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Research article

Measurement of Groundwater Eligibility as Drinking Water: Chemical Parameters

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ABSTRACT

Water is a major need for humans—the requirements of mineral content contained in water need to get human attention. Reducing water quality will be bad for human health and can even cause death. The fulfilment of water worthy of drinking and bathing in Padang City is sourced from PDAM, dug water, and drill well water. Each water source needs to be given attention to its feasibility standards, so this research aims to measure the feasibility of groundwater chemically based on data on minerals (iron, zinc, manganese), nitrogen levels, and DHL and TDS-sampling using purposive sampling techniques. The samples used in the test are dug well water and drill wells. The chemical parameters tested on both models stated the feasibility of the selection as a source of drinking water in terms of DHL, TDS, manganese, zinc, and nitrogen levels except for drill well water, whose iron content is 5.73 times more than the legal feasibility of iron content in drinking water.

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Introduction

Water is an important compound in human life. The human body is 60% composed of water. Every day, the human need for water depends on age, gender, activity, and environmental temperature. Water in the human body acts as homeostasis (an automatic regulator of physiological processes of the body to be fixed and balanced). The homeostatic process involves water as its main component in maintaining the balance of the amount of water and mineral ions (salts) in the kidneys, the balance of acid-base properties in certain organs, and the temperature of the balanced body. If the mineral ions are excess or less, the kidneys' cells will be impaired in performance and can become damaged [1-3]. The human body that lacks water (dehydration) by 2% impacts body temperature and plasma cell volume so that humans feel tired. A 7% lack of water in the body causes hallucinations, and up to 10% of humans will die.

Drinking water consumed by humans must meet the parameters of established eligibility standards. The standard eligibility parameters for drinking water consumed by humans must complete the mandatory or additional parameters' physical, chemical, and microbiological requirements [2]. Based on data from WHO, the human need for water increases with population growth, especially and developing countries. Residents in developing countries meet their water needs through groundwater supplies. Moisture in the soil is susceptible to naturally occurring a number of pollutants such as several toxic metals, dyes and others and industrial effluents that produces fluoride, arsenic, nitrates, sulfates, iron, manganese, and chlorides that harm human health [4-10]. Fluoride ions are needed to form bones and teeth, but their needs are limited. The presence of fluoride ions in groundwater can occur naturally through the dissolution of fluoride from fluoride-rich mineral rocks such as fluorspar from limestone and cryolite from igneous rocks. The mineral arsenic is found in groundwater along with fluoride in some countries. Reserve osmosis and nanofiltration have reduced levels and eliminated arsenic minerals and fluoride in groundwater [3]. Other research results related to the feasibility of surface water as a source of drinking water or other activities of living things have been carried out in Lake Maninjau, Agam-SumBar, in March-September 2015. This study was conducted by taking water samples at river estuaries that have the potential to be the entry of water pollution materials from anthropogenic activity. This study concludes that there has been heavy metal pollution in sediments and molluscs in the estuaries of the Lake Maninjau River [11]. In another survey of groundwater quality in Bojongsalam village, Rancaekek-Bandung, in July 2019, indirect observation and unstructured interviews with residents gave the result is an observation of the physical quality of groundwater that is poor and has deposits [12]. The increase in the number of people and settlements and the existence of industry or human activities such as agriculture, farming, washing, and others result in polluting water on the surface as the results of research in Krukut River, South Jakarta in December 2018-May 2019 using qualitative and quantitative combined methods. Qualitative methods are carried out by interviewing stakeholders, while quantitative methods take water samples at 5 monitoring points along the ± 7.24 km in a grab sample. The results provide data on the quality status of moderately polluted water and efforts to control environmental pollution by the local government related to the function of this river water as a material. PDAM water source raw [13].

