ALKIMIA : Jurnal Ilmu Kimia dan Terapan

ARTICLES

View Article Online

View Journal | View Issue

Determination of Heavy Metals of Commercial Bottled Water In Indonesia By ICP/MS

Tunas Alam[a]*

Abstract. Heavy metals and toxic elements four brands of commercial bottled water from Indonesia market were analyzed with an Inductive Couple Plasma-Mass Spectrometer (ICP-MS). The heavy metals and toxic elements to be analyzed were copper (Cu), iron (Fe), lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), selenium (Se) and manganese (Mn). The results are the heavy metals and toxic elements from all commercial water samples were below the permissible level of the World Health Organization (WHO) and Standar Nasional Indonesia (SNI). Hence, this determination clarify no risk about quality and safety of commercial bottled water for public drinking water.

Keywords : Commercial bottled water, heavy metals, toxic elements, ICP-MS, Indonesia

[a]*STIKes Prima Indonesia, Jl. Raya Babelan No.9,6 KM, RW.6, Kebalen, Babelan, Bekasi, West Java 17610*
Correspondence and requests for materials should be addressed to Alam, T.
(email : tunasalam182417@gmail.com)

Introduction

Commercial bottled water is a water produced from nature with treatment in the industry to reduce and remove bacteria and other toxic substances [1]. Ideally, commercial bottled water should not contain bacteria, heavy metals, and other toxic elements. Although, there is also a possibility a branded names of bottled water may be counterfeited and the suspect is water source.

Heavy metals are high molecular weight metals. Heavy metals such as Cu, Fe, and Mn play important roles in human life, and these components are coenzymes in human metabolism [2]. In the other side, heavy metals and toxic substances with exceeding concentration are generally dangerous dan toxic for human health such as Pb and Cd [3]. This study suggests that exposure of heavy metals and toxic elements may be of concern because they are associated with cancer [4]. The accumulation of heavy metals and toxic elements also depends on the chemical form. For example, only 15% inorganic Pb can be ingested, while 80% of organic Pb was absorbed [5]. The metal concentration in commercial bottled water may vary from the condition of production and the place of the water had been taken. The reality of possibility of having different metal concentration in commercial bottled water can be happen bound to the conditions of production area. Hence, the commercial bottled water needs to be monitored routinely of heavy metal and other elements in trace and ultra-trace levels.

In this paper, the results of determination of heavy metals and toxic elements from four brands of commercial bottled water were analyzed by using ICP-MS to clarify the concerns about the quality and safety of public drinking water. Inductively coupled plasma-mass spectrometry (ICP-MS) was selected as a method because it have good sensitivity, a little sample size, and provides to perform rapid multi-elemental analyses [6]. The study was compared the concentration of heavy metals and toxic elements that analyzed with permissible limit from WHO and SNI guideline values. To our best knowledge, determination of heavy metals dan toxic elements of commercial bottled water in Indonesia have not yet been reported.

Experimental

Materials

HNO_3 (pa Merck) and Standard Solution of Copper (Cu), Iron (Fe), Lead (Pb), Cadmium (Cd), Chromium (Cr), Arsenic (As), Selenium (Se) and Manganese (Mn) (each standard solution contains 1000 ppm of each heavy metals and toxic elements). Commercial bottled water samples from Indonesia market. A total of 4 samples were taken and keep stored at 2 to 4 °C. Inductive Coupled Plasma-Mass Spectrometry (ICP-MS) Perkin Elmer Elan DRC II was used to analyze samples.

ICP-MS analysis

The heavy metals and other toxic elements analysis were carried out by using ICP-MS (Perkin Elmer Elan DRC II) with parameters in Table 1. ICP-MS is a mass spectrometer with coupled ion plasma .

