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Analysis of Groundwater Quality in Rental Flats use Physical and Chemical Parameters

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Abstract: The purpose of this study was to determine the physical and chemical quality of the groundwater in the Jerakah flats area and to determine the feasibility of the water as drinking water. This research was physically carried out by analyzing groundwater samples from the rented flats of the Jerakah sub-district based on the physical parameters of the air, including taste, color, smell, temperature, turbidity, and dissolved solids (TDS) as well as chemical parameters consisting of the degree of acidity. (pH), Nitrate Content (NO_3^-), Nitrite (NO_2^-), Hardness ($CaCO_3$), Iron (Fe), Lead (Pb), Manganese (Mn), Zinc (Zn), Sulfate (SO42-), Cadmium (Cd), and Chromium (Cr). The results showed that the groundwater in the Jerakah flats had a normal pH, colorless, tasteless, odorless, low turbidity, and high dissolved solids (TDS). The levels of iron (Fe), manganese (Mn), chromium (Cr), zinc (Zn), cadmium (Cd), lead (Pb), and hardness are below the maximum hygienic sanitary limits. Manganese (Mn), Cadmium (Mn), Lead (Pb) levels exceed the maximum limit for drinking water. The groundwater in the Jerakah flat is suitable for use for hygienic sanitation, such as bathing and washing, but not suitable for drinking.

Keywords: Chemical parameters; Groundwater; Physical parameters

Introduction

Water resources have long been of interest to humans and have become a serious issue in all aspects of human life (Hojjati-Najafabadi et al., 2022). One of the largest worldwide challenges is the discharge of dangerous chemicals in water resources, which puts aquatic life and human health at serious risk. The quality of surface water in an area is influenced by natural processes, such as the intensity of rainfall, weathering processes and soil erosion, as well as anthropogenic effects, such as industrial activities, agriculture and exploitation of water resources. Groundwater quality is a very important issue due to increasing population, rapid industrialization, unplanned urbanization, flow of pollution from the highlands to the lowlands, and too much use of pesticides in agriculture.

Groundwater is one of the most widespread, renewable, and most important natural resources. Clean and healthy water is water that does not contain foreign contaminants in a tolerable amount, meaning that it does not exceed the maximum level set so that the water is safe for daily consumption. Clean and healthy water is water that can be used for daily needs and does not have a negative impact on health.

Groundwater which is often considered not polluted can actually be polluted. Contaminated groundwater is difficult to restore its quality. Groundwater quality can be seen based on water quality parameters. Water quality parameters can be carried out using various classical analyzes, including using ion-chromathography (Vaiphei et al., 2020), titrimetric, gravimetric and modern instrument techniques such as Atomic Absorption Spectrometry, inductively coupled plasma-mass spectrometry (ICP-MS), UV-Vis spectrophotometry, and others.

Semarang is one of the metropolitan cities in Indonesia. In general, metropolitan cities have a high level of pollution. This is due to the density of motorized vehicles and the large number of large industries. One of

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the impacts of many industries is waste disposal. Industrial waste that is not channeled properly will seep into the ground so that it can cause groundwater pollution. Contaminated ground water when consumed can cause disease in those who consume it. Wantasen et al. (2022) argues that the decline in air quality is caused by leaching of nutrients, some of which will become residues.

Jerakah Village is one of the villages in the city of Semarang. In this village there was once a Steel-making industry. At this time the industry is no longer operating. Even though it is no longer in operation, of course there are remnants of waste disposal that dissolve in groundwater and become suspended, causing water pollution. Based on the results of observations of the groundwater produced, it was obtained information that the groundwater produced in the rental apartment area has a fresh taste and sometimes causes smelly gas when the shower or faucet is not used after a few days. In addition, the groundwater in this area feels painful when used for bathing and causes some metals to rust easily. Based on this description, the purpose of this study was to determine the physical and chemical quality of groundwater in the Jerakah flats area and to determine the feasibility of consuming the groundwater.

Method

Ground Water Sampling

Water samples were taken from groundwater sources in rented flats in the Jerakah sub-district, Semarang city. The geographic location of the sampling is at latitude -6.9822592 and longitude 110.3639393. Samples were taken from the faucet in one of the rooms in the flat as much as 5 L.