Research on water quality continues to be carried out every year, considering the significant function and quality in supporting life on earth. The feasibility test of the quality of water used as drinking water is a standard issued by each

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country. Indonesia regulates drinking water standards and sanitation hygiene in PerMenkes No 492 of 2010 and PerMenkes No 32 of 2017. Meanwhile, water quality testing methods are conducted in a health laboratory using physical, chemical, and biological parameters (TSS, TDS, BOD, COD, pH, and D.O.) [13]. Another interesting side of drinking water is the mineral content it has. The study results related to the mineral content possessed due to spruce in the drinking water source of 4 refillable drinking water depots have not been registered BPOM in Bukittinggi provide iron and manganese levels are below the threshold set by the Ministry of Health [14]. In another study on bottled drinking water circulating in the city of Makassar in 2016, 17 samples were taken purposive sampling and tested with the organoleptic method, SPADNS spectrophotometer, multiple takes system, giving the result that 3 models do not meet chemical parameters, 1 sample does not meet biological parameters, but 100% the sample meets the parameters of physics [15]. Another recent study in 2021 on the mineral content of refillable drinking water depots in the Siulak-Kerinci area gave the results of excess iron minerals from the threshold. Permenkes set the limit at one of the drinking water depots whose water source is drilled well water [16].

The water source is on the surface and from the excavation of wells or boreholes. Research related to the physical and chemical quality of dug wells and drill wells at Puskesmas Guntur II-Demak Regency on 20 dug wells is not suitable as clean water and water drink; however, 8 wells are decent drill as a source of clean water, and 1 training well is feasible as a source of drinking water [17]. This type of drinking water contains mineral levels (TDS) of 10-100ppm [18]. Each mineral composed has a maximum permissible value (KMD) that varies. It is adapted to the human need for these minerals [11]. Dissolved minerals generally in drinking water in carbonates, bicarbonate, chloride, sulfate, phosphate, nitrate, magnesium, sodium, calcium, potassium, and minimal amounts of manganese, iron, and other elements are sometimes found [19]. Data related to water quality and the need for water during this pandemic interested the author to test the feasibility of drilling well water in two places in Padang City to increase public confidence in the feasibility of groundwater namely dug wells and drilled wells as a source of clean water.

Material dan Method

Kimia Material

The material used is *Whatman* filter paper No. 41 (*G.E. Healthcare Life Sciences*); nitric acid pro analysis 65% (*Merck*), aqua D.M. (*Brataco*), iron solution (II) nitrate in nitric acid with a concentration of 1000 mg/L (*Merck*), zinc nitrate solution in nitric acid with a concentration of 1000 mg/L (*Merck*), manganese nitrate solution in nitric acid with a concentration of 1000 mg/L (*Merck*), glacial acetic acid (*Merck*) p.a, sulfanilic acid (*Merck*), N-(1-Naphthyl) ethylenediamine dihydrochloride (*Merck*), zinc powder 99% (*Merck*), sodium nitrite (*Merck*).

Equipment/Instruments

The tools used in the study were clear glass bottles, ice boxes, 100 mL (*Merck*) chemical cups, TDS & EC meter-pH-meter (*Kopepod*) packages, measuring flasks (10, 50, and 100) mL (*Pyrex*)), pipettes (1 and 5) mL (*Pyrex*), Erlenmeyer 250 mL (*Pyrex*), measuring cups 50 mL (*Pyrex*), AAS (*Variant-240*), vortex mixer (*OHAUS*), UV-Vis spectrophotometry (*T70*).

Sampling Method

The study used purposive sampling techniques in sample determination. The sample taken must meet the criteria in terms of physical water (tasteless, colorless, and odorless), social aspects used by residents to meet daily needs and the type of water in the aquifer layer (the underground layer that contains and drains water).

A. **Sampling** [20]

Sampling using SNI reference 6989.58.2008. They were taken from drill wells at a depth of 30 meters. They were rinsed the first 3 times before use. They're stored in such containers by volume according to the needs of parameter analysis. Containers are labeled by listing the sample number, date, and time of collection. Place the container on a box containing ice cubes. The other sample is the water of the dug well, whose retrieval process is the same as the drill well water.

B. TDS Measurements [21]

The TDS meter is turned on by pressing the *mode* button and pressing the wait *set* until it appears on the ppm value screen. Insert the tool into the sample to be measured, and wait for the indicated value to stabilize. Note the value listed, remove the device, then dip it in distilled water, dry it with tissue, and off it.

C. DHL Measurements [21]

Ec-meter turned on. After that, dip the electrodes in the water sample and wait for the tool's reading to stabilize. Record the values listed on the tool screen.

D. Iron Content Measurement [22]

1. Standard Solution Manufacturing (Calibration Curve)

The existing standard 1000 ppm iron solution is diluted to 100 ppm for standard solution series makers. The density of the standard solution made is (2.0; 4.0; 6.0; 8.0;10.0) ppm in a measuring flask of 100 mL.

