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To cite this article: A Ekawanti *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **637** 012055

View the article online for updates and enhancements.

IOP Conf. Series: Earth and Environmental Science **637** (2021) 012055 doi:10.1088/1755-1315/637/1/012055

Mercury pollution in water and its effect on renal function of school age children in gold mining area Sekotong West Lombok

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Abstract. Artisanal small-scale gold mining (ASGM) has affected environment, since gold processing released mercury into the environment. Contaminated water was used as drinking water and affected human body. Kidney is one of affected organ by mercury, where children population is vulnerable for poisioned. The objective of this research was to find out mercury pollution in drinking water and its effect on renal function of children in ASGM area Sekotong in West Lombok. This preliminary study design was cross sectional. Sample of drinking water collected from various sources in Taman Sari and Telaga Lebur village. Mercury was assessed by using AAS. Renal function was evaluated from urine sample by using dipstick kit to perform proteinuria. Correlation between contaminated water consumption and renal function was statistically analyzed by Spearman's test. Mercury level found in water samples taken from well was 4.009 ppb, while from wellspring was 0.724 ppb and 0 ppb from pipe. From 15s samples, 12s samples higher than mercury threshold for drinking water. Two of 30s school age children had positive proteinuria. Spearman's test showed P-value of 0.000. It concluded that drinking water in ASGM Sekotong West Lombok has been contaminated by mercury and affected kidney function of school-age children.

1. Introduction

Mercury detected in human body is a heavy metal that comes from the environment. Mercury pollution could be from soil containing cinnabar ore, volcanoes, artisanal small-scale gold mining (ASGM), the use of cosmetics, equipment used such as battery, lamp etc. and consumption of fish [1]. Mercury contamination in West Nusa Tenggara Province (WNT) predominantly from Artisanal small-scale gold mining (ASGM) and also from nature, since rock containing cinnabar ore was found in West Nusa Tenggara (WNT) [2].

Activities of Artisanal small-scale gold mining (ASGM) in province of West Nusa Tenggara (WNT) has started in 2009 [3]. ASGM is a gold mining activity which conducted simple technology. Technology applied hazardous chemicals including mercury (amalgamation) and cyanide

IOP Conf. Series: Earth and Environmental Science **637** (2021) 012055 doi:10.1088/1755-1315/637/1/012055

(cyanidation) [4]. Mercury amalgamation has been the most common method used to recapture gold, because of the availability of mercury, it is considered to be efficient and effective [3]. The amalgamation method results in mercury emissions that get into the environment. Mercury was spilled onto the ground or agriculture land. Atmospheric transport and deposition at normal temperature is another common way for Hg to enter many water systems. In addition, Hg is often discharged together with other wastes into inadequate tailings ponds, or directly disposed into rivers and water systems [5].

Mercury and its conjugate chemicals will be absorbed by the body and cause intoxication at certain levels [1]. Once mercury enter the body, it will be distributed to almost entirely organ, the most potent affinity with neuron cell at central nervous system and kidney [6]. Many studies have demonstrated that mercury emissions affect human health [7–11]. Organ disorder depend on several factors, such as dose, route, duration of exposure, development phase (age), species of mercury and organ function [1, 12]. Study by Holmes, et al, observed that there was an increased level of low molecular weight proteins in urine of ASGM workers, although this level was only slightly above those found in the general population, but the significance of such changes in renal excretory profile is of toxicological importance [13]. Study by Ekawanti, et.al, found that 92.6 % of miner in Sekotong had proteinuria [5], so that, it is important to evaluate renal function of children in ASGM area. Krisnayanti reported that soil in Sekotong has already contaminated by mercury [3]. So that, it is important to identify the route and source of mercury from the environment to provide data for promotive health care program.

2. Materials and methods

This was a preliminary study and applied cross sectional study design. The research was conducted at ASGM area Sekotong, West Lombok Regency, West Nusa Tenggara Province. The subjects were school age children from two villages; Sekotong Tengah and Taman Sari. The source of contamination assessed by collecting sample sources of drinking water from those villages. Before conducting the study, ethical clearance was obtained from the Ethical Code Board of the Medical Faculty, Mataram University, School age children which fulfilled inclusion and exclusion criteria were selected as subjects in this study. Inclusion criteria were 6 until 12-year-old children, inhabit in ASGM area for more than one year, did not have history of kidney disorders, had permission to participate from parents by signing informed consent form.