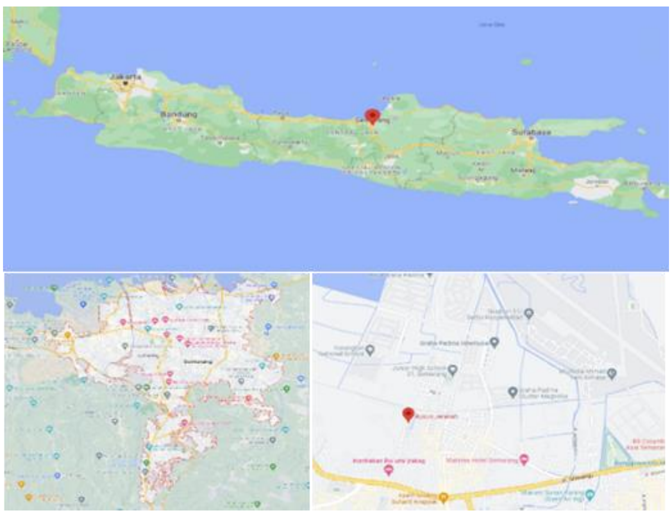

Figure 1. Groundwater sampling site

Analytical Method

This research was physically carried out by analyzing samples of groundwater originating from the flats of the Jerakah sub-district based on the physical parameters of the water, including taste, color, odor, temperature, turbidity, and the total dissolved solids (TDS) as well as chemical parameters consisting of the degree of acidity (pH), nitrate (NO_3^-) level, nitrite (NO_2) level, sulfate (SO_4^{2-}) level, hardness ($CaCO_3$) level, iron (Fe) level, lead (Pb) level, manganese (Mn) level, zinc (Zn) level, cadmium (Cd) level, and chromium (Cr) level.

Taste, color and smell are tested directly using the senses of taste, sight and smell. Temperature, TDS, and pH were measured using a water quality test kit (EZ-9901), while turbidity was tested with a nephelometer (SGZ-200BS). Colorimetric analyzes such as Sulfate, Nitrite and Nitrate were measured with a UV-Vis spectrophotometer (DR-5000, Hach, USA). Heavy metal ions were analyzed with an Atomic Absorption Spectrophotometer (Thermo Fisher Scientific iCE-3500).

Result and Discussion

Environmental Factors and Physical Parameters

Prior to sampling, the tool that will be used as a groundwater sample container must first be sterilized and cleaned so that there is no dirt or contaminants attached to the container (Kustomo et al., 2022). Sterilization of the sample container is carried out by washing and rinsing the sample container cleanly. The samples taken were then subjected to physical water tests which included taste, color, smell, temperature, turbidity, and dissolved solids. The results of the physical analysis are presented in Table 1.

The sample test results showed that the pH, color, taste, smell, temperature, and turbidity values were lower than the maximum levels specified for sanitary hygiene and consumption. Another case with the value of dissolved solids. The value of the dissolved solids test results is below the threshold for maximum levels of sanitary hygiene, but above the threshold for water suitable for consumption. Total Dissolved Solid (TDS) is the amount of dissolved solids in the form of ions, compounds, or colloids in water (Devesa & Dietrich, 2018). One of the factors in determining the suitability of water for consumption is the content of TDS in water. TDS includes the amount of material in water, this material can be carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions.

Table 1. Water Test Results with Physical Parameters

Physics Parameters	Unit	Analysis results	Sanitary Hygiene (Minister of Health regulations 32 of 2017)	Maximum Rate Consumption (Minister of Health regulations 492 of 2010)
pH	-	7.27	6.5 – 8.5	6.5 – 8.5
Color	TCU	-	50	15
Flavor	-	Tasteless	Tasteless	Tasteless
Smell	-	No smell	No smell	No smell
temperature	oC	27.7	Air temperature ± 3 oC	Air temperature ± 3 oC
Turbidity	NTU	1.34	25	5
Dissolved Solids	mg/l	550	1000	500

Water that has a high solids content generally has low politability and is unfavorable for the body (Khalid et al., 2011). The TDS content in water can also give a taste to water, namely water becomes like salt (Devesa & Dietrich, 2018). The maximum limit of TDS that is allowed for drinking water suitable for consumption is 500 mg/l. The test results showed that the TDS level in the sample was 550 mg/l. This means that the groundwater is unfit for drinking water. TDS levels in water that exceed the maximum permissible threshold can endanger human health. One of the dangers of high TDS levels is causing damage to the kidneys (Gobalarajah et al., 2020; Kumari et al., 2018). Even though the tested groundwater is unfit for consumption, the water can still be used to fulfill daily needs such as bathing and washing, this is based on the TDS level in the sample water which is still below the maximum TDS level specified for sanitary hygiene.