2. Standard Solution Absorbance Measurement

The series of concentrations of the standard solution that has been made is measured its absorbance at a maximum wavelength of 248.3 nm.

3. Sample Absorbance Measurement

A sample of filtered water with a volume of 50 mL is placed in a 250 mL Erlenmeyer. Mix each model with 5 mL of concentrated nitric acid reagents, heat in an acid cabinet until the volume of liquid in the Erlenmeyer becomes 20 mL, then remove and cool. The sample liquid that has cooled, filtered back each, is put in a 50 ml measuring flask, then add aquademineralisata to the boundary mark. Sample pumpkins are ready to be reckoned with AAS. The measurement is repeated 2 times.

E. Manganese Level Measurement [23]

1. Standard Solution Manufacturing (Calibration Curve)

The existing standard solution of 1000 ppm manganese is diluted to 100 ppm for dilution for the makers of the standard solution series. The density of the standard solution series made is (0.5; 1.0; 2.0; 3.0; 4.0) ppm in a measuring flask of 100 mL.

2. Standard Solution Absorbance Measurement

The standard solution concentration series that has been made is measured absorbance at a maximum wavelength of 279.5 nm.

3. Sample Solution Absorbance Measurement

A sample of filtered water with a volume of 50 mL is placed in a 250 mL Erlenmeyer. Mix each model with 5 mL of concentrated nitric acid reagents, heat in an acid cabinet until the volume of liquid in the Erlenmeyer becomes 20 mL, then remove and cool. The sample liquid that has cooled, filtered back each, is put in a 50 ml measuring flask, then add aquademineralisata to the boundary mark. Sample pumpkins are ready to be reckoned with AAS. The measurement is repeated 2 times.

F. Zinc Measurement[24]

1. Standard Solution Manufacturing (Calibration Curve)

The existing standard 1000 ppm zinc solution is diluted to 10 ppm for the standard solution series maker. The density of the standard solution made is (0.2; 0.4; 0.6; 0.8; 1.0) ppm in a measuring flask of 100 mL.

2. Standard Solution Absorbance Measurement

The standard solution concentration series that has been made is measured absorbance at a maximum wavelength of 213.9 nm.

3. Sample Solution Absorbance Measurement

A sample of filtered water with a volume of 50 mL is placed in 5 Erlenmeyer 250 mL. Mix each model with 5 mL of concentrated nitric acid reagents, heat in an acid cabinet until the volume of liquid in the Erlenmeyer becomes 20 mL, then remove and cool. The sample liquid that has cooled, filtered back each, is put in a 100 ml measuring flask, then add aquademineralisata to the boundary mark. Sample pumpkins are ready to be reckoned with AAS. The measurement is repeated 2 times.

G. Nitrite Level Measurement[25]

1. Nitrite Parent Solution Manufacturing

Make a 10ppm nitrite master solution by weighing 0.1 grams of NaNO2 on the watch glass. Please put it in a beaker, then dissolve it with little-by-little aquades. After disbanding, put into the pumpkin measure 100 mL. The solution concentrated at 1000 ppm is diluted by taking 1mL of the solution input into the pumpkin, measuring 100 mL, then adding aquades to the limit mark. Stir until homogeneous.

2. Maximum Wavelength Measurement of Nitrite Standard Solution

The parent solution of 10 ppm is pickpocketed by 4 mL input in a 50 mL measuring flask. Add 2.5 mL of sulfanilic acid reagent, shake and leave for 5 minutes, then add 2.5 mL of NEDA reagent (N-1-ethylene ethylenediamine dihydrochloride) aquades to the boundary mark. Beat until homogeneous. Take a concentration absorption measurement of 0.8 ppm at 400-800 nm wavelength using distilled water blanks. Create an absorbance relationship curve with the wavelength to obtain the maximum wavelength.

3. Optimum Time Measurement of Nitrite Standard Solution

The 0.8 ppm parent solution measured absorption at the maximum wavelength obtained (e.g., 540 nm) every minute for 60 minutes with distilled water blanks. Curve the absorbance relationship with time to get the optimum time of the standard nitrite solution.

