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Efficiency of Reverse Osmosis Usage in Drinking Water Depots to Reduce Iron (Fe^{3+}), Copper (Cu^{2+}) and Zinc (Zn^{2+}) Ion Levels

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ABSTRACT
Research on the efficiency of reverse-osmosis drinking water depot to decreased levels of iron (Fe^{3+}), Copper (Cu^{2+}) and Zinc (Zn^{2+}) ions have been done. The raw, the treated, and waste water are filtered using reverse osmosis (RO) three times a week. HNO_3 then was added to the sample until it reached 15 mL. The determination of the concentration of the three ions was performed using atomic absorption spectrophotometer (AAS). The results showed a decrease of Fe^{3+} concentration of 73.21%, for Cu^{2+} decrease by 80.25%, while Zn^{2+} decrease by 82.08%. For waste water obtained iron ion concentration of 0.1794 mg/L, for Cu^{2+} by 0.0239 mg/L, while Zn^{2+} by 0.0962 mg/L.

Keyword : Drinking Water Depot, Efficiency, Reverse Osmosis

ABSTRAK
Studi efektivitas penggunaan penyaring *reverse osmosis* (RO) depot air minum terhadap kadar ion besi (Fe^{3+}), tembaga (Cu^{2+}) dan zinkum (Zn^{2+}) telah selesai dilakukan. Sampel air baku, air olahan, dan air buangan disaring menggunakan RO tiga kali selama seminggu. Selanjutnya ditambahkan HNO_3 pekat ke dalam sampel sampai 15 mL. Penentuan konsentrasi ketiga ion tersebut dilakukan menggunakan Spektrofotometri Serapan Atom (SSA). Hasil penelitian menunjukkan terjadi penurunan konsentrasi ion Fe^{3+} sebesar 73,21%, untuk ion Cu^{2+} terjadi penurunan sebesar 80,25%, sedangkan ion Zn^{2+} terjadi penurunan konsentrasi sebesar 82,08%. Untuk air buangan diperoleh konsentrasi ion Fe^{3+} sebesar 0,1794 mg/L, untuk ion Cu^{2+} sebesar 0,0239 mg/L sedangkan ion Zn^{2+} sebesar 0,0962 mg/L.

Kata Kunci : Depot Air Minum, Efisiensi, Reverse Osmosis

1 Introduction

Water on the earth's surface consists of 97% salt water in the ocean, 2% still in the form of ice, 0.0009% in the form of lakes, 0.00009% is fresh water in rivers and the rest is surface water that can be utilized for the needs of human life, plants and animals that live on land. Along with the increasing progress of the industrial sector, the problem of pollution in Indonesia is also increasing. The entry of industrial waste into a body of water can cause a decrease in the quality of the water [1]

Drinking water needs in big cities are generally provided by the State-owned Drinking Water Company (PAM) which is channeled to people's homes throughout the city, and is known by the community as tap water. For Medan city itself, many drinking water depot businesses have developed to meet the drinking water needs of residents. However, of the many drinking water depots that exist, only around 200 drinking water depots are licensed by the Medan Industry and Trade Office (Disperindag) [2]).

Heavy metal contamination can come from natural factors such as volcanic activities and forest fires or human factors such as petroleum combustion, mining, smelting, industrial processes, agricultural, livestock and forestry activities, as well as waste disposal including household waste [3]. Water containing toxic and hazardous chemical compounds has its own properties. The characteristics of polluted wastewater can be identified through the assessment of turbidity, color, taste, odor, and chemical content. The water analysis laboratory determines the safe concentration limits of dissolved substances by observing changes in their chemical properties [4].

Reverse Osmosis (RO) is a purification method based on the principle of applying high pressure to water through a semipermeable layer, trapping dissolved molecules so that a more purified water filtrate is obtained. RO technology is the most advanced water purification technology today [5]. RO filters water from the smallest level of 1/10,000 microns or the equivalent of a strand of hair divided by 1 million. The very small RO membrane makes the RO filtered water very pure so that viruses, bacteria, metal elements are also filtered out and as a result the water is pure and directly drinkable [6].

For the drinking water filtration process, RO releases two final results, namely production water and waste water. During this time, the RO waste water is just thrown away or some put it in the bathtub or used for various purposes of washing, rinsing and flushing [7].

There are several water purification methods that are widely used, including ion exchange water, distilled water, water from activated carbon filtration, precipitation, boiling water, ozone sterilization, ultra violet light water, mineral water, and reverse osmosis. Among these purification techniques, reverse osmosis is a better purification technique than the others [8].

