ANALYSIS

53(264), December 1, 2017

ISSN
2278–5469
EISSN
2278–5450

Discovery

Distribution of Mercury in industrialized urban area and bottom sediments in India

Divya Tyagi☼

Department of Chemistry, Starex University, Gurugram, India

☼**Correspondence:**
Dr. Divya Tyagi,
Associate Professor,
Department of chemistry,
Starex University, Gurugram,
India;
E mail: divyatyagi77@gmail.com

Article History
Received: 23 October 2017
Accepted: 28 November 2017
Published: 1 December 2017

Citation
Divya Tyagi. Distribution of Mercury in industrialized urban area and bottom sediments in India. *Discovery*, 2017, 53(264), 651-655

ABSTRACT

The aim of this study was to determine distribution of mercury in bottom sediments and soil from different locations. Total mercury concentrations have been determined in bottom sediment (ponds, lakes, streams and rivers) and soil samples collected and analyze. Total mercury concentration in the bottom sediments was 97 ± 70 ng/g dry weight (range 29-283). Average total mercury concentration in the soil from urban areas was 146 ± 130 ng/g dry weight (range 17-746). The results of the study have shown that mercury distribution in the samples of water and bottom sediments, collected from various sites varies over a relatively large range.The mean concentration of Hg in surface soils was significantly greater than background concentrations. Forty-eight percent of the samples exceeded the “critical” concentration of 1.0 mg Hg/kg, dry weight in soils, which has been established by the Chinese government. At depths of 0–80 cm in the soil, profile concentrations of Hg also exceeded the background value.

Key Words: Chloroalkali, Aqua regia, Colloidal transport, Millennium Merlin Analyzer, Critical concentration

1. INTRODUCTION

Mercury is generally considered one of the most toxic metals found in the environment. Most mercury emission is released to the air as by- products of various industrial processes including coal combustion, mercury vapourlighs and chloroalkali production. The amount of Hg mobilized and released in to the environment has increased since the beginning of industrial age. Mercury pollution of soil is one potential environmental problem because Hg was contained in airborne fallout, waste dumping, liquid leakage and incidental emission from the workshops, waste treatment plants, and storage locations of old equipment in the former industrial plants. It has been reported that there are relatively great concentration of Hg not only in air, snow (Liu et al. 2002; Wang et al. 2004) and drinking water in urban areas (Gao et al. 2004) but also in the soil. Soil exposed to industrial sewage and sludge has been found to be contaminated with Hg (Zhu, 2001).

2. MATERIAL AND METHODS

Site description

The industrial activity in India started in the 1960s and ended around 2008. Five representative industrial sites (denoted as A, B, C, D and E) in the industrialized area were studied. Plant A was established in 1962 and its main products were chemical agents, fluorescent, and photosensitive materials. Plant B was established in 1967 and produced pesticides, polyvinyl chloride plastic, and rubber products. Plant C was built-in 1970 and its main products were coke, coal gas, ammonium sulfate, benzene, naphthalene, and hydroxybenzene. Plants D and E were established, respectively, in 1972 and 1973. Plant D mainly produced pesticides, lacquer, and building and industrial paint, while Plant E mainly produced dyestuffs, paint products, and vitriol. All of the plants have now been closed or moved, and some residential communities have been, or will be, established on the land. There are also other facilities in the area, such as hospitals, schools, residential communities, restaurants, and guesthouses. The soils in the investigated area developed ona sandy-textured alluvial deposit and are dominated by silt and sandy loams; the predominant soil types are typically fluvial in origin. Sampling locations taking up most of the site were selected based on locations of production and waste treatment sectors, which were potentially important sources of contamination. The concentration of total mercury was determined in 20 samples of bottom sediment samples (ponds, lakes, streams and rivers).