4. Nitrite Standard Solution Calibration Curve Manufacturing

The standard solution concentration series is made from a 10-ppm parent solution by suction (1; 2; 3; 4) mL, each placed in a 50 ml measuring flask. After that, add 2.5 mL of sulfanilic acid reagent, shake and leave for 5 minutes. Add 2.5 mL of NEDA reagents and aquades to the boundary mark, whisking until homogeneous. Measure absorption at the optimum time (9 minutes) with a maximum wavelength (540 nm). Create an absorbance relationship curve with concentration to obtain the calibration curve.

5. Measurement of Nitrite Levels in Samples

A water sample of 50 mL is filtered with Whatman filter paper. The first filtrate of 10 mL is discarded. Pipette 35 mL sample, put into a measuring flask 50 mL. Add 2.5 mL of sulfinic acid reagents, shake and let stand for 5 minutes. Add 2.5 mL of NEDA reagents and aquades to the boundary mark, whisking until homogeneous. Measure the absorption at the optimum time (9 minutes) with the previously obtained maximum wavelength (540 nm).

H. Nitrate Level Measurement[26]

A water sample of 50 mL is filtered, and the first filtrate of 10 mL is discarded, which is taken 35 mL is inserted in a 50 mL measuring flask. Put the zinc metal little by little (0.1 grams) in a measuring flask containing the sample while shaken with a vortex mixer. Add 1 mL of hydrochloric acid 1 N let stand for 10 minutes. After that, add 2.5 mL of sulfanilic acid reagent, shake and leave for 5 minutes. Add 2.5 mL of NEDA reagents and aquades to the boundary mark. Beat until homogeneous. Measure the sample solution at the optimum time and maximum wavelength. Create an absorbance relationship curve with concentration to obtain the calibration curve.

Data Analysis

A. Determination of Regression Equations

The curve obtained from the absorbance relationship and the standard solution concentration of the measured mineral can produce a regression equation:

$$y = ax + b \text{ ---------------------> } (1)$$

Equation (1) is a linear regression equation arranged by the symbol y to express the absorption ability of the substance measured by the instrument, x represents the measured concentration of the solution, a state the reference constant, and b states the regression coefficient. This regression equation is obtained by entering the absorbance data and solution concentration into Microsoft excel. Microsoft excel processes the data to provide linear regression equations and correlation coefficients.

B. Determination of Iron, Manganese, and Zinc Levels

The absorbance results obtained from the measurement of the sample solution are entered into the regression curve equation to calculate the concentration of iron/manganese/zinc in the groundwater sample.

C. Determination of Nitrite and Nitrate Levels

The nitrite absorbance value obtained from the measurement is used to calculate the measured concentration of the sample; after that, the levels (nitrite and nitrate) in the model can be calculated.

The equation can calculate the level of nitrite or nitrate in the sample:

$$K = \frac{x.V.Fp}{volume\ sample\ (mL)} \text{ --------------------->} (2)$$

Equation (2) is an equation used to determine nitrate levels in a sample (K). This equation expresses the relationship between the nitrate concentration in the sample solution after dilution (x), the volume of the sample solution (V), and the dilution factor (Fp) to the total volume of the sample.

Nitrate levels are obtained from nitrite reduction, so the calculation is done by reducing nitrite levels after removal. The result is converted using an equation:

$$\text{Nitrate Levels} = \text{nitrate reduction nitrite levels x } \frac{\text{B.M.nitrate}}{\text{B.M.nitrite}} \text{ ---------------> } (3)$$

Equation (3) is used to calculate nitrate levels in samples through the results of nitrate reduction levels by comparing the molecular weight (B.M.) of nitrates to the importance of nitrite molecules.

D. Data Eligibility Categorization

The data obtained from the results of water sample research is categorized with a table of drinking water quality standards according to Permenkes No. 492 of 2010.

Discussions

The following criteria for research samples are taken purposive sampling: 1) the sample is used as a daily necessity, 2) the sample is located in a residential environment. Limited time, effort, and scope of the search environment resulted in groundwater samples studying only 2 types: groundwater aquifer type of dug wells (depth 3-5 meters) and drill wells (depth 30-40 meters). Samples were taken in the morning at each location. The location of each sample is 1) the dug well is located in the yard of one of the residents. The condition of this dug well is not covered, and the water is taken through "timba." The timba tools used are ropes and plastic buckets. 2) Drill well water is taken from the faucet in the house's yard. The water is drawn using a machine flowing through paralon pipes and PVC water filter tubes.

