

DETECTION OF LEAD, MERCURY AND ARSENIC IN THREE NATURAL SPRING WATER IN NEGERI SEMBILAN

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Abstract

This study focus on detection of lead (Pb), mercury (Hg) and arsenic (As) in three selected natural spring water (NSW) in Negeri Sembilan. Three selected NSW are from Bukit Miku, Kaki Gunung Angsi and Bukit Tangga which located at difference district around Negeri Sembilan. The sampling was done in August 2016 using High Density Polyethylene (HDPE) bottles which are labelled correctly. All sample was analysis using spectrometer while following APHA-3125 method. The statistical analysis was conducted using analysis of variance (ANOVA). The concentration of Pb in NSW collected from Kaki Gunung Angsi has recorded the highest significant amount ($0.27367 \pm 0.025325 \mu\text{g/L}$). On the other hand, NSW taken from Bukit Tangga ($0.02533 \pm 0.010786 \mu\text{g/L}$) and Bukit Miku ($0.02500 \pm 0.004583 \mu\text{g/L}$) showed no significant difference ($p < 0.05$). For Hg, only one NSW which was obtained from Bukit Miku ($0.16167 \pm 0.011015 \mu\text{g/L}$) produced a recordable result. Meanwhile, NSW from Bukit Tangga and Kaki Gunung Angsi did not showed any detectable Hg element in their samples. As content in NSW taken from Bukit Miku, Bukit Tangga and Kaki Gunung Angsi is $0.58700 \pm 0.023000 \mu\text{g/L}$, $0.20500 \pm 0.061612 \mu\text{g/L}$ and $0.08300 \pm 0.003464 \mu\text{g/L}$ respectively. There is significant difference ($p < 0.05$) in As content between NSW that was obtained from all three locations.

Keywords: Lead, Mercury, Arsenic, Natural Spring Water, Negeri Sembilan

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1. Introduction

About 70 percent of earth's surface is covered by water but only 3 percent of it is drinkable. The drinkable water comes from rivers; lakes, ice caps exist in the mountain or pole, and last but not least natural spring water. Natural Spring Water (NSW) becomes well known for its benefits to environment (as water reservoir and climate control) and living organism. There are many types of NSW depending on its location, depth, nature of filtration and flows (Bryan, 1919). In addition, the quality of spring water is influenced by several factors such as climate, kind of subsoil within which water flows, characteristics and utilization of the ground (Ragno et al., 2007).

This study involved three NSW in Negeri Sembilan which fall in gravity spring classification (Bryan, 1919). Those three NSW stations are located at Bukit Miku in Johol district, Kaki Gunung Angsi in Kuala Pilah district and Bukit Tangga in Kuala Klawang district. NSW becomes a popular choice of water sources for folk in Negeri Sembilan due to its abundance and low cost. The NSW's consumer believes that the water has the health benefits and tastier compare to the regular household tap water. Most of them consume the NSW directly without any treatment.

This becomes a concern because the water quality cannot be guaranteed. The current concern about the usage of NSW is the sources, quality, and treatment before consumption and environmental pollution (Leavey, 2011). The exposure of NSW's sources to industrial and domestic pollution can lead to harmful effect such as indirect heavy metal consumption which might lead to induction of cancer formation especially in the long terms (Martin & Griswold, 2009).

Among hazardous heavy metals are lead, mercury and arsenic which have harmful effect even though in small dosage (WEPA, 2000). Lead becomes the concern when most of researcher from previous decade concentrate their study on the effect of lead existence in drinking water (Hu et al., 2010). This could be due to usage of lead pipes line from those decades which already replace by eco-friendlier choice. Nevertheless, the upgrade of piping system cannot eliminate the contamination of lead in water sources since lead do exist due to improper water management especially from industrial.

Mercury is one of heavy metal which can exist in the air and water which allow it to be spread more widely. It has negative effect toward neurological state of those who expose to it whether via inhalation or direct ingestion (Zahir et al., 2005). Mercury also can infiltrate into water sources via soil erosion due to change of weather and industrial activities (Tchounwou et al., 2003).

Arsenic can be found in natural environment and synthetic products like dye, soaps and fertilizers. Study done in Taiwan found that chronic arsenic exposure from drinking water can cause negative effect neurobehavioral in adolescence such as attention during classes and pattern on memory retrieval (Tsai et al., 2003). The researcher from Pakistan discovered that the existence of arsenic in NSW, domestically used by locals can lead to induction of cancer (Muhammad et al., 2010).

From these previous findings, the existence of such heavy metal in drinking water especially untreated drinking water like NSW should be monitor to minimize the possibility of locals in Negeri Sembilan from continuous indirect consumption of that substance.

2. Methods

2.1 Sampling area

Natural spring water (NSW) samples were collected from three different districts located around Negeri Sembilan such as Kuala Klawang, Kuala Pilah and Johol. The location of those three sampling locations are stated in the map shown in Figure 1 which are Bukit Tangga (2.846154 N,102.001404 E) in Kuala Klawang, Kaki gunung Angsi (2.729125 N,102.064571 E) in Kuala Pilah and Bukit Miku (2.599210 N,102.147355 E) in Johol. These three locations were chosen as a NSW sources because there are observed to be a very active spot for NSW intake and consumption by locals. Sampling were carried out in August 2016.