3. METHOD

Sediment and soil samples were collected with a hand corer made of stainless steel. They were placed in plastic boxes of 1 L volume and transported to the laboratory where they were dried at room temperature to constant weight. Subsequently, the samples were homogenized in agate mortar. Then the samples were sieved through first 2 mm mesh, then 0.5 mm, and were once again homogenized in an agate mortar. Finally the samples were sieved through the 0.150 mm mesh. For determination of mercury, sediment and soil subsamples (~1 g) were wet digested with aqua regia in a glass apparatus consisting of a round-bottom flask, partial condenser (30-cm long) and water cooler. 17 mL of aqua regia were added to the samples and the mixture was allowed to stand for 16 h. The flask was then gently heated for 2.0 h boiling. After cooling, the water cooler and condenser were rinsed with 5 mL of redistilled water. The digest was filtered by blotting paper and diluted with redistilled water up to 100 mL. Finally mercury content was determined by cold vapour atomic fluorescence spectroscopy (CV-AFS) using a Millennium Merlin Analyzer (PS Analytical). Standard Reference Materials: SRM 2711 – Montana Soil, SRM 2709 – San Joaquin Soil and LGC 6137 – Estuarine Sediment were analyzed routinely as laboratory reference materials. The values for total mercury 6.06 ± 0.07 µg/g (SRM 2711, n=3), 1.44 ± 0.03 µg/g (SRM 2709, n=4) and 0.37 ± 0.01 µg/g (LGC 6137, n=4) were in agreement with the certified concentrations of 6.25 ±0.19 µg/kg, 1.40 ± 0.08 µg/kg and 0.34 ± 0.05 µg/g, respectively.

4. RESULTS

Bare soil on the ground surface may serve as local “hot spots” for Hg emissions because of the large percentage of ∑Hg lying in the upper few centimeters of soil. The mean concentration of ∑Hg (4.85 mg Hg/kg, dw) in the industrial was significantly greater than the background concentration of ∑Hg in other soils (0.06 mg Hg/kg, dw; CNEMC1990), as well as the urban soil background concentration (0.28 mg Hg/kg, dw; Zhang et al.2006). According to the guidelines for Hg (Wu and Zhou 1991), 100% of the soil samples from industrial sites exceeded the "ideal" concentration (0.1 mg Hg/kg, dw) and "acceptable" concentration or "threshold" value (0.2 mg Hg/kg,dw), which indicates that very careful environmental management is necessary. Seventy-seven percent of the soil samples exceeded the "tolerable" concentration, which also corresponds to the "warning" value (0.5 mg Hg/kg, dw). This means that 77% of the area is only mildly ecologically impacted, and the foodstuff grown on this area had elevated concentrations of Hg.

Table 1 Descriptive statistics of mean Hg conc.

Site	Samples	pH	Hg mean	SD	Min	Max
A	3	8.2	9.65	17.30	1.06	44.70
B	5	8.1	13.22	20.46	1.37	76.27
C	2	8.3	1.24	1.75	0.26	6.77
D	6	8.5	.61	.44	.23	1.65
E	4	8.3	4.85	12.30	.22	76.27

Mean Hg concentrations of soils were the following decreasing order: B >A >C >E >D. Mean Hg concentrations in soils of sites B (13.22 mg Hg/kg, dw) and A (9.7 mg Hg/kg, dw) were significantly greater than any other site ($P < 0.05$). This indicates that the surface soils in areas of industries like those at Plants B and A may have the greatest Hg pollution potential. The mean concentrations of ∑Hg at these depths were significantly greater than those at depths of 180 and 400 cm. At depths of 20 or 80 cm, there were six soils (three at 20 cm and three at 80 cm) whose Hg concentrations were greater than the maximum soil cleanup standard for Hg for residential areas. No soil sample from depths of 180 and 400 cm had a ∑Hg concentration greater than 6.6 mg Hg/kg, dw. Although these five plants had almost the same periods of production, they had different distributions of ∑Hg concentration in the deep soils. Soils from site B contained the greatest mean concentration of ∑Hg in the profile. For profiles in which the maximum ∑Hg content was found tolie between 20 and 80 cm, three possible causes are possible. First, Hg could have leached downward by colloidal transport (Jacobsen et al. 1998). Second, Hg could have evaporated from the surface soil (Schl ˝ uter2000) as either methyl mercury or elemental mercury Hg°, but the degree to which Hg° evaporates is small. Nater and Grigal (1992) indicated that soils retain about 90% of the ∑Hg deposited on them. Similar findings were observed in other studies and it was found that in spite of the evaporation of Hg°, there is a net accumulation of Hg in soils (Mason et al. 1994). Finally, plants may have absorbed Hg from the soil. All three of these possibilities most likely have contributed to decreasing the concentrations of ∑Hg in the upper soils. Of these possibilities, colloidal transport appears to be the most likely mechanism for decreasing the ∑Hg concentration in the upper soils. Since maximum mean ∑Hg concentrations were observed at a depth of 80 cm, some remedial actions should be taken to remove the soils in the depth range of 0–80 cm. Surface soils, rich in organic matter, adsorb significantly greater amounts of Hg (Trost and Bisque 1972) and create strong organic complexes of great stability (Shuster 1991). Due to the affinity of Hg for organic matter, soil Hg leaching rates should be small because the industrialized urban soils in India have great concentrations of organic matter. Furthermore, the results of Landa (1978) suggested that in addition to quantity, the nature of a soils' organic matter also influences adsorption of Hg. Changes in pH can also have a major effect on a soil's ability to retain Hg. Mercury adsorption generally decreases with decreasing pH due to H^+ ions removing and replacing Hg ions. However, in this study, all samples were slightly alkaline, with a mean pH value of 8.2 (Table 1), and there was no significant correlation between soil pH and ∑Hg concentration (Table 1). This means that adsorption of Hg by soils would not change when the soil is in alkaline.