TDS-EC measurements took the newly taken water sample. TDS and E.C. values are measured using digital TDS-EC tools. The measurement results are presented in figure 1. Before use, the electronic device is calibrated according to the instructions given by the agency. The requirements for chemical groundwater eligibility in this study were reviewed from data on mineral levels (iron, zinc, manganese) and nitrogen. Water samples are used to measure, packaged in plastic bottles, and stored at 100C during the waiting measurement time. The goal is no decomposition of bacteria in the water, affecting the observations to be made [27]. Data on the absorbance measurements and regression of iron, zinc, and manganese minerals can be seen in figures 2, 4, and 6. Iron, zinc, and manganese levels were measured using AAS. Successive iron, zinc, and manganese measurements were carried out at wavelengths (248.3; 279.5; 213.9) nm. The stories of iron, manganese, and zinc of each sample can be seen in Figures 3, 5, and 7. The wavelength curve, the optimum time curve, and the linear regression equation of the standard nitrite solution can be seen in figures 8, 9, and 10. The nitrite and nitrate levels of each sample are shown in figure 11.

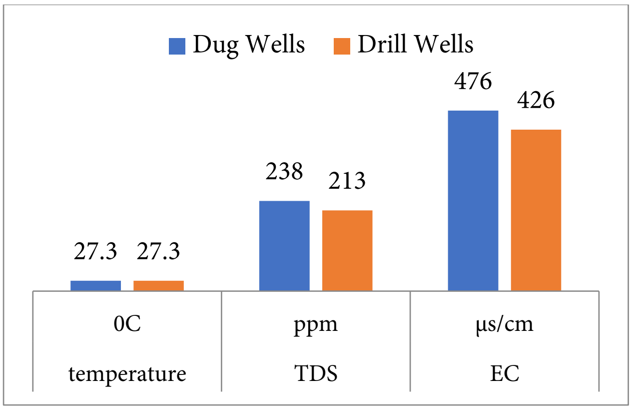

Figure 1. TDS and E.C. values

The results shown in figure 1 provide information that the temperature of both water samples is the same at 27.30C. The TDS and E.C. values of the dug well are higher than the drill. The TDS value depends on the concentration of dissolved inorganic molecules, while E.C. relies on the concentration of dissolved ions, the ability of ionized, and the temperature when measured[28]. The TDS and E.C. values that both samples had met drinking water quality. The TDS value for drinking water is small than 300 ppm. Dug wells and drill wells have TDS (238 and 213) ppm. Meanwhile, the E.C. values of the sample of dug wells and drill wells are (476 and 426) µS/cm. This value is in the (42-500) µS/cm category of drinking water[29].

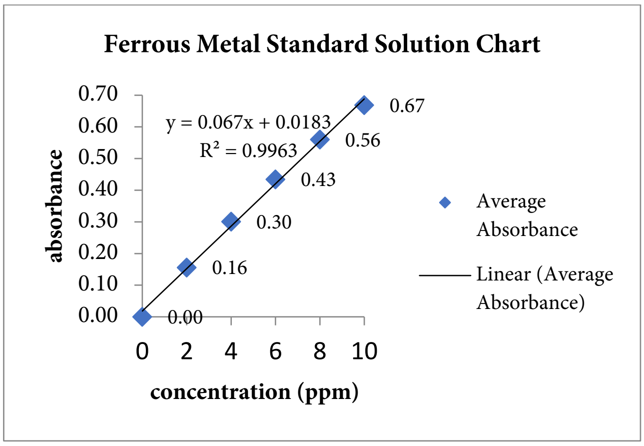

Figure 2. Iron Standard Solution Curve

The regression equation obtained from the measurement of the standard iron solution is y=0.067x+0.0183. This equation has a correlation coefficient value close to 1, meaning that the absorbance value is affected by concentration [30].