Figure 1. Three sampling locations in Negeri Sembilan

2.2 Sampling methods

Each NSW sample was carefully collected using a two litre High Density Polyethylene (HDPE) bottles which are labelled with dates and location of samples taken. As a precaution, a pair of clean rubber glove was used to avoid cross contamination and all HDPE bottles were rinsed with dedicated NSW twice before filling process have been made. Samples were transferred to the UNIPEQ Sdn. Bhd laboratory for heavy metal analysis.



Figure 2. Collecting NSW samples at Bukit Miku

2.3 Heavy metal analysis

Each NSW sample were divided into triplicates, acidified with 1% nitric acid and stored in 4°C temperature for at least 24 hours before analysis was done. Heavy metals were determined by using spectrometer according to APHA-3125 method.

2.4 Statistical analysis

The results obtained were subjected to analysis of variance (ANOVA) using IBM SPSS Statistics version 15.0 (IBM, Armonk, New York). The Duncan's post hoc multiple comparisons was used to obtain statistical comparisons among sample means and differences were considered significant at 95% confidence level ($p < 0.05$).

3. Result and Discussion

3.1 Heavy metal in NSW

3.1.1 Lead (Pb)

Result in Table 1 indicated that NSW collected from Kaki Gunung Angsi has recorded the highest amount of Pb content ($0.27367 \pm 0.025325 \mu\text{g/L}$). On the other hand, NSW taken from Bukit Tangga ($0.02533 \pm 0.010786 \mu\text{g/L}$) and Bukit Miku ($0.02500 \pm 0.004583 \mu\text{g/L}$) showed no significant difference ($p < 0.05$). According to WEPA (2000), maximum permitted level of Pb in natural spring water is 0.01 mg/L and the results in Table 1 showed that all NSW samples are below the permitted Pb level.

Table 1. Heavy metal content in NSW samples

NSW samples	Heavy metal content ($\mu\text{g/L}$)		
	Lead	Mercury	Arsenic
Bukit Tangga	0.02533 ± 0.010786^b	Not detected	0.20500 ± 0.061612^b
Kaki Gunung Angsi	0.27367 ± 0.025325^a	Not detected	0.08300 ± 0.003464^c
Bukit Miku	0.02500 ± 0.004583^b	0.16167 ± 0.011015^a	0.58700 ± 0.023000^a

Data are mean \pm S.D. (n=3)

^a Different letter in the same column indicate significant difference at $p < 0.05$

Even though they are below permitted level, long term intake of NSW might have resulted in continuous exposure to Pb which can increase the possibilities of human infertility (Apostoli et al., 2000), miscarriage, organ damage (Martin & Griswold, 2009), learning disabilities, decrease survival and growth rates in vertebrates (John et al., 2008). It is normal to detect a very low level of Pb element in groundwater ($0.4 \mu\text{g/L}$) and they are usually harmless (Fiket et al., 2007). Similar findings were also recorded by other researchers such as $0.5 \mu\text{g/L}$ (Cartier et al., 2012), $0.26 \mu\text{g/L}$ (Sullivan & Leavey, 2011) and $1.0 \mu\text{g/L}$ (Momodu & Anyakora, 2010). On the other hand, the high level of Pb (0.167 to 0.723 mg/L) was found in groundwater which normally located within the industrial production, agriculture (Khan et al., 2015), transportation area, mining (Prasad & Bose, 2001) and the usage of lead plumbing pipes in residential area also contribute to the increment of Pb exposure to human (Black et al., 1958).

3.1.2 Mercury (Hg)

WEPA (2000) stated that maximum permitted level of Hg in natural spring water is 0.001 mg/L. Figure 2 shows that only one NSW which was obtained from Bukit Miku ($0.16167 \pm 0.011015 \mu\text{g/L}$) produced a recordable result. Meanwhile, NSW from Bukit Tangga and Kaki Gunung Angsi did not showed any detectable Hg element in their samples. It also indicates that NSW collected from Bukit Miku still have lower Hg content than permitted level stated by WEPA (2000). Similar findings were recorded by several researchers such as 7.1 ng/L (Zahir et al., 2005), 12.7 ng/L (Pirrone et al., 2010) and up to 10 $\mu\text{g/L}$ (Meili et al., 1991). Bukit Miku is a forestry hill located far from industrial congested area such as Seremban and have less human activities due to its remote location. Trace amount of Hg found in NSW obtained from Bukit Miku might due to natural causes such as soil erosion, microbial and wild animal activities (Tchounwou et al., 2003) and degassing of earth's crust (Zahir et al., 2005).

