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Analysis of Potable Water Quality in Densely Populated Residential Environments (Case Study in Condongcatur Village)

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Abstract

Yogyakarta is a densely populated province in Indonesia. In order to maintain the comfort and health of the people of Yogyakarta, this study aims to analyze the quality of drinking water sources used by residents of Depok District with a population density of 3691.76 people/km^2 in 2021, by taking water samples in Condongcatur Village. The research was conducted by water intake survey method and testing experiments based on SNI No. 01-3554-2006 through test parameters of odor, taste, turbidity, pH, TDS, nitrite, nitrate, chloride, iron, and manganese levels. Based on the results of organoleptic and instrumental testing, the tested water samples were found to have met the quality standards set by PERMENKES RI No. 492/MENKES/PER/IV/2010. Thus, the source of drinking water used by Condongcatur residents has met the required qualifications. This may be because local residents were able to maintain their water quality from human activities that can pollute the water quality. Nevertheless, water quality must always be maintained at all times considering the population in the area is increasing.

Keywords: *Water, drinkable water quality, populated residential environment*

Abstrak

Yogyakarta merupakan provinsi yang padat penduduk di Indonesia. Dalam rangka menjaga kenyamanan dan kesehatan masyarakat Yogyakarta, penelitian ini bertujuan untuk menganalisis kualitas sumber air minum yang digunakan oleh warga Kecamatan Depok dengan kepadatan penduduk mencapai 3691,76 orang/km^2 pada tahun 2021, dengan mengambil sampel air di Kelurahan Condongcatur. Penelitian dilakukan dengan metode survei pengambilan air dan eksperimen pengujian berdasarkan SNI No. 01-3554-2006 melalui parameter uji bau, rasa, kekeruhan, pH, TDS, kadar nitrit, nitrat, klorida, besi, dan mangan. Berdasarkan hasil pengujian secara organoleptic dan instrument, sampel air yang diuji ditemukan telah memenuhi standar mutu yang ditetapkan oleh PERMENKES RI No. 492/MENKES/PER/IV/2010. Dengan demikian, sumber air minum yang digunakan oleh warga Condongcatur telah memenuhi kelayakan yang disyaratkan. Hal ini mungkin dikarenakan warga sekitar mampu menjaga kualitas airnya dari aktivitas-aktivitas manusia yang dapat mencemari kualitas air tersebut. Meskipun demikian, kualitas air harus selalu dijaga setiap saat mengingat populasi penduduk di daerah tersebut semakin meningkat.

Kata kunci*: air, kualitas air minum, lingkungan padat penduduk*

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INTRODUCTION

Yogyakarta is one of the provinces in Indonesia that experiences a very rapid population density. Based on data reported by the Central Statistics Agency (BPS Provinsi D.I. Yogyakarta), in 2022, the population in the Special Region of Yogyakarta (DIY) is 4,021,816 inhabitants This number has increased by up to 3% every year. This also happens in Sleman Regency, which incidentally is an association area for universities and schools in DIY Province, so that not a few migrants from outside Yogyakarta–both Indonesians and foreigners–stop by to travel. In addition, immigrants also work as traders.

Depok sub-district, including Condongcatur Village, is the most densely populated sub-district area in Sleman Regency, DIY Province with a population density of 3691.76 people/km^2 in 2021 (BPS Kabupaten Sleman, n.d.). The relatively dense population gives a feeling of anxiety and worry about the health of the environment, including the condition of drinking water sources. Various human activities have impacts on the quality of surface water because the pollutant loads from the sources might cover the waterproof surface (Begum et al., 2016; Glińska-Lewczuk et al., 2016).

Water is the main need for the residents of Condongcatur. In addition to drinking purposes, the residents of Condongcatur also use water for bathing, washing, agriculture, and animal husbandry. The feasibility of water as a source of drinking water must meet the requirements of PERMENKES No. 492/MENKES/PER/IV /2010. Based on the Ministry of Health, the quality of drinkable water is influenced by physical, chemical, and biological parameters. Therefore, this study aims to review the quality and feasibility of well water in Condongcatur by looking at several parameters such as smell, taste, pH, turbidity, TDS, levels of nitrate, nitrite, chloride, iron, and manganese. These findings will reveal the water quality conditions and offer information for water pollution mitigation, so that human health and well water can be controlled.