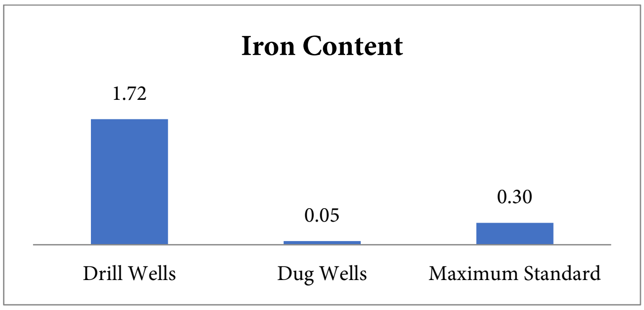

Figure 3. Sample Iron Content

Samples that have high iron content are drill wells. According to the results of a brief interview with the owner of the drill well water location, the water used has been filtered with a PVC water filter tube. This filter tube serves as a water purifier from undeserved particles as a condition of clean water [31]

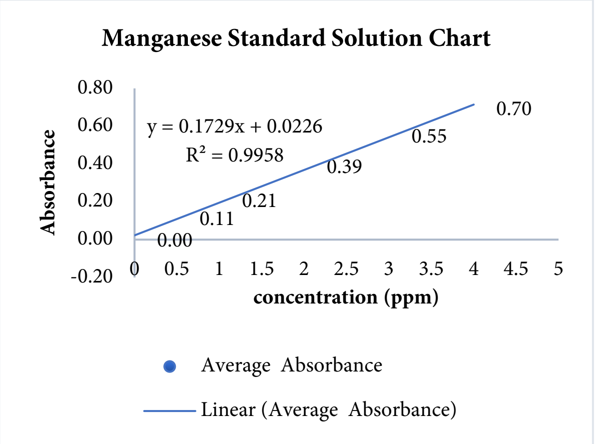

Figure 4. Manganese Standard Solution Chart

The standard solution of manganese used has a concentration (0.5; 1; 2, 3, 4) ppm. Measurements are made at a maximum wavelength of 213.9 nm. The measurement results give a regression equation of y = 0.1729 x + 0.0226 with a correlation coefficient close to 1.

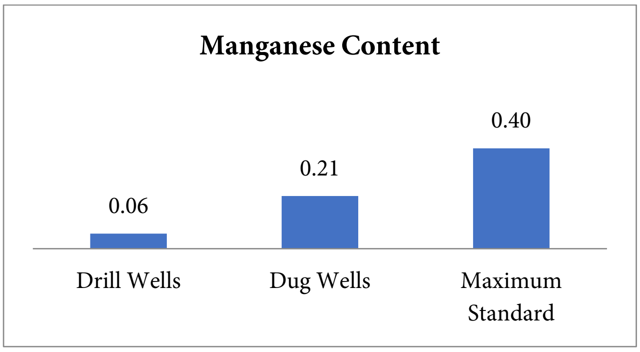

Figure 5. Sample Manganese Levels

Manganese mineral levels in samples of drill wells and dug wells are below the safe threshold of (0.06 and 0.21) ppm. Manganese mineral is one of the microminerals that helps physiological processes of the body in terms of an immune response, blood sugar regulation, development of brain function, etc. The presence of manganese in the body in excess thresholds can interfere with the health of the human nervous system so that it suffers from diseases whose symptoms resemble Parkinson's [32].

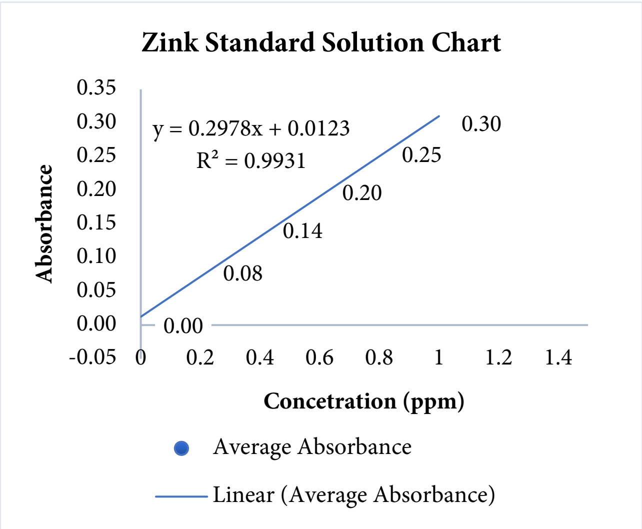

Figure 6. Zinc Standard Solution Chart

Determination of zinc in the sample uses a linear regression equation of a concentrated zinc standard solution (0.2; 0.4; 0.6; 0.8; 1). The existing regression equation gives a correlation coefficient value close to 1.