Bottom Sediments

In the bottom sediments from the same sites at which the samples of water were collected in India, total mercury concentration was 97 ± 70 Hg/g dry weight (range29-283). A relatively high concentration was noted in the sediments from ponds 154 ± 80 Hg/g (range 33-253), while lower o in the sediments from the Warta River 118± 96 Hg/g (range 47-283) and from rivers and streams 76 ±37 (range 33-113). Relatively the lowest average concentration of mercury was noted in the sediments collected from lakes 58 ± 20 Hg/L (range 29-81). The average total mercury concentration in soils from India was 146 ± 130 Hg/g dry weight (range 17-746). Relatively higher average concentrations of mercury were found in the soil samples taken from lawns and meadows 183 ± 184 Hg/g d.w. (range 31-749), lower in soil collected from urban forests 151 ± 129 Hg/gd.w. (range 17-469) and in the soil samples of no current agricultural use 136 ± 85 Hg/g d.w. (range 50-378). The lowest average mercury concentration was determined in the samples of soils of current agricultural use 84 ± 52Hg/g d.w. (range 31-207). Generally, the samples of soils along the busy streets contained higher concentrations of mercury 170 ± 149 (range 31-746) than those collected along quiet streets 118 ± 99 Hg/g d.w. (range 17-469).

5. CONCLUSION

The accumulation of ∑Hg in the surface soils is particularly obvious in industrialized urban lands in India compared with the farmland. Concentrations of ∑Hg in 48% of surface soils in the industrial sites exceeded the "critical" concentration and colloids in a macro porous soil were only mildly ecologically impacted as a result of the anthropogenic input. However, 89% of the industrialized urban land can be used for residential purposes. All the industrial surface soils need careful environmental management. Since Hg contamination was primarily confined to the top 0–80 cm, some engineering measures should be taken to remove these soils. Organic matter and nitrogen may be important sinks for Hg in the industrial soils. The making processes of Hg-containing products have caused heavy soil pollution of Hg at the industrial sites. Atmospheric Hg emitted by industrial and residential coal burning might have been the main cause of soil mercury contamination at most industrial sites in India. Another source of Hg in industrial soils was industrial leakage and runoff. The concentration of mercury in bottom sediments is a good indicator of water pollution with this element. On the one hand, bottom sediments are where mercury accumulates as a result of simple sedimentation, and on the other, mercury is released from the sediments, becoming available for further biogeochemical transformations. The rates of the two processes significantly depend on the specific environmental conditions in a given aquatic system.

SUMMARY OF RESEARCH

Mercury exceeded the critical concentration in soil. Atmospheric Hg emitted by industrial and residential coal burning is main cause of mercury in soil. Water pollution is increases due to industrial leakage system.

FUTURE ISSUSES

Industrial surface soils contain mercury and it is confined to top layer only so it needs careful environment management. Mercury settle in bottom due to sedimentation creates a lot of problem to aquatic plants and animals.

DISCLOSURE STATEMENT

There is no special financial support for this work from the funding agency.

AKNOWLEDGMENT

Much thanks to my colleagues for constructive criticism, especially to Rajeev Tyagi, Sakshamtyagi, Usha yadav and Vandana Kaushik for assistance in helping in collection of sample and data from various industries.