Chemical Parameters

In addition to physical parameters, chemical parameters are also important to determine the content of compounds or heavy metals in groundwater. Heavy metals are compounds that cannot be degraded or decomposed because they have a higher density than water. The increase in heavy metal pollution in rivers, lakes and other springs is influenced by increasing industrial activities (Joseph et al., 2019). Several parameters of heavy metals tested in this study were Iron (Fe), Manganese (Mn), Chromium (Cr), Zinc (Zn), Cadmium (Cd), and Lead (Pb). The results of the heavy metal test in the samples are shown in Table 2.

Table 2. Water Test Results with Chemical Parameters

Chemical Parameters	Unit	Analysis results	Sanitary Hygiene (Minister of Health regulations 32 of 2017)	Maximum Rate Consumption (Minister of Health regulations 492 of 2010)
Iron (Fe)	mg/l	0.077	1	0.3
Manganese (Mn)	mg/l	0.226	0.5	0.1
Chromium (Cr)	mg/l	0.016	0.05	0.05
Zinc (Zn)	mg/l	0.192	15	3
Cadmium (Cd)	mg/l	0.004	0.005	0.003
Lead (Pb)	mg/l	0.048	0.05	0.01
Hardness ($CaCO_3$)	mg/l	200	500	500

The results of the analysis showed that there were heavy metals in the sample. These heavy metals are iron, manganese, chromium, zinc, cadmium and lead. The levels of the results of the analysis of the six heavy metals were below the maximum threshold specified for sanitary hygiene needs such as bathing, brushing teeth and washing. Water suitable for bathing and washing is not necessarily suitable for consumption. Adequate water for consumption is water that meets the consumption requirements biologically, physically and chemically. Biologically, water that meets the requirements for consumption is water that is not contaminated by bacteria, physically water is colorless, tasteless, odorless, low turbidity level, and low TDS. Chemically, the content of heavy metals in water does not exceed the specified maximum threshold (Permenkes No. 492, 2010).

The test results showed that the identified samples contained three types of heavy metals that exceeded the maximum threshold. These heavy metals are Manganese (Mn), Cadmium (Cd), and Lead (Pb). Manganese, cadmium, and lead are toxic metals which are harmful to the body when consumed (Zaitseva & Zemlyanova, 2020; Genchi et al., 2020; Nicula et al., 2018). Manganese is a metal that is generally found in groundwater that has not been treated (Bruins, 2016), which can cause aesthetic problems, bad taste and color of water, and cause health problems (Jez-Walkowiak et al., 2017). Manganese metal is a metal that has a high level of toxicity and in the long term can cause morpho-functional disorders in the brain (Zaitseva & Zemlyanova, 2020). Oxidized manganese has a higher level of risk and can cause stress (Il'yaschenko et al., 2020). Based on this description, water containing manganese metal is not suitable for consumption because it has a high risk to human health.

The content of heavy metals that exceed the second maximum threshold is cadmium (Cd). Cadmium metal is a non-essential toxic transition metal that is carcinogenic which can cause health problems for humans and animals. Cadmium metal that enters the body can cause various cancers, such as lung cancer, breast cancer, prostate cancer, and kidney disease. (Genchi et al., 2020; Waalkes, 2003). Based on the results of the test analysis, it was shown that the cadmium content in the sample was quite high, namely 0.004. The cadmium level is higher than the maximum threshold for cadmium content for drinking water. The high level of cadmium in the sample is caused by several things, one of which is the sampling which is located not far from the former steel industry. Even though this industry is no longer active, the waste that was produced a few years ago is still absorbed and stored in the soil, so that the heavy metal residues in the waste mix with groundwater. This is in accordance with the opinion Haider et al. (2021) which states that cadmium metal mostly comes from urban waste disposal pollutants, smelting, mining, metal manufacturing, and the use of synthetic phosphate fertilizers.