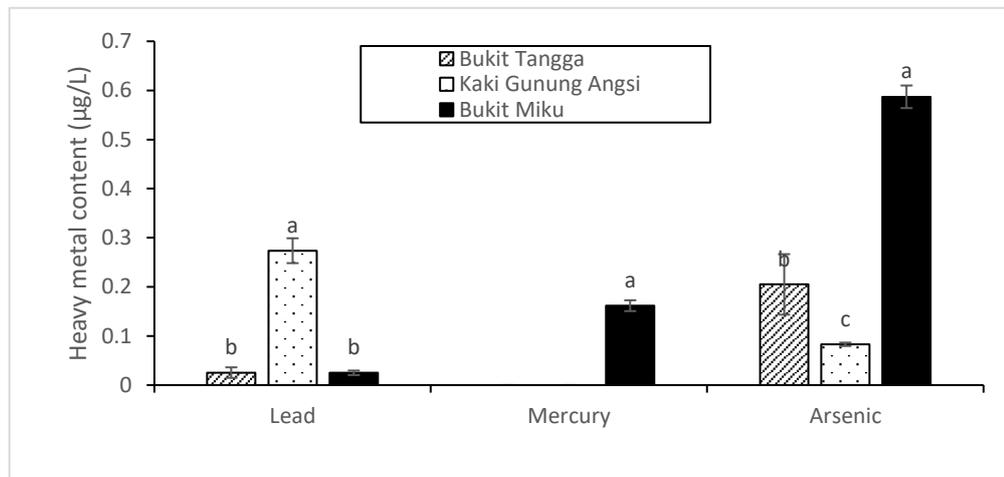


Figure 2. Comparison of heavy metal content in three different location sources

Hg are naturally occurring substances which are often present in the environment such as fresh water and seawater at low levels (Fiket et al., 2007), (Segade & Tyson, 2007) but in larger amounts, they can be dangerous especially when they converted from Hg^{2+} into inorganic mercury (Martin & Griswold, 2009) and (WHO, 2011). Zahir et al. (2005) stated that Hg exposure even in little dose are enough to affects nervous system of foetus, children and adults (Rice & Barone Jr, 2000), (Choi et al., 2008) and (Kadirvelu et al., 2003). In addition, it also a contributor to Parkinson's disease, Alzheimer's disease, rheumatoid arthritis and autism (Rizvi et al., 2005).

3.1.3 Arsenic (As)

Result in Table 1 shows As content in NSW taken from Bukit Miku, Bukit Tangga and Kaki Gunung Angsi is $0.58700 \pm 0.023000 \mu\text{g/L}$, $0.20500 \pm 0.061612 \mu\text{g/L}$ and $0.08300 \pm 0.003464 \mu\text{g/L}$, respectively. There is significant difference ($p < 0.05$) in As content between the locations of NSW sources. According to WEPA (2000), maximum permitted level of As in natural spring water is 0.01 mg/L and the results in Table 3 showed that all NSW samples are below the permitted As level.



Figure 3. Collecting NSW samples at Kaki Gunung Angsi

The results from previous research might differ from this study because of the varying type and location of the water sources. Kim et al, (2009) found that concentration of As can be as high as 0.345mg/L due to location of their sampling site which is Cheongog Spring closer to vegetable cultivation sites. The over usage of fertiliser on vegetable not only contribute to an increase concentration of As in the spring water but also leave the As compound in vegetables consume by the locals. Tsai et al, (2003) indicated that As dose as low as 0.05mg/L per day over long period can cause organ damage and neurological effect. As all NSW selected in this study located far from any known cultivation sites, thus concentration of As in those NSW are preserved under national permitted level. Study done by Muhammad et al. (2010) found that As can exist in their inorganic form especially in the well, stream and spring that located closer to industrial and cultivation sites. The As in inorganic form is more harmful than its stable form even though the concentration of both compound was the same as the latter would easily break and combine with living tissue to achieve balance states. The sampling area location can affect the reading of As level (Tamasi & Cini, 2004) and (Kim et al., 2009). These researchers found that the depth of source of spring use as a sample can lead to different reading. Kim et al, (2009) found that the concentration of As can significantly decrease with 100 m of depth where they first sample show 0.270mg/L of As concentration. However, as they go deeper as 100 m more the concentration of As decrease significantly as 0.044mg/L when the sample taken from the same spring. Lack of evidence to reassure the findings made by Kim et al (2009) since all NSW sample were taken from the outlet that being provided. However, the outlet from all NSW was not standard because it has a different depth which might lead to significant difference in As concentration reading. Tamasi and Cini, (2004) found that even though the spring water might have permitted level of As but the usage of metal or lead for its water piping and outlet also can expose the water with unwanted As. Since all NSW selected used polyvinyl chloride (PVC) in its piping system, this factor can be eliminated.

4. Conclusion and Recommendation

The level of heavy metal concentration from all NSW are lower than permitted National Standard. The trace amount of heavy metal found might be from soil erosion and location of selected NSW which are closer to road. However, these finding cannot be treated as an assurance for these waters to be consume without any treatment because the risk of

contamination from biological pollution still not being confirm. Further study can be done in other location of NSW around Negeri Sembilan including hot spring. The variable like consumer demographic characteristics also can be investigate to ensure the importance of conservation of NSW in Negeri Sembilan.

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