

Control device for Indoor mercury emission - Eco friendly model

K.Jayaprakash* and R. Mahesh

Department of Biotechnology, Karpaga Vinayaga College of Engineering and Technology
(Affiliated to Anna University, Chennai) Kanchipuram-603308.

Received 14 May 2012; revised 9 November 2012; accepted 30 November 2012

The mercury pollution and their toxicological studies, ecological sources and bioaccumulation have been extensively studied by many workers. However there is a deficiency of knowledge exist on the suitable mercury emission control techniques. In the present study an eco friendly, non-chemical and cost-benefit mercury indoor emission control device has been suggested. Data was obtained for mercury emission from air samples collected at indoor level (27.8mg/m^3). Also by the samples collected at the air discharged from the proposed unit during the gold refining process (6.3mg/m^3). Nine different small scale gold refining cottage industries were selected for the test studies with this unit. The results are encouraging. There is a significant reduction of mercury in outdoor ambient air samples. Further developments are on to design the said control device with cost benefit on commercial basis.

Keywords : Mercury emission control device, air pollution control device, Indoor mercury emission and control.

Introduction

Mercury is a natural inorganic elemental heavy metal. Concern on environmental discharge of mercury pollutant and its impact has been increasing¹. Due its volatile character and persistence of mercury vapor by emission in the air, the mercury pollution control becomes an immediate mandate. Further the inhaled mercury vapor is absorbed by biological tissues. The elemental mercury vapor interacts with biopolymers and causes ill effects in humans and animals^{1,2}. The industrial chemical process is the major source for mercury vapor pollution in air. The coal combustion, chlorine-alkaline production, metal smelting and refining, paper/pulp production are some of the industries responsible for the mercury emission³. The atmosphere is the chief route for the circulation of mercury pollutant. In addition to the above phenomenon the air-borne mercury particulate substances settle in soil, dissolved by organic species and microbes. In soil sedimentation these mercury species are converted into organic methyl mercury, which is known as a hazardous molecule enter through food chain. Nevertheless scientific uncertainties are suggested on

the quantitative determination of mercury vapor circulation in air and rate of spreading⁴.

The mercury pollution and their toxicological studies, ecological sources and bioaccumulation have been extensively studied by many workers. However there is a deficiency of knowledge exist on the suitable mercury emission control techniques. Many of the present methods are to control the mercury emission at outdoor level. In many small scale Industries the mercury vapor emission is dispersed by keeping the furnace in open air or pull out the ambient air by exhaust fans. For large scale industries the process are mostly on chemical basis. Despite many small scale industries are also contributing mercury deposition in air at indoor as well as outdoor level. The indoor emission of mercury is more dangerous than release into ambient atmosphere. There is a considerable persistence of mercury vapor in the working environment and has the chance of entry in to the GI and alveolar tissues of workers. The previous analysis by the author Jayaprakash⁵ has indicated a prevalence of high dispersed state of mercury emission of 42.7 mg/m^3 in gold refining cottage industries. In the present study an eco friendly, non-chemical and cost-benefit mercury emission control device has been suggested. The design, working principle and efficiency in controlling mercury gas have been highlighted in this paper.

*Author for correspondence
E-mail: eswaripj@gmail.com

Materials and Methods

The following are the materials used for the construction of the proposed mercury emission controlling device.

1. SS steel cylinder of 1' diameter and length of 2'.
2. Nylon mesh of (Approx. 100 holes/ 1 sq.cm.).
3. Exhaust fan.
4. Water coolant system.
5. Semi dried cow dung.
6. Outlet collecting rubber tube with glass beaker.
7. Cylinder Inner-lining by FRP

