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Determination of Metal Cadmium (Cd), Copper (Cu), Iron (Fe) and Zinc (Zn) in Drinking Water from The Boring Well of Surbakti Village, Karo District by Atomic Absorption Spectrophotometry Method

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ABSTRACT
Water is an essential requirement for human existence. In addition to traditional water usage, water is essential for enhancing the quality of human existence and facilitating industrial and technological endeavors. An investigation was conducted on the contents of Cadmium (Cd), Copper (Cu), Iron (Fe), and Zinc (Zn) in drinking water from drilled wells in Surbakti Village, Karo District, employing Atomic Absorption Spectrophotometry (AAS) techniques. Sampling occurred during weeks 1, 2, 3, 4, and 5 and was subsequently digested with concentrated nitric acid until a volume of 15 mL was attained. The metal concentrations of Cd, Cu, Fe, and Zn were quantified using Atomic Absorption Spectroscopy (AAS) using a calibration curve. The findings indicated a concentration of Cd at 0.0031 mg/L, Cu at 0.0470 mg/L, Fe at 0.2741 mg/L, and Zn at 0.2929 mg/L. In this instance, Cd produced a greater concentration of drinking water standards compared to Cu, Fe, and Zn. Nonetheless, it nonetheless met the drinking quality standards established by Regulation Minister of Health No. 492/Menkes/Per/VII/2010.

Keyword : Atomic Absorption Spectrophotometry, Borehole Water , Metal

ABSTRAK
Air adalah kebutuhan penting bagi keberadaan manusia. Selain untuk penggunaan air tradisional, air juga penting untuk meningkatkan kualitas hidup manusia dan memfasilitasi upaya industri serta teknologi. Penelitian ini dilakukan untuk menginvestigasi kandungan Kadmium (Cd), Tembaga (Cu), Besi (Fe), dan Seng (Zn) dalam air minum dari sumur bor di Desa Surbakti, Kabupaten Karo, dengan menggunakan teknik Spektrofotometri Serapan Atom (SSA). Pengambilan sampel dilakukan selama minggu ke-1, ke-2, ke-3, ke-4, dan ke-5 dan kemudian dicerna dengan asam nitrat pekat hingga volume mencapai 15 mL. Konsentrasi logam Cd, Cu, Fe, dan Zn diukur menggunakan Spektroskopi Serapan Atom (AAS) dengan kurva kalibrasi. Hasil penelitian menunjukkan konsentrasi Cd sebesar 0,0031 mg/L, Cu sebesar 0,0470 mg/L, Fe sebesar 0,2741 mg/L, dan Zn sebesar 0,2929 mg/L. Dalam hal ini, Cd menunjukkan konsentrasi yang lebih tinggi dibandingkan dengan standar air minum dibandingkan Cu, Fe, dan Zn. Namun, konsentrasi ini masih memenuhi standar kualitas air minum yang ditetapkan oleh Peraturan Menteri Kesehatan No. 492/Menkes/Per/VII/2010.

Kata Kunci : Air Sumur, Logam, Spektrofotometri Serapan Atom

1 Introduction

Water is also a substance of life, and no living creature on Earth does not need water. Research results show that 65-75% of adult body weight is water. According to health science, every person needs 2.5 - 3 liters of drinking water daily, including water in food. Humans can survive 2 - 3 weeks without food but only 2 - 3 days without drinking water [1].

Metal toxicity in humans is mostly due to non-essential heavy metals alone, although excessive doses of essential metals can poison them. Metal toxicity in humans causes several adverse effects, but most notably, damage to detoxification and excretory tissues (liver and kidneys) [2]. The toxicity of these metals is influenced by several factors, namely the level of metal consumed, duration of consumption, age, species, gender, habit of eating certain foods, physical condition, and the ability of body tissues to consume metals [3].

Mount Sinabung is one of the highland volcanoes in the Karo district, North Sumatra, Indonesia. The coordinates of Mount Sinabung are 3o10'LU and 98º23'BT, with the highest peak of this mountain being 2460 meters above sea level, the highest peak in North Sumatra. The activity of Mount Sinabung once released volcanic dust and smoke in 2010. Then, in 2013, it was issued, spewing volcanic dust again. The results of the mountain eruption emit thick black smoke. The volcanic dust covered thousands of hectares of farmers' crops around the mountain. Volcanic dust from volcanic eruptions continues flying to various mountain areas. Volcanic ash from volcanoes carried by the wind in various directions endangers residents, especially disturbing respiratory health, eyes, skin and water pollution [4].

Analysis of heavy metals and nutrients in volcanic dust in Mount Sinabung district karo north Sumatra showed that the volcanic dust has a heavy metal content [5]. Consequently, researchers want to investigate the concentrations of Cd, Cu, Fe, and Zn in drinking water sourced from boreholes in Surbakti Village, Mount Sinabung, Karo Regency, utilizing the Atomic Absorption Spectrophotometry (AAS) method..