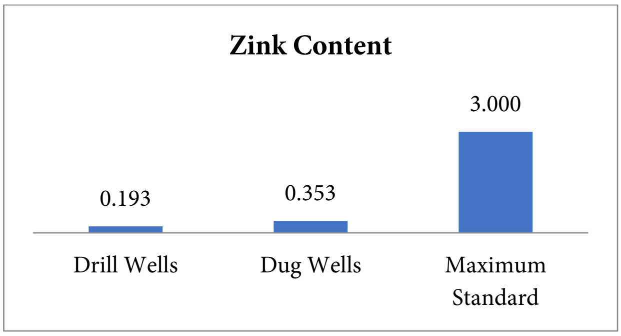

Figure 7. Sample Zinc Content

The samples studied contained zinc in amounts far from the minimum limit standards, especially in drill well water. Zinc minerals are micronutrients for the body, especially in protein formation, wound healing, and other biological processes. Zinc mineral deficiency impacts the decline of the function of organs of the body to cause disease. Clinical features of individuals experiencing zinc mineral deficiency are impaired sense of smell and taste buds, discolouration of nails, or scaly skin [32].

Other chemical parameters used to test groundwater viability are nitrite and nitrate levels. The measurement of nitrite levels begins with measuring the maximum wavelength of the standard nitrite solution of 0.8 ppm [25]. The maximum wavelength obtained is 540 nm (figure 8).

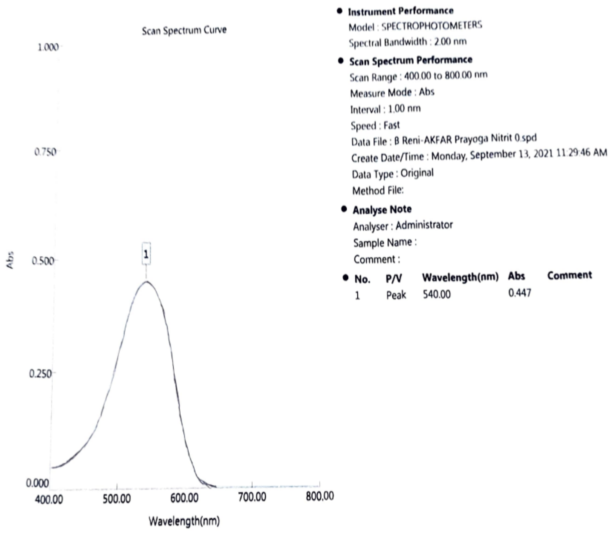

Figure 8. Maximum Wavelength Curve Nitrite Standard Solution

In the image, the maximum absorbance peak of 0.447 is at a wavelength of 540 nm. The maximum wavelength obtained is used to measure the optimum time nitrate solution reacts with sulfanilic acid and NED, which is a method of diazotization reaction. Measure the optimum time for 1 hour with time measurement every 1 minute to find reaction time at maximum absorption. The response at maximum absorption results in a steady reddish-purple discoloration and is read with a UV-Vis spectrophotometer [33].

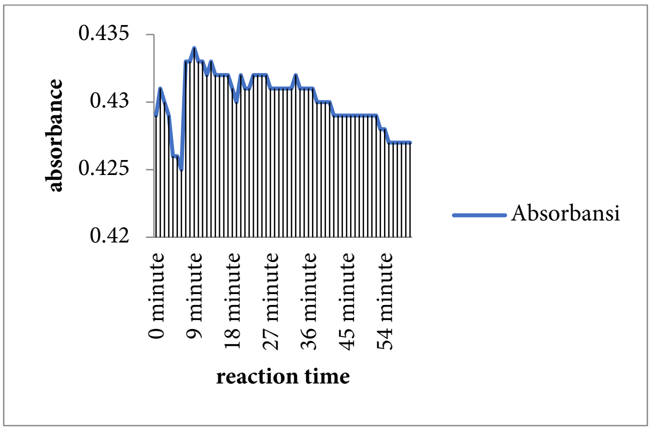

Figure 9. Optimum Time Curve of Nitrite Standard Solution

The result of the optimum time measurement is at the 9th minute with a maximum absorbance of 0.434. This optimum time measurement is used as the optimum time of sulfanilic acid and NED reactions with other standard nitrite solutions and water samples.