Table 1. Operating parameters optimize for ICP-MS (Perkin Elmer Elan DRC II)

Vacuum pressure	6.6 x 10^{-7} torr
Nebulizer gas flow (NEB)	0.95 L/min
ICP Rf Power	1350 w
Lens voltage	8 v
Analog stage voltage	-1750 v
Pulse stage voltage	900 v

Preparation of commercial bottled sample for ICP-MS analysis

In this study, total 8 elements (Cu, Fe, Pb, Cd, Cr, Mn, As and Se) were determined in four brands of commercial bottled water by using ICP-MS analysis. Approximately, about 100 ml of each sample was filtered using Whatman filter paper no. 41 and added with HNO_3 [6].

Results and Discussion

Analytical results

The results of analysis of calibration curve of each metal elements exhibited good linearity within the working range (1 – 100 µg/kg, 1 – 160 µg/kg, 1 – 250 µg/kg, and 1 – 100 µg/kg) with R2 values higher than 0.9900 (Figure. 1). All data of linearity and regression equation values were showed in Table 2.

Table 2. The regression equation and working range of the studied elements

Elements	Regression equation	Working range (μg/kg)
Cu	y = 3752x + 18466	1 - 300
Fe	y = 317.72x + 8629	1 - 250
Pb	y = 17193x + 246012	1 - 300
Cd	y = 1577.3x + 8188.6	1 - 300
Cr	y = 8900.6x + 68199	1 - 200
Mn	y = 12887x + 64398	1 - 100
As	y = 1109.8x + 8894.1	1 - 300
Se	y = 148.01x + 424.95	1 - 300

Heavy metals and toxic elements analysis

Four commercial bottled water samples with different brands were analyzed by using ICP-MS. In a previous study, content of heavy metals and other toxic elements had been at low or ultra-trace levels and these problems can be overcome with methods and instruments that have good sensitivity and one of these instruments was ICP-MS [8].

According to the results (Table. 3), Cu, Pb, and Cd in the samples are below detection limit. Previous studies have shown Pb contamination and concentration above permissible limit from WHO can adverse health effect. The source of Pb in nature are mainly in aquatic environment from smelters, battery manufacturing, and sewage effluent [7]. Pb toxicity cause nervous system especially with children which may damage their brain tissue [8].

Cu is metal which play important role in human but in high concentration these metals may cause stomach distress, liver, and kidney damage. Iron (Fe) found to be 40.67, 42.4, 52.94, and 3.48 μg/kg for sample a, b, c, and d, respectively. Toxicity of iron can cause vomiting, hemorrhage, cardiac depression and metabolic acidosis. Large quantity of Fe in human body can be caused a condition known as hemochromatosis as a result of damage tissue [8]. Cr and Mn elements are found had concentration minimum at 0.08 μg/kg in sample d and maximum at 2.26 μg/kg in sample b. In principle, Cr is not toxic for human but, chemical form of Cr^{6+} is more toxic than Cr^{3+} due to its high adsorption rate through the intestinal tracts [9]. Mn is knowing as essential coenzyme for metabolism. Although, very large concentration of Mn can cause diseases and damage in liver [10]. For As element, concentration in sample c and d are below detection limit where sample a and b had concentration 0.01 and 0.75, respectively. Selenium (Se) was below detection limit in sample d and 0.19, 0.19, and 0.02 for sample a, b, and c, respectively.

The results of heavy metals and toxic elements in commercial bottled water indicated each element was very low concentration and do not contain any risk if they are consumed. The concentration of each metal was analyzed also below the WHO and SNI guideline values. Therefore, the commercial bottled water comply with the standards with respect to heavy metal and toxic substances [8], [11].