2 Materials and Methods

2.1 Materials and Equipments

The well water sample was obtained from Surbakti Village, is a village in Sinabung Mountain area. Next, $HNO_{3\ (p)}$, Fe Standard Solution 1000 mg/L, Cu Standard Solution 1000 mg/L, Cd Standard Solution 1000 mg/L, Zn Standard Solution 1000 mg/L, and distilled water were purchased by E. Merck. The equipment used is an atomic absorption spectrophotometer (AAS), Shimadzu AA-7000.

2.2 Preparation

2.2.1 Sample Preservation

The material was treated with HNO_3 (p) until the pH reached around 2. 100 mL was transferred into a glass beaker, and 5 mL of concentrated HNO_3 was added. The mixture was further heated until nearly dry, after which 50 mL of distilled water was included and transferred into a 100 mL measuring flask via filter paper. Dilute with distilled water to the mark line and whisk until homogenous.

2.2.2 Preparation of Cd, Cu, Fe, and Zn Standard Solutions

A total of 5 mL of 1000, 100, and 10 mg/L Cd solution was each put into a 50 mL volumetric flask. Then, distilled water was added to the limit line and stirred until homogeneous, resulting in each standard solution Cd of 100, 10, and 1 mg/L. Furthermore, the manufacture of standard Cu, Fe, and Zn solutions also uses similar doses and methods with the above preparation.

2.2.3 Preparation of Cd Standard Series Solution (SNI 6989.16: 2009), Cu (SNI 6989.6: 2009), Fe (SNI 6989.4: 2009), and Zn (SNI 6989.7: 2009).

Volumes of 0.00, 0.05, 0.10, 0.15, 0.20, and 0.25 mL of a 1 mg/L Cd standard solution were added to a 50 mL volumetric flask and subsequently diluted with a diluent solution to the calibration mark, followed by thorough stirring to achieve homogeneity. A Cu standard series solution was prepared by adding 25 mL of a 1 mg/L Cu standard solution and 7.5, 10, and 12.5 mL of a 10 mg/L Cu standard solution into a 50 mL flask. Furthermore, dilute with the diluent solution to the marked line and stir until homogenous. The Fe standard series solution was prepared by adding 10, 20, 30, and 40 mL of a 1 mg/L Fe standard solution into a 50 mL flask, followed by dilution with the diluent solution to the specified line and thorough stirring to achieve homogeneity. Subsequently, a Zn standard series solution was prepared by adding 25 mL of a Zn 1 mg/L standard solution and 7.5, 10, and 12.5 mL of a Zn 10 mg/L standard solution into a 50 mL flask [6], [7], [8], [9].

2.3 Preparation of Calibration Curves for Cd, Cu, Fe, and Zn

Standard series solutions of Cd (0.001; 0.002; 0.003; 0.004; and 0.005 mg/L), Cu (0. 5; 1.0; 1.5; 2.0; and 2.5 mg/L), Fe (0.2; 0.4; 0.6; 0.8 and 1.0 mg/L), and Zn (0.5; 1.0; 1.5; 2.0 and 2.5 mg/L) were all measured for absorbance values using an AAS at specific λ of 228.8 nm, 324.8 nm, 248.3 nm and 213.9 nm, respectively.

2.4 Measurement of Cd, Cu, Fe, and Zn Levels Well Water Samples Derived from Surbakti Village

Cd, Cu, Fe, and Zn contents of well water samples derived from Surbakti Village were measured using AAS at the specific λ of 228.8 nm, 324.8 nm, 248.3 nm and 213.9 nm, respectively. The treatment was carried out 3 times for each particular λ.

3 Results and Discussion

3.1 Results

3.1.1 Cadmium (Cd)

The preparation of the standard solution curve for the element Cd was carried out by preparing a standard solution with various concentrations, namely in measurements of 0.0000; 0.0010; 0.0020; 0.0030; 0.0040; and 0.0050 mg/L, then measuring the absorbance with an AAS tool. Absorbance data for Cd standard solution can be seen in Figure 1 and Table 1 below.

