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Research Article

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ABSTRACT

Incinerated medical waste residue has more heavy metals than municipal solid waste which if not well disposed of, could pollute the environment and pose a great danger to public health.

A study was done on incinerators at Kenyatta National Hospital – Nairobi and Moi Teaching and Referral Hospital – Eldoret to assess levels of total chromium, cadmium, mercury, lead and silver from the bottom ash. Atomic absorption spectrophotometer was used for analysis.

At KNH, incinerator bottom ash had mean concentrations of 5297, 140, 4299, 2092 and 57 mg/kg of total chromium, cadmium, lead, silver and mercury respectively. At MTRH, the concentrations in the ashes of 3870, 250, 4340, 1360 and 40 mg/kg of total chromium, cadmium, lead, silver and mercury were found. These exceeded the maximum limits specified by the Kenyan National Environmental Management Agency and European Union Standards for ordinary disposal. Regular quality monitoring of heavy metals in bottom ash of the two institutions' incinerators to guide safe disposal of the residues was not practiced.

Keywords: *Heavy metals; concentrations; quality monitoring; standards.*

INTRODUCTION

Medical waste forms 10% to 25% of the health-care waste which is considered as hazardous and may be toxic or radioactive (WHO, 1994). Its management calls for a heavy responsibility, as it is dirty, foul, difficult, expensive and technically complicated task. If not done properly it can cause a significant inconvenience and become a public health risk (Naioova, 2000; Sheshinski, 2002; WHO, 2004). A poor management practice may pose as a health risk which according to Ford *et al.* (2004) may likely pollute the environment through emitted smoke and improperly disposed of bottom ash of incinerators. Incineration of hazardous waste as a treatment option is viewed as dangerous (Ridlington and Heavner, 2004). The practice is worsened by operation of incinerators by untrained or improperly trained operators. (Batterman, 2004).

While incinerating medical waste, waste that may contain heavy metals should be segregated and excluded for alternative treatment that ensures that the environment is not polluted by their emissions and heavy metal residues in the bottom ash. Healthcare waste containing for example mercury, incinerated without due care would release mercury vapour in the environment which if inhaled by humans may be toxic, fatal or lead to life threatening injuries to lungs and neurological systems (Howard, 2002; UNEP, 2009). Health-care waste has more heavy metals than municipal solid waste (Takeuchi *et al.*, 2005; Sabiha-Javied and Tufai, 2008; Zhaho *et al.*, 2010). Waste from dental clinics, broken thermometers mistaken as sharps contain mercury (US, EPA, 2011; Vieira *et al.*, 2009; Mazrui, 2010; Calhoun, 2003) which if incinerated leave mercury residue in the bottom ash while the rest is released as gaseous emission in the environment posing a great risk to public health. Cadmium, a heavy metal also common in

red bags used to store infectious waste (Hill, 1997; Lee and Huffman, 2002) if incinerated and taken by humans, bio-accumulates in kidneys with the content increasing with age. It causes human kidney damage and emphysema. Chromium vi, also a product of incinerated plastics leather treated products in industry, if incinerated and gaseous emissions inhaled or consumed orally (chromium vi) can cause cancer (WHO, 1996; Howard, 2002).

Lead commonly found in paints and plastic liners of health-care waste bins if released in the environment acts as a cumulative poison, and has adverse effect on nervous system of developing fetuses, and could cause convulsion, comma, renal failure and death (Hill, 1997; Howard, 2002).

Silver, a metal associated with photographic materials used in X-Ray films and also present in dental amalgam if released during incineration and excessively ingested, could cause skin, eyes and mucous membrane discoloration (Hill, 1997). In its ionic form, it is more toxic to aquatic organisms than any other metal except mercury.

METHODOLOGY

Daily single batches with samples taken in triplicates from bottom ashes of selected incinerators, one each, at KNH and MTRH were weighed in equal quantities for thirty consecutive days in October and November, 2008.

The samples were later sieved and weighed in 1 gm quantities. Digested and the extract analysed for heavy metals applying a standard method (Endham et al., 2000) and use of Atomic Absorption Spectrophotometer (AAS).

RESULTS AND DISCUSSION

Bottom Ash Analysis

The following were the mean daily concentrations of the heavy metals under study as isolated from the incinerators bottom ash:

- NEMA- National Environmental Management Authority.
- WSRP- Water Services Regulatory Board.
- US, EPA- Environmental Protection Authority of United States.