The subjects were recruited by using a non-probability sampling technique (purposive sampling). 20 mL of urine was collected and proteinuria was assessed immediately upon collection by using dip-stick urinalysis and the results were stated as g L^{-1}. 200 mL water sample collected from well, pipe and spring water which were used as drinking water in Sekotong Tengah and Taman Sari villages which the location was not more than 500 m from gelondong (ore glinder which used mercury in its process) or tong (ore glinder which used cyanide in its process). Mercury in water sample was measured using Atomic Absorption Spectrophotometry in Analytical Laboratory Mataram University and concentration stated as ppb. Water and urine data were analyzed using descriptive statistical methods and Spearman’s correlation test.

3. Results and discussion

3.1. Mercury concentration in drinking water sample

Mercury concentration from drinking water samples collected demonstrated as Table 1.

Table 1. Mercury concentration in drinking water of ASGM area.

Water source	Mean of mercury concentration (ppb)	Below threshold level		Higher than threshold level	
		n	%	n	%
Well	4.009 ppb	1	6.67%	12	80%
Pipe (PDAM)	0 ppb	1	6.67%	0	0%
Spring water	0.724 ppb	1	6.67%	0	0%
Total	3.500 ppb	3	20%	12	80%

Table 1. showed that the higher mercury concentration found in well water sample namely 4.009 ppb, while in pipe water sample was found no mercury contamination.

Table 2. Comparison of mercury concentration in well water sample and reference value.

Water source	Mean of mercury concentration (ppb)	Deviation standard	T value	P value
Well	4.009 ppb	2.03	1.432	0.178
Government standard	1 ppb	-		

Table 2. demonstrated that mercury concentration in well water sample (4.009 ppb) was four times higher than of government standard value (1.00 ppb). Comparison tested by using t-test resulted p value 0.178, that was meant no significantly different with government standard.

3.2. *Characteristic of research participants*

This research involved thirty school-age children from two villages in ASGM area, which has characteristic as below.

Table 3. Characteristics of research participants.

Participant characteristics	Percentage (%) (n= 32)
Age	
8 year old	11 (34.4%)
9 year old	9 (28.1%)
10 year old	12 (37.5%)
Gender	
Male	13 (40.6%)
Female	19 (59.4%)
Duration of resided	
8 year old	11 (34.4%)
9 year old	9 (28.1%)
10 year old	12 (37.5%)
Parent occupation	
Government officer	4 (12.5%)
Entrepreneur	1 (3.1%)
Farmer	20 (62.1%)
Construction worker	6 (18.8%)
Others	1 (3.1%)

Table 3. presented that most participants were female (75%), and 12% were 10-year-old children. The children participated were not from miner’s family but they lived in the vicinity of the smelting process within a radius of less than 500 m and around amalgamation and cyanidation process. Their duration of exposure was more than five years (mean = 9.03 years).

Table 4. Characteristics participant with proteinuria.

Duration of exposure (year)	Proteinuria	Percentage (n, %)
8	Negative	10 (31.3 %)
	Positive	1 (3.1 %)
9	Negative	9 (28.1 %)
	Positive	0
10	Negative	11 (34.4 %)
	Positive	1 (3.1 %)
Total		30 (100 %)

Table 4. displayed that of 30s samples two of them were had proteinuria at duration of exposure 8 years and 10 years. Protein was assessed qualitatively using the dip-stick method and was categorized as negative and positive. This was considered to indicate proteinuria since this level was higher than 300 mg L^{-1} (0.3 g L^{-1}). The effect of consumption contaminated water to renal function using Spearman's test, p value was 0.000. There was an impact of mercury on renal function.