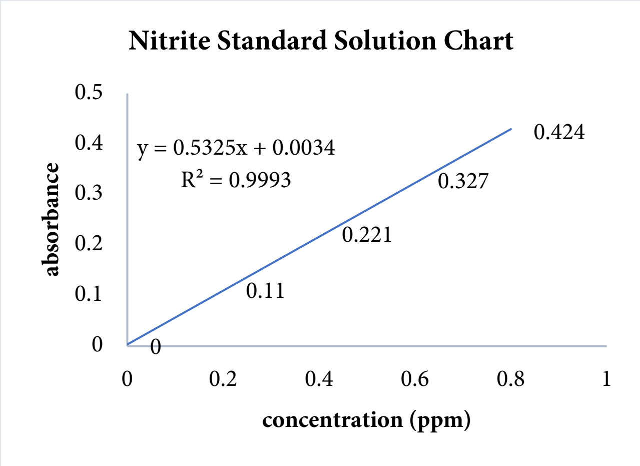

Figure 10. Nitrate Standard Solution Chart

The standard solution of nitrite measured has a concentration series (0; 0.2; 0.4; 0.6; 0.8) ppm. The measurement results provide a linear regression equation y = 0.5325x + 0.0034 with a correlation coefficient close to 1. Nitrate levels are measured by reducing nitrate to nitrite anions using zinc powder and then reacting with sulfanilic acid and NED [34].

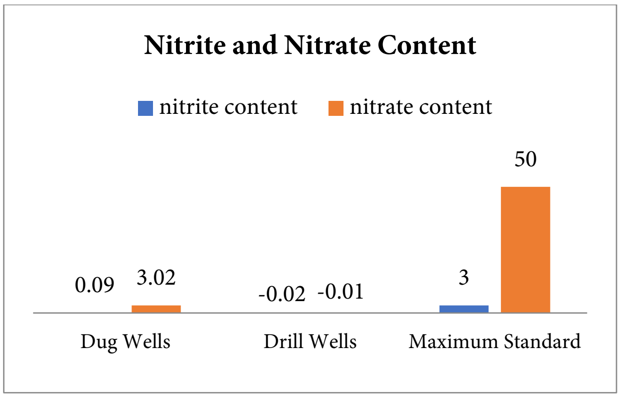

Figure 11. Nitrite and Nitrate Sample Levels

The water samples used had nitrite and nitrate levels below the maximum drinking water limit set by the government. The excavation well water sample had nitrite and nitrate levels of (0.09 and 3.02) ppm. Drill well water samples do not contain nitrites and nitrates because they are below zero (minus value). The results obtained were compared with nitrite and nitrate levels from well water samples found in Java with (0.05 and 0.09) ppm[28]. The presence of nitrites and nitrates in well water is due to ammonia's ability to dissolve in water and Nitrosomonas and Nitrobacter sp bacteria. Dissolved ammonia comes from the hydrolysis of organic nitrogen. Organic nitrogen can be sourced from the release of decaying organic matter such as leaves. Water samples from dug wells are open so that the oxidation process of ammonia by Nitrosomonas bacteria has a very big opportunity. Nitrites are unstable and easily oxidized to nitrates caused by the presence of Nitrobacter bacteria. These bacteria can be found in seawater, freshwater, and groundwater.

The presence of nitrites in drinking water can interfere with hemoglobin in the blood, which functions to bind oxygen and circulate throughout the body. Hemoglobin acts with nitrites to form stable methemoglobin that cannot bind to oxygen. As a result, the body will lack oxygen. On the other hand, the methemoglobin formed can react with secondary amines found in proteins producing n-nitrosamines. This resulting compound can trigger stomach cancer [35, 36].

Conclusion

In this work, the feasibility of groundwater, namely drill wells and dug wells as drinking water sources, has not met the feasibility of iron levels (drill wells), while chemical parameters others have complied. Each water source needs to be given attention to its feasibility standards, so this research aims to measure the feasibility of groundwater chemically based on data on minerals (iron, zinc, manganese), nitrogen levels, and DHL and TDS—sampling using *purposive sampling* techniques. The samples used in the test are dug well water and drill wells. The chemical parameters tested on both models stated the feasibility of the selection as a source of drinking water in terms of DHL, TDS, manganese, zinc, and nitrogen levels except for drill well water, whose iron content is 5.73 times more than the legal feasibility of iron content in drinking water.

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