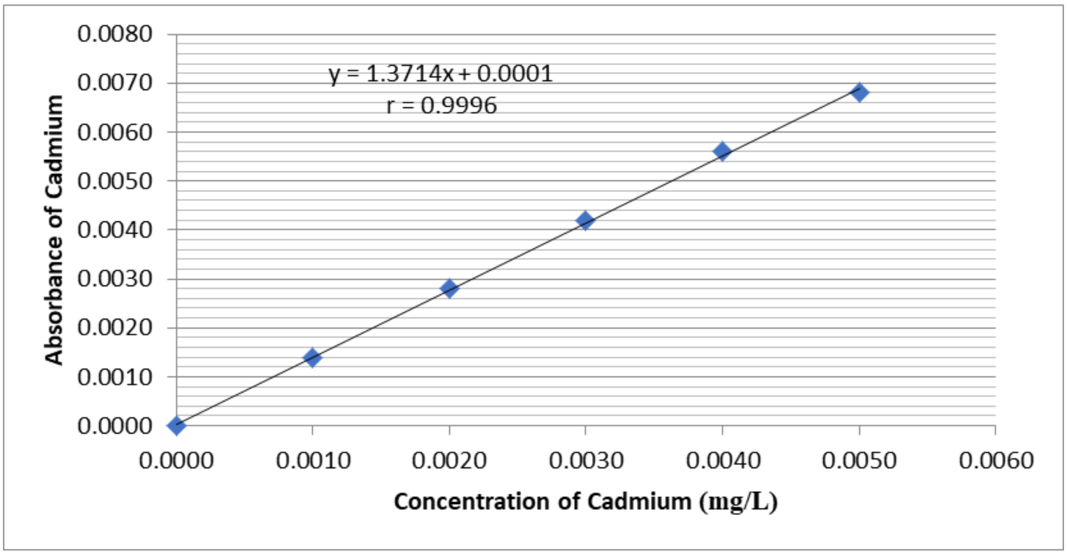

Figure 1. Cadmium (Cd) Standard Solution Curve

Table 1. Absorbance data of the standard Cadmium (Cd) solution

Concentration (mg/L)	Average of Absorbance ($\bar{A}$)
0.0000	0.0000
0.0010	0.0014
0.0020	0.0028
0.0030	0.0042
0.0040	0.0056
0.0050	0.0068

Data Processing of Cadmium (Cd) Element:

- Data Processing of Cd Element:

The absorbance measurements of the Cd standard series solution presented in Table 1 were plotted versus concentration to generate a linear curve. The equation of the regression line for this curve can be obtained using the least squares method with the data presented in Table 2.

Table 2 Derivation of the regression line equation for the determination of the concentration of elemental Cd based on absorbance measurements of Cd standard solution

No	Xi	Yi	(Xi-X)	(Yi-Y)	$(Xi-X)^2$	$(Yi-Y)^2$	(Xi-X) (Yi-Y)
1	0.0000	0.0000	-0.0025	-0.0035	6.2500×10^{-6}	1.2250×10^{-5}	8.7500×10^{-6}
2	0.0010	0.0014	-0.0015	-0.0021	2.2500×10^{-6}	4.4100×10^{-6}	3.1500×10^{-6}
3	0.0020	0.0028	-0.0005	-0.0007	2.5000×10^{-7}	4.9000×10^{-7}	3.5000×10^{-7}
4	0.0030	0.0042	0.0005	0.0007	2.5000×10^{-7}	4.9000×10^{-7}	3.5000×10^{-7}
5	0.0040	0.0056	0.0015	0.0021	2.2500×10^{-6}	4.4100×10^{-6}	3.1500×10^{-6}
6	0.0050	0.0068	0.0025	0.0033	6.2500×10^{-6}	1.0890×10^{-5}	8.2500×10^{-6}
∑	0.0150	0.0208	0.0000	-0.0002	1.7500×10^{-5}	3.2940×10^{-5}	2.4000×10^{-5}

$$X = \frac{\sum Xi}{n} = \frac{0.015}{6} = 0.0025$$

$$Y = \frac{\sum Yi}{n} = \frac{0.0208}{6} = 0.0035$$

The equation of the regression line for the curve can be derived from the equation of the line:

$$y = ax + b$$

Where :
a = slope
b = intercept

Furthermore, the slope price can be determined using the least square method as follows:

$$a = \frac{\sum(Xi - X)(Yi - Y)}{\sum(Xi - X)^2}$$
$$b = y - ax$$

By substituting the prices listed in Table 2 in the equation above, it is obtained:

$$a = \frac{2.4000}{1.7500} = 1.3714$$
$$\text{b} = 0.0035 - (1.3714 \times 0.0025)$$
$$= 0.0035 - 0.0034$$
$$= 0.0001$$

Then the line equation obtained is:

$$y = 1.3714x + 0.0001$$

- Correlation Coefficient:

The correlation coefficient can be determined using the following equation:

$$r = \frac{\sum(Xi - X)(Yi - Y)}{[\sum(Xi - X)^2 \sum(Yi - Y)^2]^{½}}$$
$$r = \frac{2.4000}{[(1.7500)(3.2940)]^{½}}$$
$$r = \frac{2.4000}{[5.7645]^{½}}$$
$$r = \frac{2.4000}{2.4009}$$

$r = 0.9996$

Concentration Determination:

The absorbance measurement data of the element Cadmium (Cd) in well water was taken to calculate the Cd level. Complete data in Table 3

Table 3. Absorbance data of cadmium (cd) element in samples measured 3 times

Sample	**Week**	**Absorbance**			**Average Absorbance ($\bar{A}$)**
		A_1	**A_2**	**A_3**	
Water Borehole	1	0.0037	0.0035	0.0030	0.0034
	2	0.0042	0.0039	0.0037	0.0039
	3	0.0047	0.0045	0.0043	0.0045
	4	0.0055	0.0052	0.0048	0.0051
	5	0.0059	0.0054	0.0049	0.0054

The concentration of Cd element in the sample can be measured by substituting the Y value (absorbance) of Cd into the equation:

$$y = 1.3714x + 0.0001$$

Table 4. Statistical data analysis of the determination Cd element concentration in borehole water

