Evaluation of Medical Waste Incinerators in Alexandria.


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ABSTRACT

Medical establishments play important roles in different activities by using of modern technology to serve the humans and the environment through different departments in the establishment and its firms. Medical wastes are considered as a hazardous waste because they contain toxic materials, infectious, or non-infectious wastes and they are considered as a hazard to millions of patients, health care workers, and visitors. Treatment processes for medical wastes comprise autoclaving, microwaving, chemical disinfection, irradiation, plasma system, and incineration. Incineration is a thermal process, which destroys most of the waste including microorganisms. Combustion process must be under controlled conditions to convert wastes containing hazardous materials into mineral residues and gases.

Hospital waste incinerators may emit a number of pollutants depending on the waste being incinerated. These pollutants include particulate matter, acid gases, toxic metals, and toxic organic compounds products of incomplete combustion, e.g., dioxins, furans, and carbon monoxide, as well as sulfur oxides and nitrogen oxides. So, there should be a reduction of emissions of most of these pollutants by air pollution control devices. This study was conducted in 51 medical establishments (ME) in Alexandria. To evaluate its incinerators. It was found that only 31.4% of total ME have their own incinerators to treat their medical waste. Also, the incinerators conditions were poor with incomplete combustion.

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So, the study recommend handling of all medical wastes of ME in Alexandria by the company which is responsible now for management of domestic solid wastes of the city.

**Keywords**: Hospital waste, medical wastes, medical wastes management, medical wastes treatment, incineration.

**INTRODUCTION**

Health care waste management is strongly influenced by cultural, social, and economic circumstances. A well-designed waste management policy, a legislative framework, and plans are essential for handling of medical waste. Medical and research facilities are moving toward the achievement of a healthy and safe environment for employees and communities.\(^{(1-4)}\)

Medical establishments play important roles in different activities by using of modern technology to serve the humans and the environment through different departments in the establishment and its firms.\(^{(5)}\)

Medical establishments include hospitals, clinics, medical centers, private practices, home health care, blood banks, veterinary offices, clinical facilities, research laboratories, clinical laboratories, all unlicensed and licensed medical facilities; \(^{(6-8)}\)

Medical waste is including but not limited to:

- Soiled or blood-soaked bandages.
- Culture dishes and other glassware.
- Discarded surgical instruments as scalpels.
- Discarded surgical gloves.
- Needles used to give shots or draw blood.
- Cultures, stocks, and swabs used to inoculate cultures.
- Removed body organs.
- Lancets, the little blades the doctor pricks finger with to get a drop of blood.(9)
- Radioactive materials such as radioisotopes.(6, 7)

These wastes are considered as a hazardous waste because they contain toxic materials, infectious, or non-infectious wastes and they are considered as a hazard to millions of patients, health care workers, and visitors.(6, 7)

In a truly integrated medical waste management system, there are six functional elements:

1. Waste generation from the sources,
2. Waste handling, separation and storage,
3. Transfer and transport, which involve the transfer of wastes from the smaller collection vehicles into the large transport equipment,
4. Separation; processing; and transportation of solid waste into treatment stations such as incinerators, and
5. Disposal which deals with the disposal of waste directly from sources to landfill site, and the disposal of residual waste from incineration to final disposal.(2)

Treatment processes for biomedical wastes comprise autoclaving, microwaving, chemical disinfection, irradiation, plasma system, and incineration.(10)

Incineration is a thermal process, which destroys most of the waste including microorganisms.(6) Combustion processes must be under controlled conditions to convert wastes containing hazardous materials into mineral residues and gases. The common objectives of waste incineration are volume reduction, removal of volatile; combustible; and destruction of toxic and pathogenic materials under the combustion conditions. These conditions are: adequate free oxygen to be available in the combustion zone, turbulence, proper combustion temperature (900-
1200 °C), a long residence time of the waste gases in a hot oxidizing environment (>2 or 3 seconds), rapid stack gas cooling (to avoid the formation of toxic dioxins and furans), and flue gas cleaning. A suitable site for a hazardous waste incinerator would be a site where the resulting air emissions would not diminish the air quality for the residents of a city or town.

