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Potential ecological risks of mercury contamination along communities area in tonasa cement industry Pangkep, Indonesia☆

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Abstract
Objective: This study compares mercury measurements at several community's sites for air, soil and water samples.
Method: This observational analytic applied accidentally random sampling for communities and environmental samples. Total mercury (THg) contaminated concentration sample derived from surround cement processes. Samples of air, water column and soil were collected in one time.
Results: it implied that THg concentration value in the air, water and soil range from 1.0126 to 4.1172 $\mu g/m^3$, 0.0750 to 2.0805 $\mu g/L^{-1}$ and 11.057 to 32.036 $\mu g/kg^{-1}$ dw, respectively. In the average, the magnitude of Hg level was in the surface soils > Air > surface water, respectively. The value of ecological risks was range from 3.0–4.4, 0.16–0.22 in the air, 3.0–4.4, 0.16–0.22 in water and 3.0–4.4, 0.16–0.22 in surface soil, respectively.
Conclusion: Mercury Risk values are still lower than standard and ecological risks still low hazard, those value however may increase due to occurrence of accumulation on those sites.

Introduction

Mercury (Hg) is a volatile material both in elemental and oxidized form in various chemical compounds in the environment. It is occurred due to the combustion conditions from which they are released and the exhaust gas environment through which they travel to.[1] Most of the Atmospheric Mercury primarily exists in the term of elemental vapor phase

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that is not highly contain water and it has an estimated the life time of atmospheric with 0.5–1 year.[2] Hg in an oxidized form present in the environment much lower level, either in the gas phase (gaseous oxidized Hg; GOM) or bound to particles (particle-bound Hg; PBM), which is readily removed by wet and dry deposition.[2,3]

Thus, the spatial impacts of Hg emissions on ecosystems and human health range from local to global in scale. A research conducted to investigate Hg pollution and its accumulation in aquatic habitat and also assess the environmental and health risks at artisanal Buladu gold mine and vicinity areas in Gorontalo Province, Indonesia[4] found that total mercury (THg) contaminated concentration derived from the ore amalgamation processes were released to distance and may pollute digged well and agricultural land surround the point source. Thus, research also indicates and insists that the ecological and toxicological effects of Hg strongly depend on the various chemical species present.[5]

Due to the releases of fine particles in the heavy metals, including mercury, it is discovered in some fish makes it difficult to clearly establish the role of fish consumption on a healthy diet,[6] particularly since certain elements, such as mercury can be efficiently transferred to higher-level organisms, becoming more concentrated at the top of the food chain.[7] This study compares mercury measurements at several community's sites for the air, soil and water samples.

Methods

Design

This research was applied an observational analytic with accidentally random sampling for communities and environmental samples on the study site.

Population and study setting

This research conducted by collect data on soil, water, and dust air in communities who lived around the Tonasa plant (Biringere village) to analyze THg and ecological risk around Tonasa settlements.

Variables

Variable of this research is total Hg concentration in dust, water column, and surface soil. The ecological risk assessment is also conducted to know the risk magnitude of contamination Hg along communities in Tonasa Plant, Pangkep, Indonesia.

Data collection

Dust Air Samples were collected in 10 baghouse dust and 12 kiln feed grab samples were taken over a 2-days period. Samples were collected in 10 Hg point sources within the communities site areas that located surround the Cement Industry. The distance from a measurement site for those 10 stations of about 300 m of the closest to 7 km for the most far from the cement power plant as the dust point source. For analysis purpose, a three-inch by four-inch zippered polyethylene bag with a subset of the grab sample was provided. Then, samples were stored in these bags at room temperature until digestion and were opened only to permit extraction of a quantity sufficient for digestion.

Data analysis

The assessment of ecological risks is for hazard quotient (HQ) by applying the quantitative screening. The Dose of Eco toxicity estimation of exposure response is compared to the estimate of potential risks for ecology. Here the formulation:

$$HQ = \frac{Dose}{NOAEL} \text{ or } HQ = \frac{EEC}{NOAEL}$$

Statistical analysis was done using one-way analysis of variance ANOVA with the ($p < 0.05$) was applied to evaluate the significance level of Mercury magnitude among the various areas by using SPSS, software of IBM (version 22). Then, concentration–response curves from toxicity tests were analyzed with STATA software. The significance was set at $p < 0.05$ (significant) and $p < 0.01$ (highly significant).

Ethical aspect

Obtained from Faculty of Public Health Committee.

Results

Mercury concentration in air, water column, and surface soil

The different level of Hg pollutant in air, water column and surface soil are mostly due to the purpose of the area use such as the cement industry and with its other Hg pollutant point sources (Table 1).