No	**Xi**	**(Xi-X)**	**$(Xi\text{-}X)^2$**
1	0.0024	-0.0007	4.9000×10^{-7}
2	0.0027	-0.0004	1.6000×10^{-7}
3	0.0032	0.0001	1.0000×10^{-8}
4	0.0036	0.0005	2.5000×10^{-7}
5	0.0038	0.0006	3.6000×10^{-7}
n	$\bar{X} = 0.0031$		$\sum (Xi\text{-}X)^2 = 1.2700 \times 10^{-6}$

$$SD = \sqrt{\frac{\sum (\text{Xi} - \text{X})^2}{n-1}}$$

$$= \sqrt{\frac{1.2700\ x\ 10^{-6}}{4}}$$

$$= 0.0006$$

Cadmium (Cd) concentration in borehole water $= X \pm SD$

$= 0.0031 \pm 0.0006$ (mg/L)

3.1.2 Copper (Cu) Element

Preparation of a standard solution curve for the element of Cu was carried out by preparing a standard solution with various concentrations, namely at measurements of 0.0000; 0.5000; 1.0000; 1.5000; 2.0000 and 2.5000 mg/L, then measuring the absorbance with an AAS tool. Absorbance data of Cu standard solution can be seen in Table 5 and the its calibration curve presented in Figure 2.

Table 5. Absorbance data of Copper (Cu) standard solution

Concentration (mg/L)	Average of Absorbance (Ā)
0.0000	0.0000
0.5000	0.0424
1.0000	0.0735
1.5000	0.1161
2.0000	0.1567
2.5000	0.1876

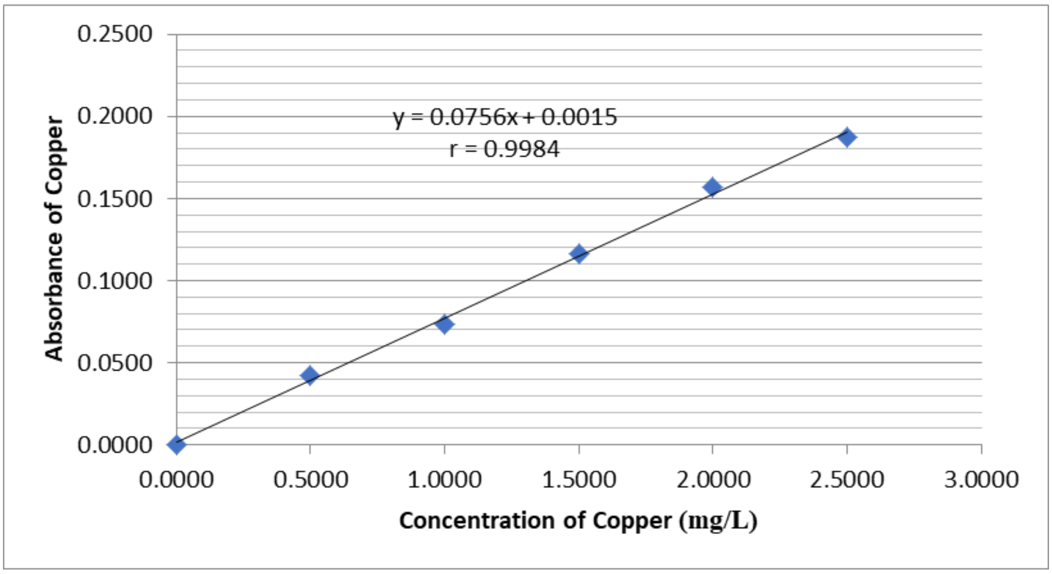

Figure.2. Cu Standard Solution Curve

Copper (Cu) Element Data Processing:

- Derivation of Regression Line Equation by Least Square Method

The absorbance measurements of the Copper (Cu) standard series solution are presented in Table 5, plotted versus concentration to yield a linear curve. The equation of the regression line for this curve can be obtained using the Least Squares approach with the data presented in Table 6.

Table 6. Derivation of the regression line equation for the determination of the concentration of Cu based on the measurement of the absorbance of the standard solution of Cu

No	Xi	Yi	(Xi-X)	(Yi-Y)	$(Xi-X)^2$	$(Yi-Y)^2$	(Xi-X)(Yi-Y)
1	0.0000	0.0000	-1.2500	-0.0960	1.5625	0.0092	0.1200
2	0.5000	0.0424	-0.7500	-0.0536	0.5625	0.0029	0.0402
3	1.0000	0.0735	-0.2500	-0.0225	0.0625	0.0005	0.0056
4	1.5000	0.1161	0.2500	0.0201	0.0625	0.0004	0.0050
5	2.0000	0.1567	0.7500	0.0607	0.5625	0.0037	0.0455
6	2.5000	0.1876	1.2500	0.0916	1.5625	0.0084	0.1145
∑	7.5000	0.5763	0.0000	0.0003	4.3750	0.0251	0.3308

$$X = \frac{\sum Xi}{n} = \frac{7.5}{6} = 1.25$$

$$Y = \frac{\sum Yi}{n} = \frac{0.5763}{6} = 0.0960$$

The equation of the regression line for the curve can be derived from the equation of the line:

$$y = ax + b$$

where :
a = slope
b = intersept
Furthermore, the slope price can be determined using the least square method as follows:

