Assessment of Water Quality in Rural Water Supply System in Jambon Village, Kulon Progo City

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Abstract. Water quality in water supply systems is an important issue that needs to be evaluated to ensure health for human consumption. This research aims to assess the water quality in the water supply system in Jambon Village, Kulon Progo City, Indonesia. In this research, samples from several places were taken and tested in laboratory. The water quality test includes Fe (iron), CaCO3 (total hardness), and KMnO4 (calcium permanganate). The research results show that the Fe value at all sampling points were in accordance SNI (National Standard) for raw water quality, while CaCO3 levels were in the range of 113,26 and 126,53 mg/l. It is below the maximum standard of raw water, but higher than that of drinking water. $KMnO_4$ test results were above the allowable value. $KMnO_4$ value were between 31,5 and 38,5 mg/l which indicates the presence of contamination with a high organic substance content. Some efforts are needed to improve water quality, such as more adequate water treatment and educating the public about the importance of maintaining water quality.

1 Backgrounds

Water is a vital resource that is irreplaceable for human life. The availability of sufficient clean water can fulfill basic human needs, as well as support economic growth and sustainable development. However, the increasing population induces an increase in demand for clean water. This situation may increase pollution that threatened quality of clean water.

Many communities in Indonesia have to deal with problem of water quality. Clean water that is suitable to use is water that meets physical, chemical and microbiological qualities (Setioningrum, at al., 2020). According to Septiawan and Soetiman (2021), due to poor quality of drinking water and housing sanitation, the country suffered a loss of 56 trillion or 2.3% of GDP. This poor quality is caused by very low public awareness of the environmental ecosystem and low budget allocation from both central and regional governments.

In Yogyakarta Province, only 46.3% of drinking water facilities were declared to meet the requirements for safe water quality. Bantul Regency has the highest percentage, namely 80.2%. Meanwhile, the lowest percentage occurred in Kulon Progo Regency with a figure of 18.3% (Dinkes Yogyakarta, 2022). Heldi et al., (2015) observed water quality of several

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water distribution system managed by local community (SPAMDes) in Yogyakarta Province. The study result showed that more than 50% of water source of the SPAMDes system in Kulon Progo Regency have poor water quality. 80% of spring water and 67% of shallow well were below the water quality standard. One of the cases occurred in Jambon Village, Nanggulan, Kulon Progo Regency. A SPAMDes system in Jambon village managed by the Tirto Sari Ponces group located in Jambon Village complained that the well water used for daily needs tends to contain lime. This is proven by the presence of lime in the water that is cooked and settled as well as the presence of scale on the lime equipment, also the pipes used to drain the water are often clogged with scale. According to Liu et al., (2017), during the distribution of water to consumers, water quality may be impacted through the pipe network due to processes such as pipe material release, biofilm formation and release, accumulation and suspension of loose sediment. If this is allowed, SPAMDes consumers will consume hard water, while the effect of consuming hard water is very detrimental to daily life and causes kidney stones (Noor et al., 2019).

Since the construction of SPAMDes in 2017 until now, water quality testing has only been carried out three times, twice from the Community Health Center and once from the Civil Engineering department of Yogyakarta Muhammadiyah University, resulting in a lack of knowledge of SPAMDes managers regarding water quality. Support and assistance from the government/regional health centers is very necessary in efforts to improve the quality of public health services (Hairani et al., 2023). To maintain the safety and health of SPAMDes consumers, there is a need for regular water quality testing as an evaluation of the processing system and distribution system to ensure that the water consumed by the public is safe and meets standards.

In this research, laboratory tests and checks will be carried out on the water parameters that have been determined in the Republic of Indonesia Minister of Health Regulation No. 2 of 2023 concerning Drinking Water Quality Requirements. The water quality tests included Fe, KmnO4, and $CaCO_3$. Fe is the heavy metal iron (Fe) is a toxic (poisonous) group which results in poisoning (in the form of vomiting), nausea, stomach pain, diarrhea and fatigue. Potassium permanganate ($KMnO_4$) is a chemical compound used in many industries because of its strong oxidant properties. The impact of too high a concentration of KMnO4 in water is skin and eye irritation, respiratory problems and damage to internal organs. Calcium carbonate ($CaCO_3$) is a compound found in limestone in large quantities (Hariyati, et al. 2019) The impact of consuming $CaCO_3$ can cause allergic reactions such as skin rashes, itching, swelling of the face, lips, or tongue.

This research also discussed about the distribution of water quality along the pipe system of SPAMDes. The distribution analysis was conducted using Inverse Distance Method by the help of ArcGIS software. IDW is The Inverse Distance Weighted (IDW) method is a simple deterministic method that takes into account the surrounding points. Points that are closer to the estimated location will be given a greater weight than those that are further away.