METHODS

This study was conducted to determine the feasibility of drinking water in the densely populated Condongcatur Village. There are 7 (seven) well water samples that were collected from different points in Condongcatur Village. Sampling technique of the well water follows the guidelines from the Indonesian National

Standardization Agency under SNI No. 6989.58:2008 for groundwater samples.

Materials and Tools

The materials used are $(NH_2)_2H_2SO_4$, $(CH_2)_6O_4$, HCl, sulfanilic acid, H_2SO_4, NaOH, K_2CrO_4, $AgNO_3$, N-(1-naphthyl)-ethylenediamine dihydrochloride, nitrate stock solution, nitrite stock solution, iron stock solution, manganese stock solution, and distilled water.

The tools used include pH meter, nephelometer, UV-Vis spectrophotometer, Atomic Absorption Spectrometer (AAS), oven, desiccator, burette, and analytical balance.

Well water samples that have been collected were tested at the Integrated Laboratory of Islamic University of Indonesia Yogyakarta to obtain physico-chemical parameters of water such as total dissolved solids (TDS), pH, N levels as NO_3^- and NO_2^-, Cl^-, Fe and Mn. In order to see the turbidity parameter, the testing was conducted at the Water Quality Laboratory of Environmental Engineering Department, Islamic University of Indonesia Yogyakarta. While the odor and taste parameters were done by research team organoleptically. The physico-chemical parameter testing protocols refer to SNI (Indonesian National Standard) No. 01-3554-2006 concerning testing bottled drinking mineral water (BSN, 2006). The quality standards for drinking water according to PERMENKES No. 492/2010 are as stated in **Table 1.**

Table 1. Drinking Water Quality Standards (PERMENKES, 2010)

Parameter	Unit	Standard
Odor	-	No odor
Taste	-	No taste
pH	-	6.5-8.5
Turbidity	NTU	Max. 5
TDS	mg/L	Max. 500
Nitrite (NO_2^-)	mg/L	Max. 3
Nitrate (NO_3^-)	mg/L	Max. 50
Chloride (Cl^-)	mg/L	Max. 250
Iron (Fe)	mg/L	Max. 0.3
Manganese (Mn)	mg/L	Max. 0.4

RESULTS AND DISCUSSION

The water samples used in this study came from wells of residents in the Condongcatur Village, Depok District, Sleman Regency, Yogyakarta. This area is one of the densely populated areas. Therefore, to maintain mutual health, it is necessary to conduct research on the quality of raw water that is usually used for bathing, washing, and especially drinking. The results of potable water quality testing against are presented in **Table 2**.

Table 2. Results of Water Quality Analysis

Parameter	Unit	Result	Comment
Odor	-	No odor	Accepted
Taste	-	No taste	Accepted
pH	-	6.80-7.05	Accepted
Turbidity	NTU	0.21-1.31	Accepted
TDS	mg/L	320.0-575.0	Accepted
NO_2^-	mg/L	< 0.0097	Accepted
NO_3^-	mg/L	1.01-21.05	Accepted

Cl^-	mg/L	7.92-31.86	Accepted
Fe	mg/L	< 0.0573	Accepted
Mn	mg/L	< 0.2060	Accepted

Odor and taste testing is the primary test of water quality that can be analyzed organoleptic. Odor testing does not use special instruments, but with olfactory sensing (nose), while taste can be tested using the sense of taste (tongue). Based on the sensing results, the seven water samples did not have a distinctive smell and striking taste. Thus, water samples in Condongcatur Village have met the parameters of the Ministry of Health in terms of smell and taste. Contaminated water with vast range of chemicals such as metals, organic compounds, and minerals could produce unpleasant odor and taste on water. (Akcaalan et al., 2022). The pollutants could come from waste sources of residents, industry, and fertilizer (Indrasari et al., 2019).

pH values of water samples are between 6.80-7.05 indicating neutral water and safe to drink. Lower pH (< 7.0) water contains more hydrogen ions (H^+) and tends to precipitate metals in water, while greater pH (>7.0) is comprised of hydroxyl ions (OH^-) which both conditions are more toxic for aquatic life (Chen et al., 2012). The greater pH of water could also cause dry, itchy, and irritated body skin.

Turbidity refers to water clarity and indicates the existing pollutants, organic matter, and sediments in water. Turbidity of water samples have been tested using turbidimeter and those are in the range of 0.21-2.31 NTU (Nephelometric Turbidity Units) which are acceptable for drinking water based on the Ministry of Health regulations. This result indicates that small amounts of solid matters suspended in the water (Pramesti & Puspikawati, 2020).