Table 3. Concentration of different trace elements in commercial bottled water

Metals (μg/kg)	Sample				Acceptable level of WHO (μg/kg)	Acceptable level of SNI (μg/kg)
	a	b	c	d		
Cu	< d.l.	< d.l.	< d.l.	< d.l.	max. 50	max. 500
Fe	40.67	42.4	52.94	3.48	max. 100	max. 100
Pb	< d.l.	< d.l.	< d.l.	< d.l.	max. 10	max. 5
Cd	< d.l.	< d.l.	< d.l.	< d.l.	max. 3	max. 30
Cr	2.16	2.26	2.06	0.08	max. 70	max. 50
Mn	1.43	0.65	0.62	0.89	max. 100	max. 50
As	0.01	0.75	< d.l.	< d.l.	max. 10	max. 10
Se	0.19	0.19	0.02	< d.l.	max. 10	max. 10

< d.l. : below detection limits

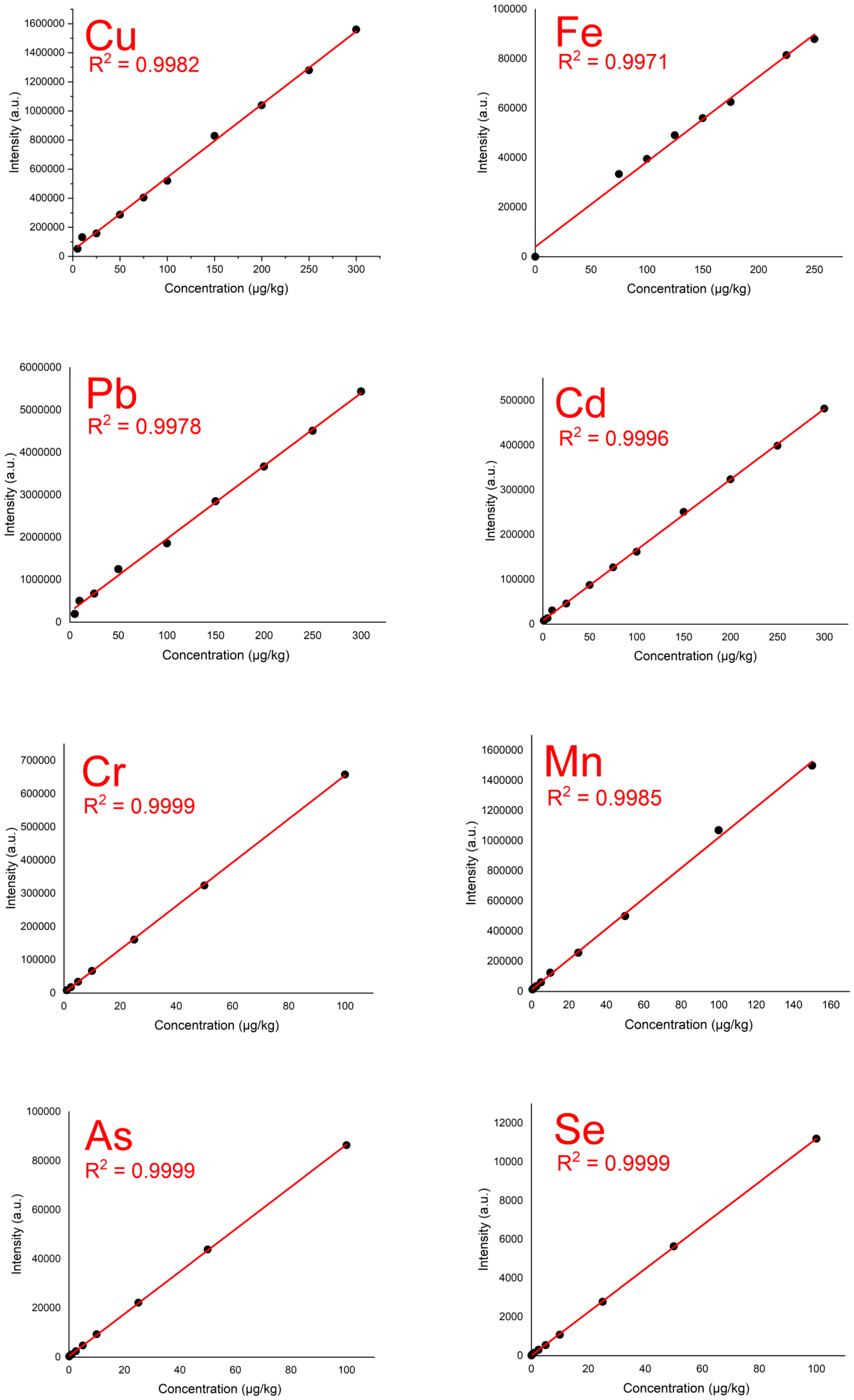

Figure 1. Calibration curve of each heavy metals and trace elements

Conclusion

In this work, four different brands of commercial bottled water were analyzed by ICP-MS and the results showed concentration of heavy metals and toxic elements was very low and below guideline values of WHO and SNI. Also, the results indicated no risk concern to quality and safety for commercial bottled water especially in Indonesia market.

References

[1] M. A. Saleh, E. Ewane, J. Jones, and B. L. Wilson, “Chemical Evaluation of Commercial Bottled Drinking Water from Egypt,” *J. Food Compos. Anal.*, vol. 14, no. 2, pp. 127–152, 2001, DOI: 10.1006/jfca.2000.0858.

[2] G. N. Abdel-Rahman, M. B. M. Ahmed, B. A. Sabry, and S. S. M. Ali, “Heavy metals content in some non-alcoholic beverages (carbonated drinks, flavored yogurt drinks, and juice drinks) of the Egyptian markets,” Toxicol. Reports, vol. 6, no. November 2018, pp. 210–214, 2019, DOI: 10.1016/j.toxrep.2019.02.010.

[3] J. Briffa, E. Sinagra, and R. Blundell, “Heavy metal pollution in the environment and their toxicological effects on humans,” Heliyon, vol. 6, no. September 2019, p. e04691, 2020, DOI: 10.1016/j.heliyon.2020.e04691.