2 Research methods

2.1 Research Location

This research was carried out in Jambon Village, Kulon Progo Regency, located in Yogyakarta Province, Indonesia. A rural water supply system has been built in Jambon Village since 2017, managed by the local people (Tirto Sari Ponces Group). This system supplies the raw water to 120 consumers for daily use. It used the artesian well as the water source. From the artesian well, the water is conveyed to several reservoirs and the consumers. In this research, samples were taken from 4 different places as shown in Tabel 1 and Fig.1.

The samples were tested in Hydraulic and Environmental Laboratory of Civil Engineering Study Program, Universitas Muhammadiyah Yogyakarta. Several tests conducted were Fe (iron content), $KMnO_4$ (calcium permanganate), and $CaCO_3$ (calcium carbonate). After being tested, the value of each parameter was compared to the standard allowable raw water released by Minister of Health Regulation No. 2 of 2023.

This research attempts to identify the distribution of water quality by using Inverse Distance Weighting (IDW) Method. It applies the interpolation method by considering the distance parameter. The interpolation method for analyzing water quality can be carried out using ArcGIS software which provides more accurate interpolation results. Pramono (2008) revealed that the results were close to the minimum and maximum values of the data sample.

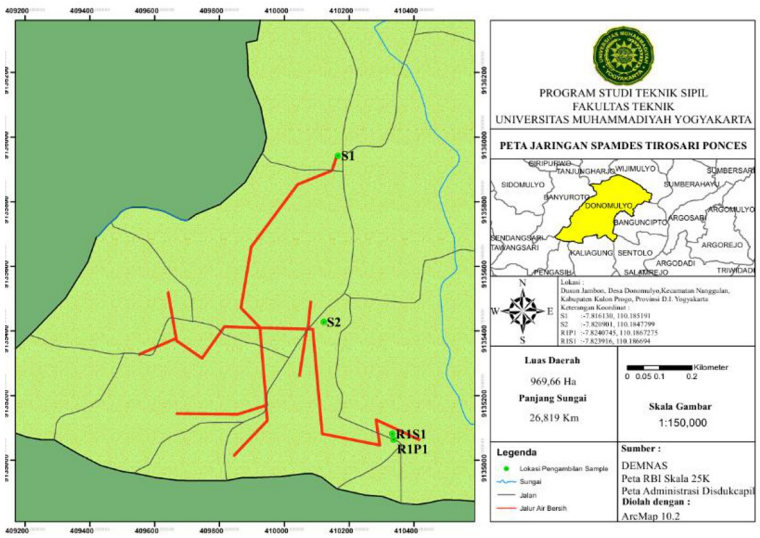


Fig 1. Map of Water Sample Locations

Table 1. Sampling Location

No	Location	Code	Coordinate point	Documentation
1	Main Reservoir Near Drinking Water Depot	S1	-7.816130, 110.185191	
2	Reservoir Near Resident's House	S2	-7.8207901, 110.1847799	

3	SPAMDes Customer Home	R1P1	-7.8240745, 110.1867275	
4	Water Well Resident's House	R1S1	-7.823916, 110.186694	

2 .2 Materials and Tools

For water quality test, some materials were prepared, such as water sample, distilled water, (4N) H2SO4, KmnO4, oxalic acid, KCN5, pH 10 buffer, EBT. The apparatus used in this research included plastic cups, pipettes, volume pipettes, 100 ml measuring tubes, 250 ml Erlenmeyer *flasks,* electric stoves, 50 mL burettes, 100 mL measuring cups, 1000 mL beakers, test tubes.

2.3 Testing Stage

2.3.1 Fe (Iron)

The reaction tube was filled with 10 ml of sample water; 1 drop of Fe standard liquid was added and 5 drops of (4N) H2SO4 and KmnO4 were added; add 5 drops of KCN5 liquid then shake until the color changes; compare with standard Fe solution. Fig. 2 showed the sample before and after testing.