REFERENCE

1. Agamuthu, P., & Mahalingam, R. (2005). Mercury emissions: Is there a global problem? *Waste Management Research, 23*, 485–486.
2. CNEMC (China National Environmental Monitoring Center) (1990). *The background concentrations ofsoil elements in China*. Beijing: China Environmental Science Press (in Chinese).
3. Feng, X., Tang, S., Shang, L., Yan, H., Sommar, J., & Lindqvist, O. (2003). Total gaseous mercury inthe atmosphere of Guiyang, PR China. *Atmospheric Environment, 304*, 61–72.
4. Gao, X. L. (1987). The distribution of mercury pollution in air in Beijing urban areas. *Environmental Science, 8*, 33–36 (in Chinese).
5. Gao, J. J., Zhang, L. P., Huang, S. B., Ma, M., & Wang, Z.(2004). Preliminary health risk assessment of heavy metals in drinking waters in Beijing. *Environmental Science, 25*, 47–50 (in Chinese).
6. Gaudet, C., Lingard, S., Cureton, P., Keenleyside, K.,Smithe, S., & Raju, G. (1995). Canadian environmental quality guidelines for mercury. *Water Air and Soil Pollution, 80*, 1149–1159.
7. Gobat, J. M., Aragno, M., & Matthey, W. (1998). The living soil. Bases of pedology. In *Biology of soils*.
8. Lausanne: Polytechnic and Romandes University Presses (in French).
9. Hollis, J. M. (1991). *The classification of soils in urban areas*. Oxford: Blackwell.

10. Hylander, L. D., & Goodsite, M. E. (2006). Environmental costs of mercury pollution. *Science of the Total Environment, 368*, 352–370.
11. Jacobsen, O. H., Moldrup, P., de Jonge, H., & de Jonge,L. W. (1998). Mobilization and transport of natural. *Physics and Chemistry of the Earth, 23*, 159–162.
12. Jiang, J. K., Hao, J. M., Wu, H., Streets, D. G., Duan, L.,&Tiao, H. Z. (2005). Development of mercury emission inventory from coal combustion in china. *Environmental Science*, *26*, 34–39 (in Chinese).
13. Landa, E. R. (1978). The retention of metallic mercury vapor by soils. *Geochima et Cosmochimica Acta, 42*, 1407–1411.
14. Landis, M., Keeler, G., Al-Wali, K., & Stevens, R. (2004).Divalent inorganic reactive gaseous mercury emissions from a mercury cell chlor-alkali plant and its impact on near-field atmospheric dry deposition. *Atmospheric Environment, 38*, 613–622.
15. Lechler, P. J., Miller, J. R., Hsu, L. C., & Desilets, M. O. (1997). Mercury mobility at the Carson River Superfund Site, east-central Nevada, USA: Interpretation of mercury speciation data in mill tailings, soils, and sediments. *Journal of Geochemical Exploration, 58*,259–267.
16. Li, C. L. (1992). The reason of high mercury concentration in Beijing soil. *Environmental Monitoring in China, 8*,78–80 (in Chinese).Li, X. X., Lu, A. X., Wang, J. H., Ma, Z. H., & Zhao, C. J. (2006). Analysis and assessment of soil environmental quality of some farmlands in Beijing. *Transaction of 16 Chinese Society of Agricultural Engineering, 22*, 60–63(in Chinese).
17. Linde, M., Bengtsson, H., & Öborn, I. (2001). Concentrations and pools of heavy metals in urban soils in Stockholm, Sweden. *Water Air and Soil Pollution Focus, 1*, 83–101.
18. NEUMAN K., LYONS W.B., ROSI E.J., MEYER J.L. Hgand other trace metals in water, suspended matter, and biotain the Chattahoochee River. In: Nriagu J.O. (ed.) 11th Annual International Conference on Heavy Metals in the Environment, University of Michigan, School of Public Health, AnnArbor, MI, 2000.
19. BOSZKE L., KOWALSKI A., SIEPAK J. Distribution of mercury in surface water and soil from Poznań City (Wielkopolska District, Poland). In: Horvat M., Ogric N., FaganelliJ. Kotnik J. (eds.). Mercury as a Global Pollutant. Part2. Biogeochemistry. Materials Geoenvironment 51, pp. 861-863. 2004.
20. BODALY R.A., RUDD J.W.M., FLETT R.J. Effect of urban sewage treatment on total and methyl mercury concentrations in effluent. Biogeochemistry 40, 279, 1998.