All participants in the present study were directly exposed to mercury, since they has been living in the contaminated atmosphere, water, food stuff and soil in the vicinity of the mining activities. Study by Krisnayanti showed that soil and rice in Sekotong has higher mercury level than threshold [5]. Since, gold mining started at 2009 in Sekotong, so that the mercury exposure happened when the children in utero. Fetus was more vulnerable period than other period of children, immaturity of kidney affected excretion of mercury from the body and it was a mechanism of nephrotoxicity [14, 15].

Some study subjects were children that had direct contact with mercury from mercury panning after school and standing in close proximity to burning processes. This type of child activity has also been reported in other gold mining areas [7]. The duration of exposure to mercury contaminants was an average of 9.03 years. This period was much shorter than the 14.8 years needed to show specific clinical manifestations in previous reports. [9]. Other study by Ekawanti, et al, found that in miners and their families need shorter period (5.4 years) to had manifestations including proteinuria and anemia [5]. This manifestation is affected by the type and dose of mercury, the age or developmental stage, duration of exposure and route of exposure [1, 16]. Subjects in this research did not evaluated children of miners, so that they did not had an intensive contact to mercury. Although, some studies found that low level of inorganic mercury exposure did not affected renal function [17, 18]. Weakness of this study that did not identified the dose and species of mercury exposure.

Protein levels in urine were obtained by converting the qualitative proteinuria dip-stick results categorized as negative, trace, +1, +2, +3, +4 to quantitative values of 0 g L^{-1}, <0.3 g L^{-1}, 0.3 g L^{-1}, 1 g L^{-1} and ≥20 g L^{-1}, respectively. Proteinuria was identified by results of +2 and ≥ 0.3 g L^{-1} [19, 20]. This result was similar to findings of proteinuria in patients exposed to products containing mercury [21]. In addition, proteinuria is a clinical manifestation of mercury intoxication with elemental, inorganic and ethyl-mercury [22]. This study found that two children have proteinuria, also the same as found by same studies [5, 9, 21, 23–26]. Nephrotoxicity happened when mercury exposure level more the level for neurotoxicity. Common causes of urinary mercury excretion were elemental [27] and organic mercury exposure [8]. The source of mercury was from minerals containing cinnabar (mercury containing ore) as source of mercury from nature [2]. These children lived around small scale mining, that activity in processing gold was conducted at home, this process would directly exposed the children to mercury vapor during the smelting process. When inhaled, mercury would be dispersed rapidly into the blood and might deposit in other organs e.g. brain, kidney, placenta, thyroid and others [6]. In ASGM area Sekotong, most of the water sources for amalgamation processes and daily life come from the same well, and often the tailing ponds are nearby the well [5]. In this study found that mercury concentration in well water samples were higher than Indonesia Ministry of Health standard [28, 29].

Persistent proteinuria indicates kidney disease and the most common impacts of this condition are diabetes, hypertension, obesity and medicine or chemical substances [12, 24]. One of the chemical substances that affects proteinuria is mercury [27], and to confirm this, repeated tests are required. People with consistent positive results in repetitive measurement could be categorized as having persistent proteinuria and considered to have kidney disease. A weakness of this preliminary study was that there were no repeated tests to confirm persistent proteinuria. Evaluation of blood urea nitrogen and serum creatinine is needed in future studies.

The distance from gold processing location determined the level of mercury concentration that accumulates in well water, where the closer the distance from the gold processing location, the higher mercury concentration level [30]. In addition, according to Hanafiah study, soil nature affected mercury uptake into groundwater, where sand-dominated soil had large macro pores, soil dominated by dust (sift) had moderate pores (meso), and those that are predominantly mud had a lot of small pores (micro). The slope of the soil affected speed of water flow which in turn will affect the deposition of mercury in water [31]. The construction of a watertight well wall is a construction that meets the requirements according to Chandra study that watertight well can reduce mercury pollution from the ground [32]. Most of well were watertight well, and all of wells were closer to gold processing location (gelondong)

4. Conclusion

It concluded that drinking water in ASGM Sekotong West Lombok has been contaminated by mercury and affected kidney function of school-age children. This result need further investigation to evaluate kidney function test.

Acknowledgments

We thank to Mataram University for funding this research. We thank to the headmaster of SDN 4 Sekotong Tengah for supporting sample collection. We thank to H. Idris for helping sample preparation and sample measurement.

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