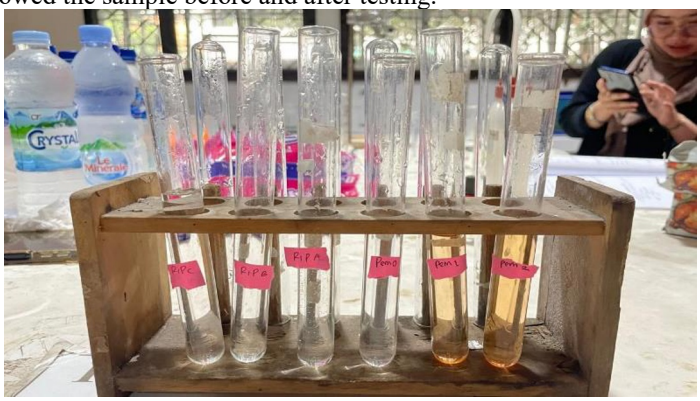
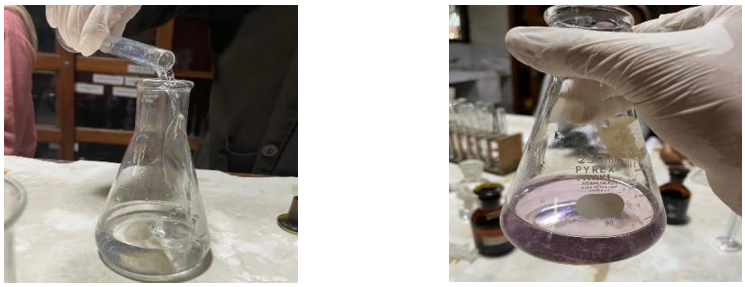


Fig 2. Samples before and after testing

2.3.2 KmnO4 (Calcium Permanganate)

Put 10 ml of sample water into a 100 ml measuring tube, add distilled water to the measuring tube until 100 ml and shake the measuring tube until mixed; move to an *Erlenmeyer flask*, add 5 ml of (4N) H_2SO_4; add diluted $KMnO_4$ until light pink; Heat on an electric stove until boiling, add 10 ml $KMnO_4$ and heat for 10 minutes; Remove the *Erlenmeyer flask* and add 10 ml of oxalic acid until it turns clear; Titrate with a burette filled with $KMnO_4$ until it becomes light pink again. Fig 3 (a) and (b) respectively showed the samples before and after testing



(a) (b)

Fig 3. Sample water (a) before testing, (b) after testing $KMnO_4$

2.3.3 $CaCO_3$ (Total Hardness)

5 ml of sample water was added to the measuring container and diluted with 50 ml of distilled water; add 1 – 2 ml of pH 10 *buffer solution and a little EBT indicator;* titrated with $CaCO_3$ solution until blue; note the results of the $CaCO_3$ used (SNI 06-6989.12-2004). Fig 4 (a) and (b) respectively showed the samples before and after testing

(a) (b)

Fig 4. Sample (a) before, (b) after being tested with $CaCO_3$ solution

2.4 Results and Discussion

2.4.1 Fe (Iron)

Based on the results of Fe (Iron) testing as shown in Table 2, it can be seen that the samples were is accordance with the allowable raw water. Based on the Republic of Indonesia Minister of Health Regulation Number 2 of 2023, the Fe content for clean water is 0.3 mg/l, so all samples are declared to meet the standard.

Table 2. Fe test results

Sample	Location	Meets/Does Not Meet Standards
1	Main Reservoir	Meet the standards
2	Second Reservoir	Meet the standards
R1P1	SPAM Customer Home	Meet the standards
R1S1	Water Well Resident's House	Meet the standards

2.4.2 $KMnO_4$ (Calcium Permanganate)

Based on the results of the KmnO4 test shown in Table 2, the lowest value were located in the second reservoir, namely10 mg/l. The Republic of Indonesia Minister of Health Regulation Number 32 of 2017 sets the maximum $KMnO_4$ content for clean water at 10 mg/l so that none of the samples met the standard. $KMnO_4$ defines the organic substances containing in the water. The organic substances that contain carbon elements from plants and animals can easily polluted water due to bacteria using oxygen dissolved in water. Waste pollution in the water which is so high is not feasible used for daily needs (Apriyanti and Apriyani, 2018).

Table 3. $KMnO_4$ test results

Sample	Location	$KMnO_4$ (ml/l)	Meet/Dose not Meet Standard
1	Main Reservoir	37,5	Does not Meet Standards
2	Second Reservoir	31,5	Does not Meet Standards
R1P1	SPAM Customer Home	38,5	Does not Meet Standards
R1S1	Water Well Resident's House	37,9	Does not Meet Standards

Based on mapping using *ArcGis software*, it can be seen in the image regarding the distribution of water quality at SPAMDes Tirto Sari Ponces based on the KmnO4 parameter, showing that the results in the white area are higher, while in the green area they tend to be lower.