$$a = \frac{\sum(Xi - X)(Yi - Y)}{\sum(Xi - X)^2}$$

$$b = y - ax$$

By substituting the prices listed in Table 6 obtained:

$$a = \frac{0.3308}{4.3750} = 0.0756$$

$$\text{b} = 0.0960 - (0.0756 \text{ x } 1.25)$$

$$= 0.0960 - 0.0945$$

$$= 0.0015$$

Then the line equation obtained is:

$$y = 0.0756x + 0.0015$$

- Correlation Coefficient

The correlation coefficient can be determined using the following equation:

$$r = \frac{\sum(Xi - X)(Yi - Y)}{[\sum(Xi - X)^2 \sum(Yi - Y)^2]^{½}}$$

$$r = \frac{0.3308}{[(4.3750)(0.0251)]^{½}}$$

$$r = \frac{0.3308}{[0.1098125]^{½}}$$

$$r = \frac{0.3308}{0.3313}$$

$$r = 0.9984$$

Concentration Determination:
To calculate the concentration of Cu, the absorbance measurement data of the element Copper (Cu) in borehole water was taken. Complete data in table 7

Table 7. Absorbance Data of Copper (Cu) Element in Samples Measured 3 times

Sample	**Week**	**Absorbance**			**Average Absorbance (Ā)**
		A_1	**A_2**	**A_3**	
Water Borehole	1	0,0028	0,0023	0,0023	0,0025
	2	0,0043	0,0041	0,0038	0,0041
	3	0,0058	0,0056	0,0054	0,0056
	4	0,0063	0,0059	0,0056	0,0059
	5	0,0077	0,0071	0,0068	0,0072

The concentration of Copper (Cu) element in the sample can be measured by substituting the Y value (absorbance) of Copper (Cu) into the equation: y=0.0756x+0.0015.

Table 8. Statistical data analysis of the determination of the concentration of Cu in borehole water

No	Xi	(Xi-X)	(Xi-X)2
1	0.0132	-0.0338	0.0011
2	0.0343	-0.0127	0.0001
3	0.0542	0.0072	0.0005
4	0.0582	0.0112	0.0001
5	0.0753	0.0283	0.0008
n	$\bar{X}$ = 0.0470		$\sum (Xi-X)^2$ = 0.0021

$$SD = \sqrt{\frac{\sum (\mathrm{Xi} - \mathrm{X})2}{n-1}}$$
$$= \sqrt{\frac{0.0021}{4}}$$
$$= 0.0229$$

Copper (Cu) concentration in borehole water $= X \pm SD$
$= 0.0470 \pm 0.0229$ (mg/L)

3.1.3 Iron (Fe) Element

Preparation of the Iron (Fe) standard solution curve was carried out by preparing a standard solution with various concentrations, namely in measurements of 0.0000; 0.2000; 0.4000; 0.6000; 0.8000 and 1.0000 mg/L, then measuring the absorbance with an SSA tool. Absorbance data for Iron (Fe) standard solution can be seen in Table 9 below.

Table 9. Absorbance data for Iron (Fe) standard solution

Concentration (mg/L)	Average of Absorbance (Ā)
0.0000	0.0000
0.2000	0.0091
0.4000	0.0153
0.6000	0.0241
0.8000	0.0307
1.0000	0.0367

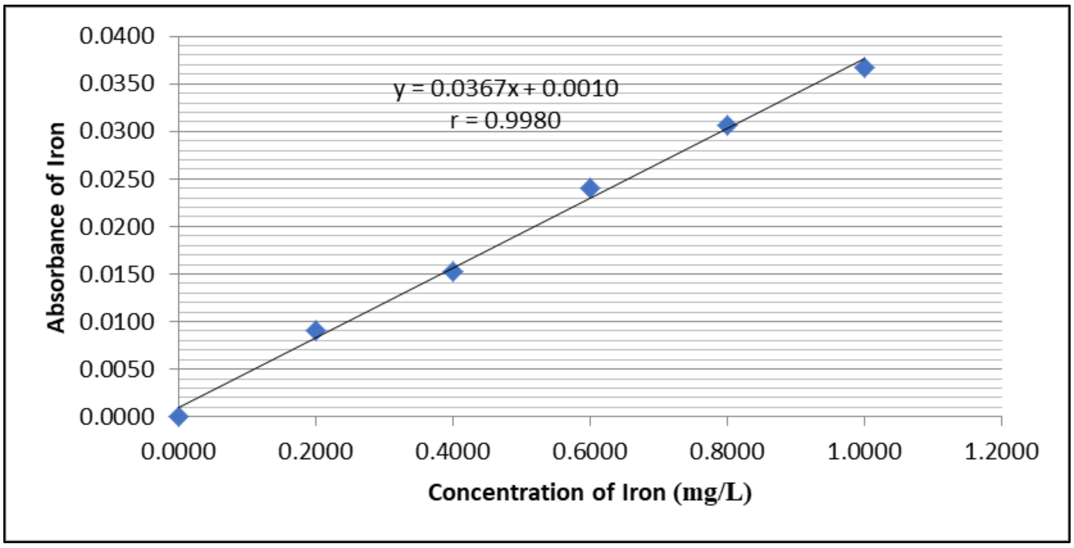

Figure 3. Iron (Fe) Standard Solution Curve

Iron (Fe) Data Processing:

- Derivation of regression line equation by Least Square Method

For the purpose of obtaining a curve in the form of a linear line, the absorbance measurement results of the Iron (Fe) element standard series solution are plotted against the concentration in Table 9. It is possible to obtain the regression line equation for this curve by using the Least Squares approach with the data that is presented in Table 10.