The device was set up as per the diagram given in Figure 1. The above described unit was installed at the air out let of the chimney above the smelters or the furnace .Before installation semidried cow dung was filled in the cylinder. The selection of biomaterial cow

dung is, based on its high fibrous and lack of any chemical reaction between the organic cow dung and the mercury vapor. Due to low density and colloid nature of the cow dung the mercury globlet can easily settled in the cylinder. It was allowed to maintain a temperature ranging at 20-22 degree Celsius by the attached coolant system. The vapor concentration of mercury in the air was measured using palladium chloride (PdCl_2) soaked filter paper discs. The darkening of the paper due to Hg granules which was appeared as carbon dusts was measured by cold vapor mercury analyzer (MA 5800/A, EC India Ltd.) the methodology was given elsewhere ⁵.The mercury content was determined by using a cold vapor atomic absorption kit (Varion 4S) to obtain accuracy, the method was standardized with known amount of mercury. Data was obtained for mercury emission from air samples collected at indoor level. Also by the samples collected at the air discharged from the proposed unit during the gold refining process. The mercury values in air were statistically analyzed to know the functional efficiency of the controlling device. The energy cost estimation as per the formula and the calculator given at www.productiveenergy.com. Ten different small scale gold refining cottage industries were selected for the test studies with this unit.

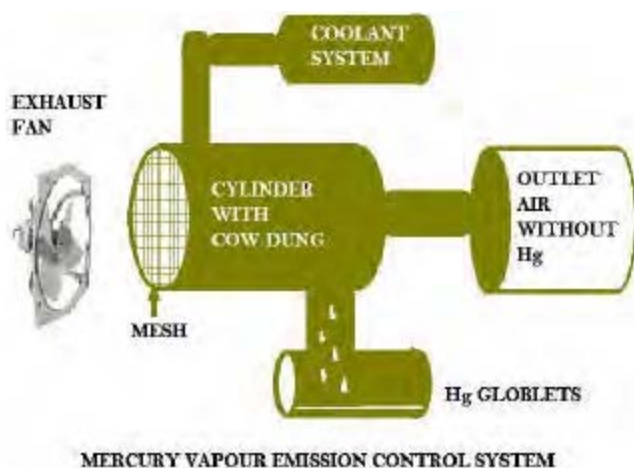


Figure 1—Ground diagram of the device

Results and Discussion

The quantitative determination of mercury vapor present in the indoor air at the time of gold refining process in nine selected workshops has shown a range of 15.1 to 41.3 mg /m³. The mean value of the in door mercury vapor was 27.8 ± 2.86 mg/m³ on the other hand the corresponding mercury content in the air

Table 1—Functional efficiency in controlling Mercury Vapor

Trail No	Mercury used in (g)	Mercury vapor in Indoor air (mg/m ³)	Mercury vapor in air at the out let end (mg/m ³)	Weight of recovered Mercury in (g)
1	2	15.1	2.1	0.853
2	3	33.6	8.2	1.211
3	3	26.5	6.1	1.759
4	1	29.2	5.4	0.320
5	3	41.3	11.3	1.518
6	2	36.1	6.6	1.055
7	2	23.4	5.8	1.242
8	1	18.5	5.1	0.632
9	1	22.7	6.4	0.307
Mean	2	27.8 ± 2.86*	6.3 ± 2.32*	0.433

*The values are after SEM and Statistically Significant at 95% Confident level (P<0.05).



Figure 2—Hg distillation and globlets

samples collected at the outlet end had a range between 2.1 to 11.3 mg/m³. The mean value was 6.3 ± 2.32 mg/m³ mercury (Table 1).

This would suggest that the proposed device is controlling the emission of mercury vapor in the air discharged out from the working environment. The Heat transfer required for the conversion of gaseous mercury in to solid form obey the Heat transfer equation

$$Q = mC_p (\Delta t)$$

Q = Net Heat transfer rate depend on the coolant water circulation and the temperature of the cow dung(Q should always be negative in this case as heat loss is due to cow dung)

m = The volume of mercury contaminated air entered in to the device

C_p = Specific heat of gas

Δt = Temperature difference between the vapor entered in to the device and the air discharged from the outlet

Further Table 1 is also furnished with data on the amount of mercury used for the preparation of gold amalgamation. It was found out as an average of 2gm in nine workshops under study. There was a recovery of 0.433gm mercury by sedimentation from the cow dung after the smelting process (Figure 2).

From the foregoing results it would reasonable to presume the functional efficiency of the device designed in this present investigation in controlling mercury emission. The efficiency of this device in transforming the vapor in to solidified mercury is depend on the amount of mercury concentration (or) contamination of the air circulated in the cow dung chamber and the retention time.

