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Research Paper

Saying 'No' to Incineration: a Review

Public Health

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ABSTRACT

Tons of medical waste is generated each day and a significant proportion of this waste is hazardous, which requires proper disposal. Incineration is one of the oldest techniques available for hospital waste disposal. Poor design, construction, siting, operation and maintenance result in low combustion temperatures. This leads to the production of toxic emissions like dioxins, furans, polycyclic aromatic hydrocarbons, acidic and green house gases, particulate mater and ashes, which have a potential to seriously harm human health and environment. There is an increased opposition in India and around the world against incineration of medical waste. Therefore it becomes imperative to employ environmentally friendly technologies.

Introduction:

According to World Health Organization 75% to 90% of the waste generated by health-care facilities is similar to the general municipal waste, but the remaining 15% to 25% waste is infectious and hazardous, thereby posing a serious risk to human health and environment. [1] It is imperative to dispose this hazardous waste in the most efficient manner. Incineration is one of the oldest and most popular methods used to dispose biomedical waste. [2] However, this technology is fraught with flaws. The production of toxic residues during the incineration process and their subsequent release in the environment has made incinerators a potential health hazard. Growing public opposition to incinerators and stricter regulations to bring down emissions are reasons enough for healthcare facilities to consider alternative means of disposing waste.

Present scenario:

There are 1,68,869 healthcare facilities (HCFs) with 17,13,742 beds in India, which generate about 484 tons of waste/day [3] [4]. 92 percent of this waste gets treated in 198 common bio-medical waste treatment facilities (CBWTFs) and 22,245 on-site treatment and disposal facilities.78 percent of the healthcare facilities utilize the services of CBWTFs. 37 tons of waste is disposed with the general municipal waste, dumped illegally or enters the recycle market [4].

The commonest treatment method employed is incineration. According to a Central Pollution Control Board (CPCB) estimate, about 217 medical waste incinerators are not equipped with any air pollution control device [4] to meet the modern emission standards. Medical waste incinerators in India, like other developing countries, suffer parlous shortcomings in terms of design, construction, siting, operation and management, which often result in poor incineration performance, for example: low combustion temperature, incomplete decomposition of the waste, inappropriate disposal of the residual ash and emission of potent carcinogens [5].

Toxic emissions:

The process of incineration results in the production of many organic and inorganic pollutants in the form of fly ash, bottom ash and stack gases. [6] Organic pollutants - like Polychlorinated dibenzo dioxins (PCDDs), Poly-chlorinated dibenzo furans (PCDFs) and polycyclic aromatic hydrocarbons (PAHs) - are produced as a result of the use of chlorinated organic compounds in the form of PVC plastics [7] and inadequate incineration temperatures [6]. PCDD/Fs are among a dozen Persistent Organic Pollutants enlisted in Stockholm Convention [8], which bio-accumulate in the human tissues and persist in the environment – soil, air and water - for a considerable length of time. International community, encouraged by Stockholm Convention, has set the dioxin emission limit at 0.1ng/m^3. According to Batterman dioxin emissions from small -scale incinerators in low and middle-income countries can be 100 (10ng TEQ/m^3) to 40,000 (4000ng TEQ/m^3) times more than the prescribed limit [9]. Dioxins, furans and PAHs have tremendous health impacts on both humans and animals that range from carcinogenesis, mutagenesis, endocrine disruption, reproductive and developmental effects [10] [11] to increased risk of diabetes, cardiovascular diseases and chronic obstructive pulmonary diseases [12].

Heavy metals like mercury, lead, cadmium, chromium and Arsenic besides others are a by-product of incineration. A greater concentration of these metals is present in the bottom ash [13] (with the exception of mercury) [6], which when landfilled has the potential to leach and contaminate the sub-soil and ground water [14]. Heavy metals bio-magnify in living tissues and are toxic to brain and other organs; they can irritate skin and mucosa [15].

Inorganic acidic gases, especially hydrogen chloride (HCl), hydrogen fluoride (HF), hydrogen bromide (HBr), sulphur oxides (SO_X), and nitrogen oxides (NO_X) are formed and emitted by incinerators [16]. These acidic gases lower the pH of rain, making it acidic and severely impact the respiratory health [14]. Incineration also releases green house gases, especially CO_2 and CO. a ton of CO_2 is generated on incinerating a ton of waste [15].

Incineration emits a variety of particulate matter, most of which are ultrafine (<0.1micro meter) in size [14]. Contemporary air pollution control devices are quite incapable of containing these ultrafine particles and only prevent 5% to 30% of the "respiratory" (<2.5 micro meter) sized particles from being released into the atmosphere [14]. These particles are capable of reaching the remotest recesses of the lungs, thus impairing their normal function.

Incineration ash - both bottom and fly ash is considered hazardous under international law. Bottom ash or clinker comprises 90% of the total ash produced, whereas the rest 10% is fly ash – fine particles trapped by air pollution control devices [15]. Incineration ash in either form contains significant amounts of heavy metals, organohalogens and other chemical pollutants.