Table 1.0: Heavy Metals in Bottom Ash of Hospital Incinerator (KNH)

Item (day)	Chromium mg/L (daily mean conc.)	Cadmium mg/L (daily mean conc.)	Lead mg/L (daily mean conc.)	Silver mg/L (daily mean conc.)	Mercury mg/L (daily mean conc.)
Mean	5.297	.140	4.299	2.09193	0.057
SD	2.486759	.054081	1.881	0.74403	0.018
Variance	6.18	0.00	3.53	0.55	0.000
Mean mg/kg of ashes	5297	140	4299	2092	57

Table 2.0: Maximum Permissible Levels (Standards)

	Enforcing Body	Heavy Metal	Max. Conc. mg/L
1	NEMA/WSRB	Lead	0.01
2	- do -	Lead and it compounds	0.1
3	- do -	Chromium (vi)	0.05
4	- do -	Chromium (total)	2.0
5	- do -	Cadmium	0.01
6	- do -	Cadmium and its compounds	0.1
7		Total mercury	0.005
8	EPA (US)	Silver	0.14

The mean operating temperatures for the incinerator at KNH were 188°C minimum and 902°C maximum. The metals, chromium (total), cadmium and lead and mercury fall above the maximum levels permitted by the standards (National Environmental Management Agency/Water Services Regulatory Board Guidelines, 2006) levels as in Table 2.0 and are significantly higher than the standard, $p = 0.000$ (df=29). Similarly, silver is also significantly higher than the standard (United States Environmental Protection Agency) with a concentration of 0.14 mg/l; $p = 0.000$ (df=29).

The bottom ash had therefore a mean concentration of heavy metals of total chromium, cadmium, lead, silver and mercury of 5297, 140, 4299, 2092 and 57 mg/kg respectively. Zhao *et al.* (2008) demonstrated that bottom ashes from medical incinerators with heavy metal residues if not properly disposed of could leach from the ashes and pollute the environment.

Table 3.0: Heavy Metals in Bottom Ash of Hospital Incinerator (MTRH)

Item (day)	Chromium mg/L (daily mean conc.)	Cadmium mg/L (daily mean conc.)	Lead mg/L (daily mean conc.)	Silver mg/L (daily mean conc.)	Mercury mg/L (daily mean conc.)
Mean	3.87	0.25	4.34	1.36	0.04
SD	2.20	0.18	2.70	0.60	0.05
VARIANCE	4.83	0.031	7.29	0.35	0.002
Mean mg/kg of ashes	3870	250	4340	1360	40

The mean operating temperatures for the incinerator at MTRH were 186°C minimum and 938°C maximum.

From the analysis, the mean levels of the five different pollutants (heavy metals) recovered from the bottom ash at MTRH incinerator are significantly higher than the levels specified by National Environmental Management Agency/Water Services Regulatory Board, standards for disposal in the environment or receiving water bodies. All the metals, chromium (total), cadmium, lead and mercury are of higher concentrations than those permitted for disposal by National Environmental Management Agency and Water Services Regulatory Board Guidelines and are significantly higher, $p = 0.000$ (df=29). Similarly, silver concentration is significantly higher than the level specified by (United States Environmental Protection Agency), $p = 0.000$ (df=29) (same table).

The bottom ash with mean concentrations of heavy metals, total chromium, cadmium, lead, silver and mercury of 3870, 250, 4340, 1360 and 40 mg/kg, respectively, which if not properly disposed of is likely to leach from the ashes and pollute the environment as indicated in the case of KNH above.

Incinerating healthcare waste bearing mercury risks public health as it readily sublimates, appearing as vapour in the environment and can be inhaled by humans. The positions of the two incinerators under study in the two institutions by virtue of their situation make render the heavy metals they discharge a public health risk. This is an obvious threat because when mercury in unacceptable concentration was traceable in bottom ash of incinerator, it implies that much of it had undergone sublimation and was discharged as mercury vapour in the environment in the two institutions. The healthcare waste likely to emit mercury during incineration, a heavy metal isolated from the bottom ash, includes dental amalgam from dental clinics which has 50% mercury, (Calhoun, 2003) thermometers, blood pressure cuffs, laboratory chemicals, certain electrical switches, paints, fluorescent lamps and bulbs (GAIA, 2009). Cadmium bearing waste that if incinerated could contribute to this heavy metal traced in the bottom ash would be red liner plastic bags used for refuse bins (Hill, 1997). Lead, which was also isolate in high quantities in the incinerators of the two institutions, would originate from incinerated red liner bags used for storage of infectious waste, paints and batteries (Hill, 1997; Howard, 2002). The origin for silver in the bottom ash of the incinerators must have been photographic material used for X-Ray films. The category was not among the four categories studied.

CONCLUSION

Concentrations of heavy metals in the bottom ash of the incinerator under study at KNH, total chromium, cadmium, lead, silver and mercury at 5297, 140, 4299, 2092 and 57 mg/kg respectively exceeded the maximum levels allowed for ordinary disposal in the environment by National Environmental Management Agency and the United States Environmental Protection Agency. At MTRH the concentrations of heavy metals in the bottom ashes, 3870, 250, 4340, 1360 and 40 mg/kg respectively also exceed the maximum levels specified by the said standards.

There was no regular monitoring of heavy metal concentrations in the bottom ashes of the incinerators in the two institutions to quality to ensure for safe disposal of bottom ashes in the environment.

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