pasaribu (2021), are a maximum of 0.5 ppt and a maximum of 0.2 ppt respectively with a low salinity value classification of 0 - 0.16 ppt; medium salinity 0.16 - 0.48 mS/cm; high water salinity 0.48 - 1.44 mS/cm; very high water salinity 1.44 - 2.56 mS/cm; extreme salinity > 2.56 mS/cm (Ravikumar et al., 2013). From the results of tests that have been carried out, the water quality in the Wijimulyo Area for salinity parameters still meets water quality standards. However, it has been at the threshold and is included in the medium category.

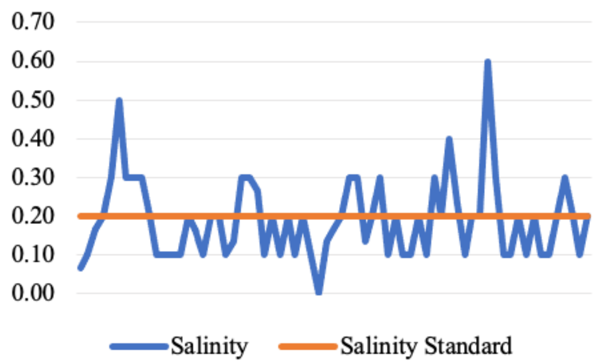

Figure 6 . Water salinity in Wijimulyo

It was found that 46.4% of samples exceeded drinking water quality standards and belonged to the low and high salinity categories. Extreme salinity levels can limit the types of organisms that can live in them. The difference in salinity affects organisms living in waters. Marine organisms have adapted to survive in high salinity, while freshwater and terrestrial organisms usually cannot survive in the same salinity (Agustina et al., 2023). In addition, human activities such as intensive agricultural activities with excessive fertilizer use and industrial activities that produce waste without being treated first can cause an increase in salinity (Ez-zaouy et al., 2022). Salinity monitoring is essential in maintaining the sustainability of water sources because it is related to aquatic ecosystems and the quality of consumable water sources (O'Donnell, 2021).

3.7 Dissolved Oxygen (DO)

Dissolved oxygen is unbound oxygen and not mixed in water or other liquids, which plays a role in various biochemical processes and physiological activities. The dissolved oxygen content in water is an important indicator of water quality and an essential factor in fish growth. The concentration of dissolved oxygen can also describe environmental conditions. High dissolved oxygen content indicates that water can be purified quickly because dissolved oxygen can help in the decomposition of various pollutants in water (Wei et al., 2019). The value of DO in water is influenced by several other parameters, such as pH and temperature (Montana Science Partnership, 2012).

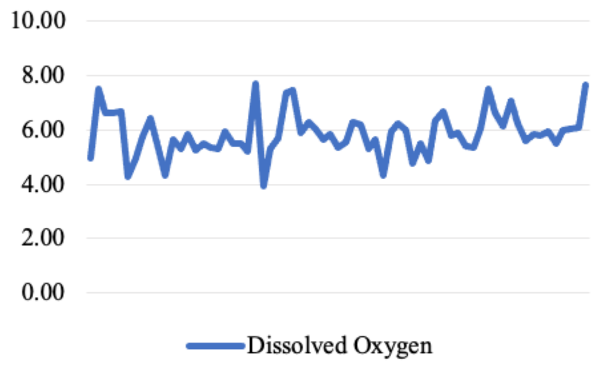

Figure 7 . Dissolved oxygen water in Wijimulyo

The water testing results in the Wijimulyo Area showed an average DO value of 5.9 ± 0.8 mg/l, shown in Figure 7, which was by water quality standards in Indonesian National Standard 3553:2015, which was at least 4 mg/l. Low levels of DO in water can lead to a "dead zone" where organisms cannot survive (Montana Science Partnership, 2012). Increased pollution, including the release of organic waste, can reduce DO levels in water. Low levels of DO indicate higher levels of water pollution that can be caused by factors such as high temperature, high organic matter content, and breathing of aquatic organisms (Debska et al., 2021). Mitigation includes controlling pollution, maintaining riparian vegetation, and maintaining good water flow to ensure healthy DO levels (EPA, 2015).