Table 10. Derivation of the regression line equation for the determination of the concentration of the element Iron (Fe) based on the measurement of the absorbance of the standard solution of Iron (Fe)

No	Xi	Yi	(Xi-X)	(Yi-Y)	$(Xi-X)^2$	$(Yi-Y)^2$	(Xi-X)(Yi-Y)
1	0.0000	0.0000	-0.5000	-0.0193	0.0250	3.7249×10^{-4}	9.6500×10^{-3}
2	0.2000	0.0091	-0.3000	-0.0102	0.0900	1.0404×10^{-4}	3.0600×10^{-3}
3	0.4000	0.0153	-0.1000	-0.0040	0.0100	1.6000×10^{-7}	4.0000×10^{-4}
4	0.6000	0.0241	0.1000	0.0048	0.0100	2.3040×10^{-5}	4.8000×10^{-4}
5	0.8000	0.0307	0.3000	0.0114	0.0900	1.2996×10^{-4}	3.4200×10^{-3}
6	1.0000	0.0367	0.5000	0.0174	0.0250	3.0276×10^{-4}	8.7000×10^{-3}
∑	3.0000	0.1159	0.0000	0.0037	0.7000	9.4829×10^{-4}	0.02571

$$X = \frac{\sum Xi}{n} = \frac{3}{6} = 0.5$$

$$Y = \frac{\sum Yi}{n} = \frac{0.1159}{6} = 0.0193$$

$$a = \frac{0.02571}{0.7000} = 0.0367$$

$$\begin{aligned} b &= 0.0193 - (0.0367 \text{ x } 0.5) \\ &= 0.0193 - 0.0183 \\ &= 0.0010 \end{aligned}$$

Then the equation of the line obtained is :

$$y = 0.0367x + 0.0010$$

- Correlation Coefficient

The correlation coefficient can be determined using the following equation:

$$r = \frac{\sum(Xi - X)(Yi - Y)}{[\sum(Xi - X)^2 \sum(Yi - Y)^2]^{½}}$$
$$r = \frac{0.02571}{[(0.7000)(9.4829x10^{-4})]^{½}}$$
$$r = \frac{0.02571}{[6.63803x10^{-4}]^{½}}$$
$$r = \frac{0.02571}{0.02576}$$
$$r = 0.99980$$

Concentration Determination:

To calculate the concentration of Iron (Fe), the absorbance measurement data of Iron (Fe) in borehole water was taken and the data were displayed Table 11.

Table 11. Absorbance Data of Iron (Fe) in Samples Measured 3 times

Sample	Week	Absorbance			Average of Absorbance ($\bar{A}$)
		A_1	A_2	A_3	
Water Borehole	1	0.0098	0.0091	0.0089	0.0092
	2	0.0105	0.0098	0.0096	0.0099
	3	0.0115	0.0114	0.0111	0.0113
	4	0.0120	0.0118	0.0116	0.0118
	5	0.0134	0.0131	0.0129	0.0131

The concentration of Iron (Fe) in the sample can be measured by substituting the Y value (absorbance) of Iron (Fe) into the equation:

$$y = 0.0367x + 0.0010$$

Table 12. Statistical data analysis of Iron (Fe) concentration determination in borehole water

No	Xi	(Xi-X)	$(Xi-X)^2$
1	0.2234	-0.0507	0.0025
2	0.2425	-0.0316	0.0009
3	0.2806	0.0065	0.0004
4	0.2942	0.0201	0.0004
5	0.3297	0.0556	0.0031
n	$\bar{X}$ = 0.2741		$\sum (Xi-X)^2 = 0.0069$

$$SD = \sqrt{\frac{\sum (\text{Xi} - \text{X})2}{n - 1}}$$

$$= \sqrt{\frac{0.0069}{4}}$$

$$= 0.0415$$

Iron (Fe) concentration in borehole water $= X \pm SD$

$$= 0.2741 \pm 0.0415 \text{ (mg/L)}$$

3.1.4 Element Zinc (Zn)

Making a standard solution curve for the element Zn was done by preparing a standard solution with various concentrations, namely at measurements of 0.0000; 0.5000; 1.0000; 1.5000; 2.0000 and 2.5000 mg / L, then measuring the absorbance with an AAS tool conditions. Absorbance data for Zn standard solution can be seen in Table 13 and its calibration curve is presented in Figure 4.