Based on the previous research of drinking water quality treatment through ozonation, ultraviolet, and reverse omosis processes, it shows that the results of drinking water treatment through the reverse osmosis process show the best results compared to ultraviolet and ozonation processes [9]. Groundwater generally contains very high levels of iron metal compared to other metals, and is usually compounded with other metals such as compounds with copper such as chalcopyrite as well as zinc. Therefore, the author wants to see the efficiency of using reverse osmosis in drinking water depots to reduce the levels of iron (Fe^{3+}), copper (Cu^{2+}) and zinc (Zn^{2+}) ions [10].

2 Materials and Methods

2.1 Equipment

In this study, one Atomic Absorption Spectrophotometer (AAS) device type AA-6300 Shimadzu was used. The glassware used was made by Pyrex and Whatmann filter paper.

2.2 Materials

The materials used are raw water, treated water and waste water taken from drinking water depots in the Binjai city area. Standard solutions of $Fe(NO_3)_3$ in HNO_3 0.5 mol/L, $Cu(NO_3)_3$ in HNO_3 0.5 mol/L, and $Cu(NO_3)_3$ in HNO_3 0.5 mol/L p.a E.Merck with a concentration of 1000 mg/L, concentrated nitric acid solvent p.a.E.Merck.

2.3 Sample Preparation by Deconstruction

HNO_3 (concentrated) was poured into the sample until the pH reached 2.5. The sample was measured out of 100 mL, transferred into a glass beaker, and added 5 mL of concentrated HNO_3. After heating until nearly dry, distilled water was poured into a 100-mL measuring flask and diluted using distilled water until and stirred until homogeneous. The concentrations then were measured using an atomic absorption spectrophotometer.

2.3.1 Optimum Conditions for Analysis

The optimum analysis conditions are obtained through the maximum absorption of each element using parameters such as wavelength, lamp current, slit width, trailer flow rate, burner gas flow rate, and burner height. The solutions used were 5 mL of Iron (Fe) 1000 mg/L mother liquor, 5 mL of Copper (Cu) 1000 mg/L mother liquor, and 5 mL of Zn (1000 mg/L) mother liquor.

2.3.2 Fe, Cu, and Zn Calibration Curves

The calibration curves of Fe, Cu, and Zn were perform using the atomic absorption of each standar solution, respectively. Each element is Fe 0.0; 0.2; 0.4; 0.6; 0.8 and 1.0 mg/L, Cu 0.0; 0.5; 1.0; 1.5; 2.0 and 3.0 mg/L and Zn 0.0; 0.1; 0.5; 1.0; 1.5 and 2.0 mg/L.

3 Results and Discussion

The results of the iron (Fe), copper (Cu), and zinc (Zn) metal standard series solutions against concentration were plotted into a calibration curve. The equation of the regression line of the curve is determined using the least squares method. Thus, the concentrations of Fe, Cu, and Zn in mg/L were obtained. To measure the efficiency of reverse osmosis usage in drinking water depots, the equation is used:

$$reduction\ \% = \frac{[raw\ water\ concentration] - [treated\ water\ concentration]}{[raw\ water\ concentration]} x100\%$$

where, raw water is water before going through the reverse osmosis process, and processed water is water after going through the reverse osmosis process. The following are data and images of calibration curves for each metal.

Table 1. Absorbance Data of Iron Solution

Concentration (mg/L)	Absorbance (%)
0.0	0.0002
0.2	0.0107
0.4	0.0203
0.6	0.0298
0.8	0.0386
1.0	0.0492

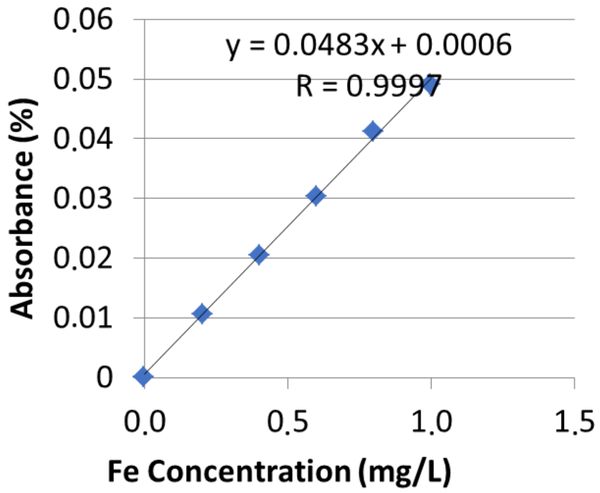

Figure 1. Calibration Curve of Iron (Fe) Standard solution

Table 2. Copper Solution Absorbance Data

Concentration (mg/L)	Absorbance (%)
0.0	0.0006
0.5	0.0489
1.0	0.0975
1.5	0.1527
2.0	0.2049
3.0	0.2985