From all test samples, it is known that 46.4% of samples obtained have met the quality standards for all physical and chemical parameters studied (Total dissolved solids, turbidity, temperature, conductivity, pH, salinity, and DO). The non-conformity in water quality standards in the Wijimulyo Area is generally on the parameters of total dissolved solids, conductivity, and salinity. Those can be caused by several factors, including high mineral content in the water due to the geological conditions of Kulon Progo Regency, which is a mineral-rich area (Wijayanti et al., 2018), hot weather in Kulon Progo resulting in lower water volume and concentrating dissolved compounds (Ngabirano et al., 2016), waste contamination, proximity to the beach (sea water), and soil erosion (Quench, 2022). The findings indicated that teachers and students required consistent and long-term training in using test equipment, routine facility supervision and maintenance, and collaboration with the health office and the district environmental center to raise sanitation awareness and maintain clean water sources.

Strategies for improving and strengthening learning for teachers, vocational students, community leaders, and community groups are shown in Figure 8. This scenario requires regular monitoring for about three months or twice per semester and is included in the assessment of student learning according to their level and ability.

The initiative focuses on water quality management, prioritizing pollution-prone areas, raising household awareness, and promoting SDG 6 clean water and sanitation through education, community involvement, and collaboration with government, NGOs, and the private sector. Addressing water quality and sanitation issues in SMK students and teachers can build capacity for individual and community health, self-reliance, and sustainable community development. Vocational school teachers can encourage Wijimulyo residents to become more knowledgeable about water quality.

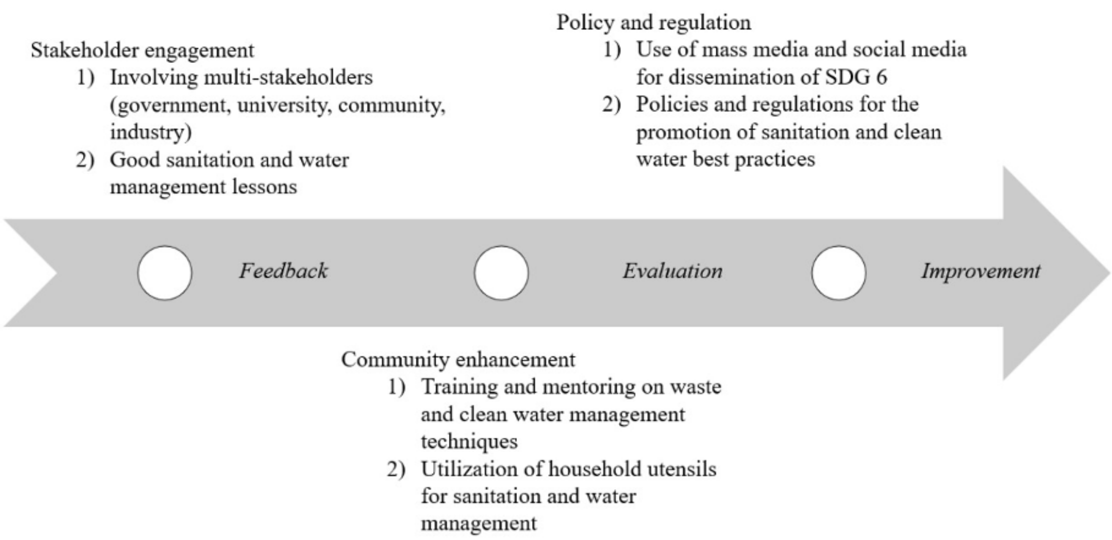

Figure 8 . Strategies for improving and strengthening learning

4. CONCLUSION

In general, Wijimulyo Regional water samples that have been tested obtained average value results by TDS quality standards of 265 mg/l; turbidity by 0.4 NTU; temperature of 24.1°C; conductivity of 0.4 mS/cm; pH 7.1 ± 0.7; salinity 0.2 ± 0.1 ppt; and DO 5.9 ± 0.8 mg/l. The overall sample showed that 46.4% had met water quality standards, and 53.6% had not met water quality standards with non-conformity generally at high values of TDS, salinity, and turbidity parameters. Geological conditions, weather, waste contamination, and location proximity to the coast highly influence the three parameter values. Dissemination of SDG 6 that can be pursued, including awareness-raising education on SDG 6 issues in schools and communities, community involvement and collaboration with the government, NGOs, and the private sector in implementing SDG 6 programs, and regular monitoring and evaluation of water quality.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

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