Table 2—Estimated Cost of the Device

Sl. No	Item	Rupees/ US dollar
1	SS Cylinder (1' X 2')	150.00
2	2 Nylon Mesh	20.00
3	Exhaust Fan	1200.00
4	Mono block Pump	1500.00
5	Inner lining of the Cylinder by FRP	100.00
	Total	2970.00/ (55.23\$)

Table 3—Energy Calculations

Sl. No	Electrical Appliance	Rupees/ US dollar
1	Exhaust Fan	
	Horse Power : 1	2500.00
2	0.5 Hp Mono block pump	1000
	25 liters/hour	
	Total	3500.00 / (65.08\$)

$$dx/dt = \mu x$$

x = Amount of mercury

t= Retention time

μx = Recovered mercury

The distilled mercury can be collected periodically and may be reused. Table 2 is presented with the estimated cost of the device. It was calculated as the total amount of Rs.2970(55.23\$). The results of energy calculation are given in Table 3. It was estimated as Rs.3500 (65.08\$) for 1000 hours operation per year. The fibrous rich organic cow dung used in the cylinder for the recovery of mercury is renewable. Therefore the present projected device is eco friendly equipment.

Conclusion

The admissible recommended mercury vapor content in occupational environment is 0.1mg/m³.⁵ The results of present study have exhibited an average of 27.8 mg/m³ at the time of gold refining process in these small cottage industries. Now days there are efforts to reduce anthropogenic mercury emission. However its presence in air is significant and alarming level in edible fishes⁶. The mercury contamination in air can be bio transformed in to methyl mercury and bio magnified in the food chain. The deleterious effect of mercury in human population is still unpredictable^{4,7,8,9}. Gold jewel ornament manufacturing workshops are one of the contributing source of mercury emission in air. The present eco friendly device demonstrates a significant reduction of

mercury emission and recovery. Research is under way to find out a suitable colloidal state of organic fiber or cow dung preparation at which total mercury vapor emission control is achieved. A zero emission of mercury by adapting alternate ways like using sodium bi carbonates to remove the impurities and melting the gold grains in glass wool cotton also being disseminated among goldsmiths. It is desirable to replace cotton wool instead of renewable cow dung fillings. The above studies and the improvement of the device on commercial scale of trials are on. Much more clear studies with large number of trials are underway to ascertain the efficiency of this device.

Acknowledgements

The authors are grateful for the encouragements shown by the Director, Advisor, Dean and Principal, KVCET, Chennai – 603308. The author K.J thanks to Er.B.Rajkumar , Sothern Associated Industrialist, Coimbatore – 641006 for the device preparation and provision of Thermo Anemo meter TIFF 3220, thanks are also due to Certified Goldsmith association, Gobichettipalayam – 638452 to conduct trials.

References

- 1 Clarkson, T, The toxicology of Mercury. *Crit Rev Clin Lab Sci* .1997;34 ,369-403
- 2 Roonay J.P.K. The role of thiols, dithiols, nutritional factors and interacting ligands in the toxicology of mercury. *Toxicology*, 2007;234,145-156
- 3 Li,p Feng X.B, Qiu G.L, Shang L.H, Li Z.G. Mercury pollution in Asia. A review of the contaminated sites .*J of Hazard Materials*. 2009, 168:591-601.
- 4 Lin C.J, Pongtrueksa P, Lindberg S.E, Pehkonen S.O, Byun D, Jan C. Scientific Uncertainties in atmospheric Mercury models: Model Science Evaluation. *Atmosphere and Envoinrment*:2006;**40**,2911-2928.
- 5 Jayaprakash.K Mercury vapor inhalation and its effect on glutathione peroxides' in goldsmiths exposed occupationally. *Toxicology and Industrial Health.*, 2009 **25**(7): 463-465.
- 6 Goyer R and M. Mehlman(ed). *Toxicology of Trace Elements*, 1977 (Hemisphere Publishing Co., Washington)
- 7 Dean W. Boening. Ecological effects, transport and fate of mercury: A general review. *Chemosphere*, 2000, **40**: 1335-1351.
- 8 Crump, K.L and Trudeau. V.L. Mercury induced reproductive impairment in fish. *Environmental toxicology and Chemistry*, 2009,28(5):895-907.
- 9 Mohammad Sekhvatjou et al. seasonal variation of mercury vapor concentration in industrial, residential and traffic areas. *Afric J of Biotechno*, 2011, 10(**57**): 12232-12236.