Table 13. Absorbance data for Zinc (Zn) standard solution

Concentration (mg/L)	**Average of Absorbance ($\bar{A}$)**
0.0000	0.0000
0.5000	0.1431
1.0000	0.2408
1.5000	0.3783
2.0000	0.4851
2.5000	0.5790

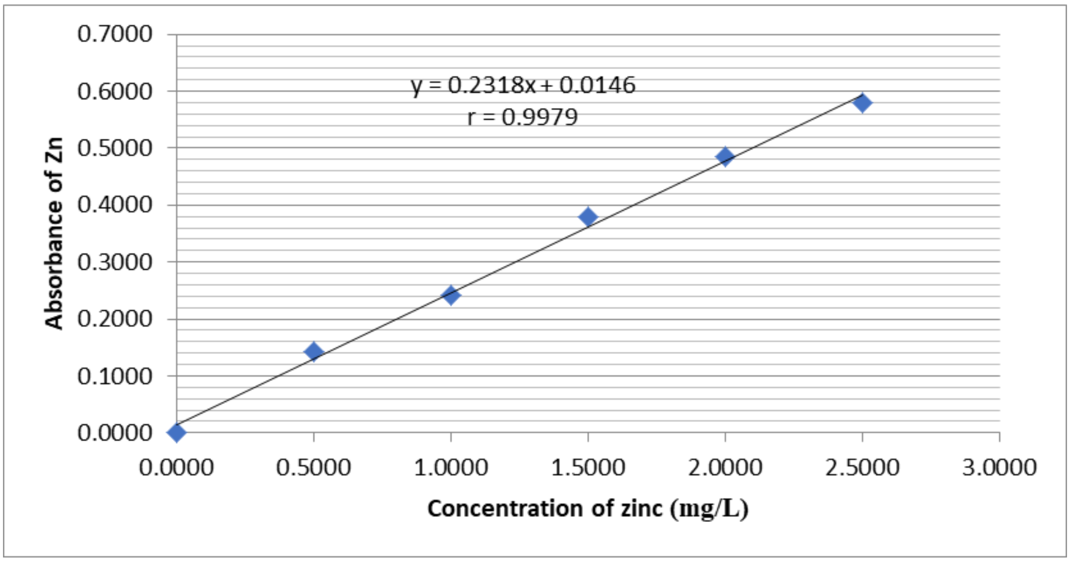

Figure 4. Zinc (Zn) Standard Solution Curve

Data Processing of the Element Zinc (Zn):

- Derivation of Regression Line Equation by Least Square Method

The absorbance measurement results of the Zinkum (Zn) element standard series solution in Table 4.13. were plotted against the concentration to obtain a curve in the form of a linear line. The regression line equation for this curve can be derived by the Least Square method with the data in Table 14.

Table 14. Derivation of the regression line equation for the determination of Zn concentration based on absorbance measurements of Zn standard solution

No	Xi	Yi	(Xi-X)	(Yi-Y)	$(Xi-X)^2$	$(Yi-Y)^2$	(Xi-X) (Yi-Y)
1	0.0000	0.0000	-1.2500	-0.3043	1.5625	0.0925	0.3803
2	0.5000	0.1431	-0.7500	-0.1612	0.5625	0.0260	0.1209
3	1.0000	0.2408	-0.2500	-0.0635	0.0625	0.0040	0.0158
4	1.5000	0.3783	0.2500	0.0740	0.0625	0.0055	0.0185
5	2.0000	0.4851	0.7500	0.1808	0.5625	0.0327	0.1356
6	2.5000	0.5790	1.2500	0.2747	1.5625	0.0754	0.3433
∑	7.5000	1.8263	0.0000	0.0005	4.3750	0.2363	1.0145

$$X = \frac{\sum Xi}{n} = \frac{7.5}{6} = 1.25$$

$$Y = \frac{\sum Yi}{n} = \frac{1.8263}{6} = 0.3043$$

Then the equation of the line obtained is :

$$y = 0.2318x + 0.0146$$

- Correlation Coefficient

The correlation coefficient can be determined using the following equation:

$$r = \frac{\sum(Xi - X)(Yi - Y)}{[\sum(Xi - X)^2 \sum(Yi - Y)^2]^{½}}$$

$$r = \frac{1.0145}{[(4.3750)(0.2363)]^{½}}$$

$$r = \frac{1.0145}{[1.033375]^{½}}$$

$$r = \frac{1.0145}{1.0165504}$$

$$r = 0.9979$$

Concentration Determination:

To calculate the concentration of Zn element, and the absorbance measurement data of Zn element in borehole water was taken and the complete data in Table 15.

Tabel 15. Absorbance data of Zn in Samples measured 3 times

Sample	Week	Absorbance			Average of Absorbance (Ā)
		A_1	A_2	A_3	
Water Borehole	1	0.0649	0.0639	0.0635	0.0641
	2	0.0758	0.0754	0.0749	0.0753
	3	0.0863	0.0858	0.0854	0.0858
	4	0.0939	0.0934	0.0929	0.0934
	5	0.0947	0.0938	0.0933	0.0939

$$y = 0.2318x + 0.0146$$

Tabel 16. Statistical data analysis of Zn concentration determination in borehole water