Figure 2. Calibration Curve of Copper (Cu) Standard Solution

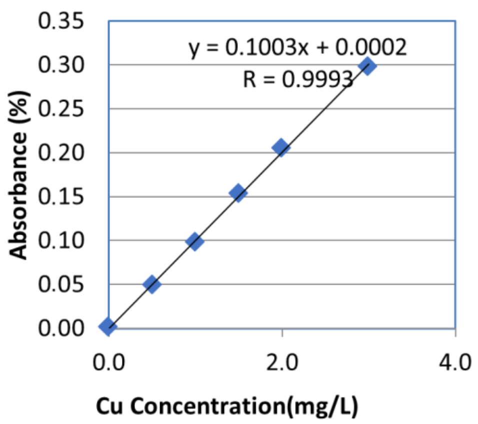

Table 3. Zinc Solution Absorbance Data

Concentration (mg/L)	Absorbance (%)
0.0	0.0002
0.1	0.0437
0.5	0.1485
1.0	0.2968
1.5	0.4494
2.0	0.6082

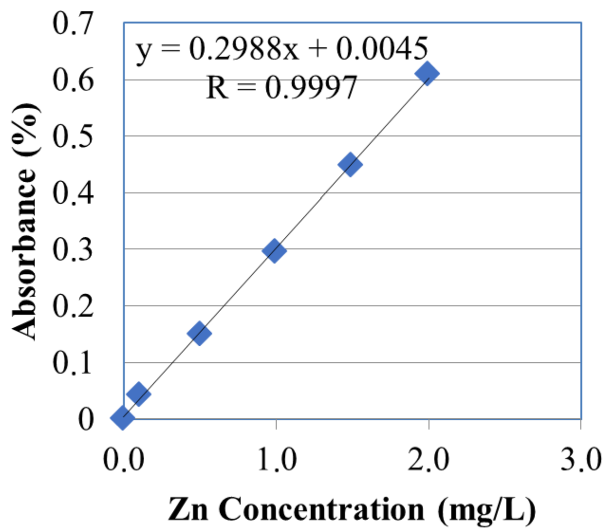

Figure 3. Calibration curve Zn standard solution

Table 4. Measurement results of metal content in samples

Element	Metal content (mg/L)		
	Raw water	Treated water	Waste water
Fe	0.3719 ± 0.0043	0.0966 ± 0.0123	0.1794 ± 0.0113
Cu	0.0628 ± 0.0008	0.0129 ± 0.0040	0.0239 ± 0.0050
Zn	0.2241 ± 0.0030	0.0399 ± 0.0034	0.0962 ± 0.0038

Table 5. Results of metal content reduction

Element	Metal Content Reduction (%)
Fe	74.03
Cu	79.46
Zn	82.19

From the results obtained, the treated water used as drinking water contains levels of iron, copper, and zinc ions still below the threshold according to the minister of health regulation number 492/Menkes/Per/IV/2010 concerning drinking water quality. While the waste water contains levels of iron, copper, and zinc ions that are still safe for drinking water quality standards, but it is not recommended for direct consumption because it has not gone through a process [11].

4 Conclusion

In conclusion, it was obtained the efficiency of using reverse osmosis in drinking water depots to reduce the levels of iron (Fe^{3+}), copper (Cu^{2+}) and zinc (Zn^{2+}) metal ions. Where for Fe^{3+} ion was a decrease of 73.21%, for Cu^{2+} ion was a decrease of 80.25%, while Zn^{2+} ion was a decrease in concentration of 82.08%. In contrast, the metal content in the waste water at the drinking water depot is 0.1794 mg/L for Fe^{3+} , 0.0239 mg/L for Zn^{2+}, and 0.0962 mg/L for Zn^{2+} which still meets the drinking water standards for the metal content according to the health minister's regulation with number 492/MENKES/PER/VII/2010. Further research needs to be done to see the efficiency of using reverse osmosis to reduce the levels of other metals and the feasibility of reverse-osmosis process waste water to be used as drinking water.

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6. Conflict of Interest

Authors declare no conflicts of interest

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