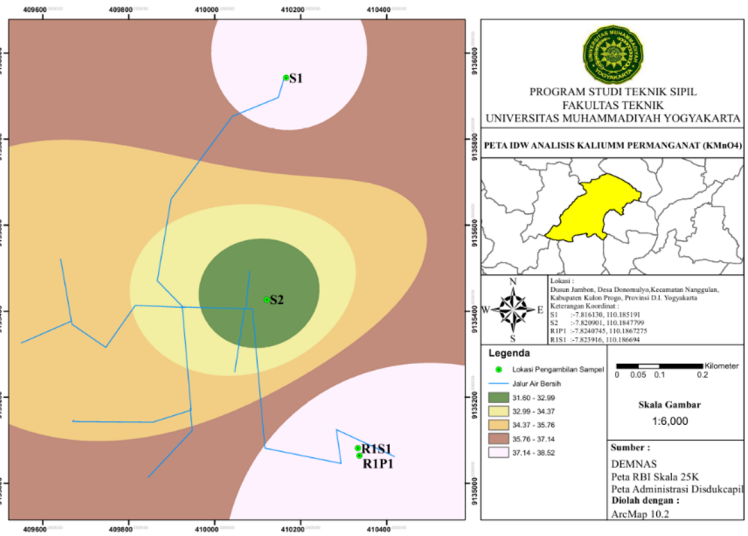


Fig 7. IDW map analysis of KmnO4 levels

2.4.3 $CaCO_3$ (Total Hardness)

Based on the results of $CaCO_3$ testing in sample water, the sample water at SPAMDes Tirto Sari Ponces showed the lowest results in residents' homes using well water at 113,26 mg/l and the highest in SPAMDes customer homes at 126,53 mg/l. In the Republic of Indonesia Minister of Health Regulation Number 32 of 2017 the maximum permitted level for $CaCO_3$ is 500 mg/l for raw water and 100 mg/l for drinking water. So, the tested results meet the specified standards, but it is not safe to drink.

The value of $CaCO_3$ identifies the hardness level of the water. The high water hardness can also be observed from soap that is difficult to foam because one part of the soap molecule is bound by Ca and Mg elements (Herdini, et al, 2023). Apart from household losses, according to WHO, water has high hardness It can have an impact on health, namely it can cause blockages in blood vessels, kidney stones (Urolithiasis), and high levels of calcium in the blood. To reduce the CaCO3 levels, the water needs to be boiled first before drinking. Based on research by Filaeli, A. (2012), boiling water can reduce CaCO3 levels by 90%.

Table 3. CaCO3 test results

Sample	Location	$CaCO_3$ (mg/l)	Meets / Does not Meet Standards
1	Main Reservoir	126,53	Meets Standards
2	Second Reservoir	126,53	Meets Standards
R1P1	SPAM Customer Home	118,37	Meets Standards
R1S1	Water Well Resident's House	113,26	Meets Standards

Based on mapping using *ArcGis software*, it can be seen in the image related to the distribution of water quality at SPAMDes Tirto Sari Ponces based on the CaCO3 parameter that the results in the purplish white area are lower as in sample R1S1, while in the deep purple area it tends to be higher as in sample R1P1.

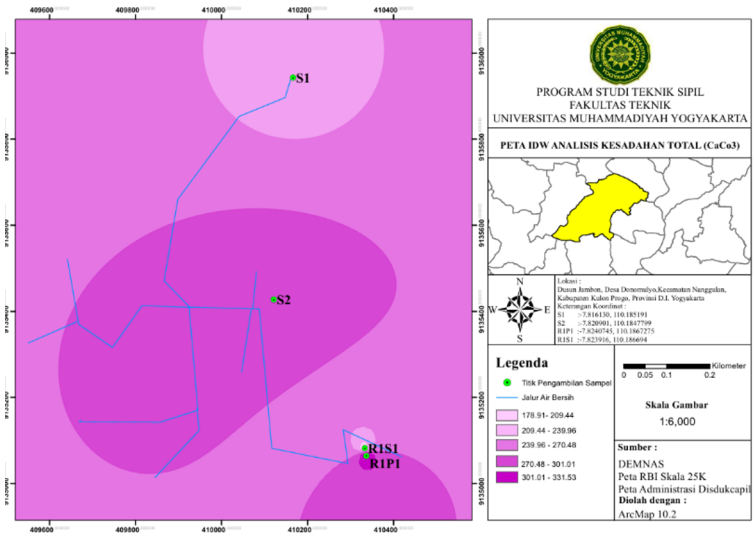


Fig 8. IDW map of CaCO3 analysis

3 Conclusion

Research on water quality at SPAMDes Tirto Sari Ponces Dusun Jambon, Nanggulan, Kulon Progo which was carried out using $CaCO_3$, $KMnO_4$ and Fe tests has shown significant results. The $CaCO_3$ test results show that the water quality in the area is still in the good category. The Fe test shows that the iron concentration in the water is still within safe limits. Meanwhile, the $KMnO_4$ test shows data that exceeds the specified standard standards, which indicates that the water contains dangerous chemicals. Thus, it can be concluded that the water quality in the area is still relatively good and the concentration of chemicals is not safe. Therefore, the results of this research can be used as a basis for developing more effective water management strategies and for reducing water pollution.

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