The content of heavy metals that exceed the third maximum threshold is lead (Pb). Lead is a potentially toxic element when absorbed by the body (Charkiewicz & Backstrand, 2020). Lead can affect the function of the reproductive system, liver, endocrine, immune system, and gastrointestinal system (Krzywy et al., 2010). Lead exposure to humans in various ways, all of which involve environmental pollution. Lead can enter the body through consumption, inhaling lead-containing groundwater, motor vehicle fumes, and other products that contain lead (Charkiewicz & Backstrand, 2020). The test results showed that the lead content in the sample was higher than the maximum threshold (0.048) for drinking water (0.01) and close to the maximum threshold in the sanitary hygiene category (0.05). This means that the water in the research location is unfit for consumption, but still suitable for bathing and washing. The use of water for bathing and washing should also consider the dangers of lead contained therein, considering that the amount of lead in the body will accumulate.

In addition to heavy metal content, water suitable for consumption must have a hardness level below 500 mg/l. The results of the sample analysis obtained a water hardness value of 200 mg/l. Referring to the hardness threshold of drinking water and sanitary hygiene, the hardness of the sample is still below the maximum threshold. In addition to looking at the maximum threshold for water hardness, the use of water should also consider its hardness level. The level of water hardness is classified into three, namely low, medium, high, and very high. The classification of water hardness is presented in Table 3.

Table 3. Classification of Hardness Levels

$CaCO_3$ Content	Hardness Level
0 – 75	Soft
75 – 150	Currently
150 – 300	Hard
> 300	Very Hard

Based on table 3, it can be identified that the level of hardness in the groundwater sample is high (200). The hardness is due to the location of the Rusunawa located on the coast of the Java Sea which has a rock geomorphology in the form of solid limestone from the coastal area with a hollow stone arrangement that allows groundwater to flow through the aquifer (Ahn et al., 2018). The content of limestone can cause physicochemical changes in groundwater due to the displacement of the reaction mass of limestone mineral dissolution (Spencer, 1985). Hard water is not water that is dangerous, but with high Ca2+ levels it causes water to become cloudy. Hard water that enters the body at certain levels can be beneficial to health, but if the water hardness exceeds the maximum permissible limit, it can cause health problems, such as kidney stones and cardiovascular disease (Chawla et al., 2016).

Table 4. Water Test Results with Chemical Parameters

Chemical Parameters	Unit	Analysis results	Sanitary Hygiene (Minister of Health regulations 32 of 2017)	Maximum Rate Consumption (Minister of Health regulations 492 of 2010)
Nitrate (NO_3^-)	mg/l	0.199	10	50
Nitrite (NO_2^-)	mg/l	0.009	1	3
Sulfate (SO_4^{2-})	mg/l	28.92	400	250

The results of analysis of nitrate ions, nitrite ions, and sulfate ions in the samples showed that the levels of the three ions were far below the maximum sanitary and consumption hygiene thresholds. The results of the analysis of the three ions are presented in Table 4.

The levels of the three ions are still far below the maximum threshold for sanitary hygiene and consumption feasibility. This is because the Jerakah flat is far from the paddy fields, so the samples taken from the Jerakah flat do not contain significant nitrate ions, nitrite ions and sulfate ions. Water pollution is influenced by agricultural and industrial processes which produce enormous pollutants and worsen water quality, fertilizer use (Singh & Goldsmith, 2020), and production of synthetic organic chemicals (FAO, 2017). One of the causes of these compounds entering the groundwater is caused by the use of fertilizers or pesticides (Sui et al., 2020). Low levels of nitrate ions, nitrite ions and sulfate ions in the water indicate that the groundwater in the Jerakah flat is not polluted by pesticide waste.

Conclusion

Based on the results of the discussion, it can be concluded that the groundwater in the Jerakah flat has a normal pH, colorless, tasteless, odorless, low turbidity level, and high total dissolved solids (TDS). Iron (Fe), Manganese (Mn), Chromium (Cr), Zinc (Zn), Cadmium (Cd), Lead (Pb), and hardness levels were below the maximum sanitary hygiene threshold. Manganese (Mn), Cadmium (Mn), Lead (Pb) levels exceed the maximum threshold for drinking water. The groundwater in the Jerakah flat is suitable for use for sanitary hygiene, such as bathing and washing, but not suitable for drinking.

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Conceptualization and methodology, Putut Marwoto (P.M), and Sigit Priyatmoko (S.P); formal analysis, M.A.P. and D.E.N. Investigation, Mohammad Agus Prayitno (M.A.P) and Deni Ebit Nugroho (D.E.N); writing— original draft preparation, M.A.P., P.M., S.P.; writing—review and editing, M.A.P.; Visualization. M.A.P. All authors have agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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