No	Xi	(Xi-X)	$(Xi-X)^2$
1	0.2153	-0.0776	0.0060
2	0.2619	-0.0310	0.0009
3	0.3071	0.0142	0.0002
4	0.3399	0.0470	0.0022
5	0.3421	0.0492	0.0024
n	$\overline{X}$ = 0.2929		$\sum (Xi-X)^2 = 0.0117$

$$SD = \sqrt{\frac{\sum (\mathrm{Xi} - \mathrm{X})2}{n-1}}$$

$$= \sqrt{\frac{0.0117}{4}}$$

$$= 0.0541$$

Zn concentration in borehole water $= X \pm SD$

$= 0.2929 \pm 0.0541$ (mg/L)

Tabel 17. Results of determination of Cd, Cu, Fe, and Zn in samples

Ion Cd^{2+} (mg/L)	Ion Cu^{2+} (mg/L)	Ion Fe^{3+} (mg/L)	Ion Zn^{2+} (mg/L)
0.0031	0.0470	0.2741	0.2929

3.2 Discussion

Water resources are among the most vital natural resources for human existence. Water is an essential daily requirement for humans, indicating that survival is impossible without it. Consequently, its quality is still regarded as essential for the sustenance of human life and other organisms. Water contamination resulting from inorganic and organic substances derived from human activities, including industrial and home waste, encompasses numerous deleterious heavy metals.

The permissible limits of metals as stipulated in the Minister of Health Regulation No. 492/Menkes/Per/VII/2010 on drinking water quality. The maximum concentrations are as follows: Cd, Cu, Fe, and Zn were found to be (0.003, 2, 0.3, 3) mg/L, respectively. Elevated concentrations of metals can result in adverse health consequences, including renal disease, pulmonary disease, nausea, emesis, and hepatic damage. This study involved quantifying the concentrations of Cd, Cu, Fe, and Zn in borehole water contaminated by dust from the Mount Sinabung eruption, utilized for potable purposes. The research results indicate levels of Cd, Cu, Fe, and Zn were 0.0031 mg/L, 0.0470 mg/L, 0.2751 mg/L, and 0.2929 mg/L, repectively [10].

According to Minister of Health Regulation Number 492/Menkes/Per/VII/2010, the concentration of Cd exceeds the drinking water quality standards, while Cu, Fe, and Zn are still below the threshold. The research results obtained from borehole water samples used for drinking water contain levels of Cd, Cu, Fe, and Zn. The utmost limit of Cadmium (Cd) has been surpassed, as indicated by the results of the aforementioned discussion. We suggest that the community in Surbakti village filter the borehole water before consuming it, as it contains high levels of Cd. This can lead to health issues as the cadmium accumulates in the body [10].

4 Conclusion

According to Minister of Health Regulation Number 492/Menkes/Per/VII/2010, the concentration of Cadmium (Cd) exceeds the drinking water quality standards, while Copper (Cu), Iron (Fe), and Zinc (Zn) are still below the threshold. The research results obtained from borehole water samples used for drinking water contain levels of Cd, Cu, Fe, and Zn. The utmost limit of Cadmium (Cd) has been surpassed, as indicated by the results of the aforementioned discussion. We suggest that the community in Surbakti village filter the borehole water before consuming it, as it contains high levels of cadmium (Cd). This can lead to health issues as the cadmium accumulates in the body..

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6. Conflict of Interest

Authors declare no conflicts of interest.

References

[1] Suripin, *Pelestarian Sumber Daya Tanah dan Air*. Yogyakarta: Andi, 2022.
[2] M. K. Abd Elnabi *et al.*, “Toxicity of Heavy Metals and Recent Advances in Their Removal: A Review,” *Toxics*, vol. 11, no. 7, 2023, doi: 10.3390/toxics11070580.
[3] V. Milanković *et al.*, “Metals on the Menu—Analyzing the Presence, Importance, and Consequences,” *Foods*, vol. 13, no. 12, 2024, doi: 10.3390/foods13121890.
[4] W. Mueller, H. Cowie, C. J. Horwell, F. Hurley, and P. J. Baxter, “Health Impact Assessment of Volcanic Ash Inhalation: A Comparison With Outdoor Air Pollution Methods,” *GeoHealth*, vol. 4, no. 7, 2020, doi: 10.1029/2020GH000256.
[5] S. Suparto, “Sebaran dan Karateristik Material Vulkanik Hasil Erupsi Gunung Sinabung di Sumatera Utara,” *J. Tanah dan Iklim*, vol. 39, no. 1, pp. 9–18, 2015.
[6] B. S. Nasional, “Cara Uji Kadmium (Cd) dengan Spektrofotometri Serapan Atom (SSA)-nyala,” SNI 6989.16:2009, 2009.
[7] B. S. Nasional, “Cara Uji Tembaga (Cu) dengan Spektrofotometri Serapan Atom (SSA)-nyala,” SNI 6989.6:2009, 2009.
[8] B. S. Nasional, “Cara Uji Besi (Fe) dengan Spektrofotometri Serapan Atom (SSA)-nyala,” SNI 6989.4:2009, 2009.
[9] B. S. Nasional, “Cara Uji Seng (Zn) dengan Spektrofotometri Serapan Atom (SSA)-nyala,” SNI 6989.7:2009, 2009.
[10] “Ministry of Health Regulation Number 492/Menkes/Per/IV/2010 regarding drinking water quality requirements”.