Table 1: Harmful effects on human health and environment

	Health Effects	Environmental Effects
Dioxin and Dioxin like compounds	Carcinogenesis Modulation of hormones, receptors and growth factors Immune suppression, susceptibility to infection and auto-immune response Developmental impacts like birth defects and fetal death Male and female reproductive toxicity Organ toxicity, diabetes, weight loss, etc.	Deposition in the soil and on the surface of leaves Enter the leaves through stomata Can be taken up by the roots of woody plants Livestock feeding on contaminated vegetation ingest dioxins Found in milk and meat

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Heavy Metals Lead Cadmium Arsenic Chromium Mercury	Nervous system disorders, lung and kidney problems, and decreased mental abilities in children Renal damage, calcium deficiency, respiratory and gastric tissue irritation, carcinogenesis Damages many tissues including nerves, stomach, intestines and skin, causes decreased production of red and white blood cells and abnormal heart rhythm Damages nose, lung and stomach It is a neurotoxin. Also damages heart, kidneys and lungs. Delayed development of motor functions in the fetus	Bioaccumulation in plants and animals Contamination of soil and drinking water Methylated mercury in the sea food
Particulate Matter	Respiratory diseases Cardio-vascular diseases	Air pollution
Gases Hydrogen Chloride, Hydrogen fluoride and Hydrogen bromide Sulphur oxides and Nitrogen oxides Methane and Carbon dioxide	Respiratory troubles	Damage the incinerator, especially the air pollution control equipment Acid rain, photochemical smog Green house effect
Other organic compounds Polychlorinated Biphenyls Chlorinated benzenes Poly Aromatic Hydrocarbons Volatile Organic Compounds	Toxic effects on reproductive and nervous system. Immunological effects Carcinogenesis. Damage to the developing fetus, lungs, immune system, thyroid, kidneys and Central Nervous System Carcinogenesis Respiratory problems	Biomagnification Ozone formation in lower atmosphere Poor ambient air quality

Problems with Incineration:

Paul Connett and GAIA have identified various problems related to the operation of incinerators in the developing countries: it is not financially feasible to retrofit existing incinerators with high cost air pollution control equipment; a paucity of qualified, trained professionals to operate the incinerators, (especially the on-site incinerators); weaker regulation apparatus and lack of technical ability to test releases allow incineration operators to either evade or manipulate emissions monitoring; large scale corruption and budgetary chaos severely affects the frequency and quality of maintenance; interruptions in the regular delivery of waste, and poor availability of fuel and electricity have significant impacts on the functioning of an incinerator; increase in the toxicity of residual ash with a corresponding increase in the filtration capacity of air pollution control equipment; and the incineration ash is dumped in easily accessible unlined pits, where there are ample chances of groundwater contamination and scavenging [15] [17]

Global and local opposition:

There has been a large-scale opposition to incineration of medical waste and consequently they are being phased out all across the world and replaced by new, less polluting technologies.. Phillipines became the first country to ban incineration in 1999 [15]. A 1994 U. S. Environment Protection Agency (USEPA) draft report identified medical waste incinerators as the largest source of dioxin pollution in the United States [18] and consequently the number of medical waste incinerators in United States came down from 6200 (in 1988) to 107 (in 2005) [19]. Various countries in Europe have shifted to non-incineration treatment technologies. Slovenia, Portugal, France and Ireland prefer to use steam-based systems, like autoclaves, to treat large quantities of medical waste. [18] Medical waste incinerators in China account for 11.5% of the total PCDD/F emissions. [20] A 2005 World Bank report states that if China continues to establish more incinerators without a regulation on the emissions, the global dioxin levels might double. Chinese authorities have identified 147 substandard medical waste incinerators and have decided to dismantle them [9]. A survey conducted between 2001 and 2002 found that none of the in-house incinerators in Delhi met emission requirements. India adopted new guidelines for medical waste incineration in 2004, which banned on-site incineration (permitted only under exceptional circumstances) and raised the standards for design and operation of the incinerators. [21] Despite the establishment of clear cut rules, citizens of South Delhi's Okhla region had to wage a long war against a Common bio-medical waste management facility located in their backyard, before it was finally shut-down [22].

Alternate technology options

As incinerators become obsolete, novel technologies are sought to treat medical waste. Low thermal processes, operating between 93ºC-177ºC, such as autoclaves, hydroclaves, and microwaves, which typically employ steam to disinfect the waste material are gaining popularity. The latest equipment has mechanism to shred the waste before exposing it to steam – this serves two purposes: significant reduction in waste volume, and better steam penetration. Plasma pyrolysis use very high temperatures (540ºC-8300ºC) to break down the waste into its chemical components [23]. CPCB gave its approval to use plasma pyrolysis for biomedical waste disposal in 2011 [24], and in a pilot study conducted by it in 2013 found that the dioxin emissions are within the prescribed norms when treating plastic waste [25].

Conclusion

Incinerators have become an economic and an environmental liability. On the pretext of treating infectious medical waste, incinerators are generating more harmful residues. India is slowly, but surely waking up to the reality of harm meted to both, human and environmental health by the incinerators. Therefore, it becomes imperative to phase out this costly and polluting technology and replace it with an environmentally friendly one.

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