Total Dissolved Solids (TDS) are the number of solid particles contained in water. TDS can provide information of beneficial minerals for human beings such as Mg, Ca, Na, and K, as well as contaminations by residents' activities (soil from irrigation, damaging farming or pesticides) (Islam et al., 2016; Wang, 2021). All samples collected from Condongcatur Village meet the maximal TDS in the water (< 500 mg/L), indicating feasible for drinking water.

Nitrite and nitrate nitrogen levels were investigated by colorimetric method using a UV-Vis spectrophotometer at specific wavelengths based on SNI No. 01-3554-2006. In principle, nitrite in acid condition at pH of 2.0-2.5 reacts with sulfanilic acid and N-(1-naphthyl)-ethylene diamine dihydrochloride and then forms a purplish-red color. Absorbance of the formed color is measured

spectrophotometrically at the maximum wavelength of 540 nm. Meanwhile, water containing nitrate will react with hydrochloric acid and change the absorbance spectrum at the maximum wavelength of 220 nm and 275 nm.

Water samples contain nitrite and nitrate nitrogen of <0.0097 mg/L and 1.01-21.05 mg/L, respectively, suggesting acceptable for drinking water sources based on the regulation of Ministry of Health. In addition, the levels of NO_3-N in the water samples are still below the guidelines of World Health Organization (WHO) (50 mg/L). Higher levels of nitrate could give methemoglobinemia effect in infants (US EPA, 2015).

Determination of chloride levels in water samples is carried out by argentometric titration-Mohr method (Ngibad & Herawati, 2019). The samples containing chloride reacted with $AgNO_3$ to obtain precipitation (AgCl, white color) as the equivalent condition at the range of 7-10 (Shing, 2014). In this regard, K_2CrO_4 as the indicator of the titration has been added to the solution and the titration was continued until a brownish-red precipitate (Ag_2CrO_4) formed indicating the end point of titration because silver chromate salts have formed (see reaction 1 and 2).

$$Cl^-_{(aq)} + AgNO_{3(aq)} \rightarrow AgCl_{(s)} + NO_3^-{}_{(aq)} \quad (1)$$

$$2AgNO_{3(aq)} + CrO_4^{2-}{}_{(aq)} \rightarrow Ag_2CrO_{4(s)} + 2NO_3^-{}_{(aq)} \quad (2)$$

The chloride levels in the water samples are 7.92-31.86 mg/L. These levels are acceptable for drinking water by Ministry of Health. However, the World Health Organization (WHO) mentioned that the unpolluted waters often contain below 10 mg/L. Nevertheless, the maximum level of chloride accepted is 250 mg/L and the above number could cause corrosion in plumbing, pumps, and pipes, but not poisonous to body health.

Iron (Fe) levels in the water samples have been determined by Atomic Absorption Spectrometer (AAS) due to significant precision and accuracy. The analytical procedure of iron contents followed SNI No. 01-3554-2006. From the experiments, water samples contain iron <0.0573 mg/L. This indicates that water samples from Condongcatur are acceptable to drink and safe for humans. Excessive iron can be observed from water color – cloudy matter and brownish (Hasanuddin & Syarif, 2022). In addition, water containing more iron will have a metallic taste, stains on clothes (Annem, 2017), support the infection risks due to bacterial virulence (Patruta & Hörl, 1999), and lead depression and respiratory disorders (Tautkus et al., 2004).

Manganese is one of the essential elements needed for humans. Mn elements work with adverse enzymes to breakdown

proteins and carbohydrates, to grow bones, to keep the body immune and smooth reproductive systems. However, the high levels of manganese may lead to Parkinson's diseases analogous symptoms (Avila et al., 2016; Friedman et al., 2023). The manganese levels in the water samples have been found to be 0.0125–0.2056 mg/L. These levels are acceptable for human health according to Indonesian Ministry of Health guidelines (<0.4 mg/L).

CONCLUSION

Based on tests that have been carried out on water samples both organoleptically and instrumentally, water samples have met the thresholds determined by the Indonesian Ministry of Health guidelines (PERMENKES No. 492/MENKES/PER/IV/2010) on the parameters tested (odor, taste, pH, turbidity, TDS, chloride, nitrite, nitrate, Fe, and Mn). Therefore, the source of drinking water used by residents in Condongcatur Village, Depok District, Sleman Regency is safe at this moment. This may be due to the residents keeping the water quality from harmful activities such as agricultural crop, plants fertilization, and septic tank.

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