[4] S. Kilic, “Survey of trace elements in bottled natural mineral waters using ICP-MS,” Environ. Monit. Assess., vol. 191, no. 7, 2019, DOI: 10.1007/s10661-019-7578-x.

[5] M. Jaishankar, T. Tseten, N. Anbalagan, B. B. Mathew, and K. N. Beeregowda, “Toxicity , mechanism and health effects of some heavy metals,” vol. 7, no. 2, pp. 60–72, 2014, DOI: 10.2478/intox-2014-0009.

[6] R. M. Abdul, L. Mutnuri, P. J. Dattatreya, and D. A. Mohan, “Assessment of drinking water quality using ICP-MS and microbiological methods in the Bholakpur area, Hyderabad, India,” Environ. Monit. Assess., vol. 184, no. 3, pp. 1581–1592, 2012, DOI: 10.1007/s10661-011-2062-2.

[7] A. Jammu, R. Ullah, R. Asghar, Z. Tanveer, S. Aziz, and M. Babar, “Determination of heavy metals levels in water of River Jhelum in the State of Determination of heavy metals levels in water of River Jhelum in the State of Azad Jammu and Kashmir , Pakistan Department of Biotechnology, Mirpur University of Science and Te,” no. September, 2018.

[8] WHO, “Guidelines for drinking-water quality. World Health Organization,” Geneva, no. Fourth edition, pp. 491–493, 2008.

[9] O. V Anishchenko, M. I. Gladyshev, E. S. Kravchuk, N. N. Sushchik, and I. V Gribovskaya, “WATER QUALITY AND PROTECTION : Distribution and Migration of Metals in Trophic Chains of the Yenisei Ecosystem near Krasnoyarsk City,” vol. 36, no. 5, pp. 623–632, 2009, DOI: 10.1134/S0097807809050121.

[10] K. Mckinley, I. Mclellan, F. Gagné, and B. Quinn, “The toxicity of potentially toxic elements (Cu , Fe , Mn , Zn and Ni) to the cnidarian Hydra attenuata at environmentally relevant concentrations,” Sci. Total Environ., vol. 665, pp. 848–854, 2019, DOI: 10.1016/j.scitotenv.2019.02.193.

[11] SNI, “SNI 01-3553-2006,” BSN, 2006.