The mean highest level of Total mercury was in the surface soils > Air > surface water, respectively. Hg level concentrations in water and surface soil are closely associated with Hg level in air. The higher Hg in air the bigger of Hg in those two compartments, because the Hg dust may drop to those two media and may accumulate in soil or soluble in water. In addition, it obviously may also be produced to the abundance of transporting process that Hg emit into water and soil by different process.

Ecological risks of mercury in air, water column, and surface soil

The elevated value was observed in St.6 and St.7 (Table 2). These sites are the closest site from the point source and it is an open area, where pollution may easily drop.

Table 1 Hg concentration in air, water, and soil in Biringere, Pangkep Regency, Indonesia 2019.

Stations	Mercury (Hg) concentration			
	Hg in air $\mu g/m^3$	Hg in water $\mu g/L^{-1}$	Hg in soil $\mu g/kg^{-1}$ dw	Standards
I	1.0140	1.0750	20.075	Air droplet:
II	3.0215	1.0805	21.080	50 $\mu g/m^3$
III	3.0183	0.0750	19.178	Water column:
IV	1.0126	0.0805	11.057	2.00 $\mu g\,L^{-1}$
V	3.0228	0.0750	12.022	Soil: 100 $\mu g\,kg^{-1}$ dw
VI	3.0167	2.0805	32.036	Sediment:
VII	2.0165	0.0750	21.146	30 $\mu g\,kg^{-1}$ dw
VIII	4.1172	0.0805	12.117	
IX	2.0515	0.0750	14.081	
X	2.0471	0.0805	11.067	

Table 2 Potential ecological risks of Mercury (Hg) on air, water and soil in Biringere Kabupaten Pangkep, Indonesia 2019.

Station	Ecological risks of mercury (Hg)			
	Air	Water	Soil	Standards
I	0.02028	0.5375	0.20075	If: HQ 0.1: No hazard; HQ 0.1–1.0:
II	0.06043	0.54025	0.2108	Low hazard; HQ 1.1–10: Moderate
III	0.060366	0.0375	0.19178	hazard; HQ > 10 High hazard
IV	0.020252	0.04025	0.11057	
V	0.060456	0.0375	0.12022	
VI	0.060334	1.04025	0.32036	
VII	0.04033	0.0375	0.21146	
VIII	0.082344	0.04025	0.12117	
IX	0.04103	0.0375	0.14081	
X	0.040942	0.04025	0.11067	

Discussion

Hg concentration in air, water column and surface soil

The level Hg concentration in the water column is mostly affected by the location of the area from its pollutant point sources. This may be attributed to the large amounts of silica generated and emitted, the wind flow to the site, and the continual production of cement of the plant that use the silica as the basic raw materials. The magnitude of Hg in air can directly be attributed to plant emission, and the volatile industrial waste.

The daily concentrations of Mercury in air samples remained below the WHO standard of 0.01 $\mu g\,L^{-1}$ and the total mean concentration of Hg 0.03 $\mu g\,L^{-1}$ was considerably lower during the study. A remarkable study result of relationship between Hg concentrations level in air and water as well as surface soil were observed also by Mallongi, et al. of the Hg level in Buladu River. Another study conducted a measurement site < 1 km from the power plant, show a distinct diel pattern in TGM, with peak concentrations occurring during the night ($1.7^{-0.3}$ ng/m^3) and minimum concentrations mid-day (1.5–0.2 ng/m^3).[8]

Ecological risks of mercury in air, water column, and surface soil

The magnitude concentration of mercury in air, water column, and surface soil along the community near the Tonasa cement industry are varied. Those obvious Hg trend variation levels among the different community's areas are highlights necessary to describe the environment role situation and also to the human behavior and health being who are exposed to the Hg pollutant. The ecological risks point of view of Hg values are in the most site > 1.

This estimated calculation results values seem to indicate that air, water and surface soils in the study sites mostly are still save and does not implicate an appreciable ecological and human health risk. Nevertheless, it must be remembered either that the limit value set by WHO or estimated intake does not exceed the allowable standard, however the mercury may accumulate in such biota and in human body who are living the contaminated areas. As a result, the consumption of biota and the food that directly contact to the air and source from water might be of concern in long period.[8–10]

Conclusion

Most of the level concentration of Hg in the media environment are still lower and under the standard value which mean that environmental and human are still safe to live in the surround the cement industry temporarily. However, as the contaminant of Hg are accumulated in the sites, obviously their level may become higher as time goes, which may produce hazard both to environment and human being. As a recommendation, we suggest dwelling that located in first ring about 300 m distance from the point source should be protested safely by the industry and give compensation, Then, consumption of biota from the river and those contaminated from air Hg dropped are done according to the data concerning levels of environmental pollutants in the most consumed fish and seafood species as well as the food sold around the sites.

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Conflict of interest

The authors declare no conflict of interest.

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