Hospital waste incinerators may emit a number of pollutants depending on the waste being incinerated. These pollutants include particulate matter, acid gases, toxic metals, and toxic organic compounds products of incomplete combustion, e.g., dioxins, furans, and carbon monoxide, as well as sulfur oxides and nitrogen oxides. So, there should be a reduction of emissions of most of these pollutants by air pollution control devices. These emissions such as dioxins and furans cause hazards for human beings.

MATERIAL AND METHODS

This study was conducted from February 2000 till September 2002 in 51 medical establishments (ME) in Alexandria. The field work was divided into the following steps:

Two simple representative random samples were taken, one sample from raw waste and the other from ash after incineration, where the ash sample was divided into 2 sub-samples one for physical and chemical analysis and the other for biological analysis.

The following parameters were determined for each sample according to standard methods:

A) Before incineration:
1- Moisture.
2- pH.

B) After incineration:
1- Total bacterial count.
2- Volatile solids.
3- Heavy metals.

RESULTS AND DISCUSSION

Table (1) shows different handling methods of medical wastes (MW) in the study. It was found that 16 ME (31.4%) had incinerators such as El-Ma’moura Chest Hospital and Gamal Abd El-Nasser Hospital. On the other hand, the medical establishments which had no incinerators were 35(68.6%) such as El-’Agamy General Hospital and El-Qabbarry General Hospital. There is a significant difference ($P < 0.05$) between medical establishments according to the presence of incinerators.

According to the Priminister Executive Decree No. 338/1995, Article No. (38), infectious wastes generated from the hospitals, medical centers,….etc may be treated by incineration within residential areas. So, about 69% of ME do not comply with Environmental low No. 4/1994.

Also, it was found that 12 ME incinerators (23.5%) are functioning such as Gamal Abd El-Nasser Hospital, Medical Research Institute, and Central Blood Bank. On the other hand, the non-functioning incinerators in the medical establishments were 4ME (7.8%). VIZ, El-Shatby both Obstetrics and Pediatrics Hospitals and El-Gomhouria General Hospital.
Table (1) shows also that 29ME (56.9%) transport their wastes to the nearest incinerators such as Ras El-Tin General Hospital, El Qabbary Chest Dispensary, and Sidi Gaber Polyclinic. On the other hand, the disposal of medical wastes in communal containers (1 ME, 2%) was the minority.

Table (2) and figure (1) present the moisture percentage of medical raw samples before incineration, which ranged between 2.33% to 31.89%. Moisture content below 30% is needed for self incineration.\(^{(17,18)}\). All samples comply with this value except one sample.

If the moisture is more than 50%, wastes would require additional fuel to be combusted. In addition, this high moisture % can cause damage to the burners and may cause corrosion to the insulation of the incinerator.\(^{(13)}\)

Table (2) and figure (2) show that pH of raw wastes ranged between 5.02 to 8.62. The pH should range between 6-8.\(^{(19, 20)}\) Almost all the medical raw waste samples comply with this value. However, there are two values, which were beyond this range (5.02 and 8.62).

In this respect, acidity causes corrosion of incinerators’ insulation and causes destruction of the refractory.\(^{(21)}\)

Table (2) presents the bacterial colony count of the ash which ranged as the following:

At 20°C, the colonies ranged between 0 – 570000 Col/Kg.
At 37°C the colonies ranged between 0 – 940000 Col/Kg.

The presence of these colonies is an indication of poor conditions of medical waste incineration. These conditions are temperature, turbulence rate, and residence time. Temperature should range between 700-900°C. Turbulence rate or the degree of mixing between the waste
Table (1): Treatment Methods of Medical Waste According to Medical Establishments.

<table>
<thead>
<tr>
<th>No.</th>
<th>Medical waste treatment</th>
<th>Medical establishments</th>
<th>Hospitals</th>
<th>Medical Centers</th>
<th>Polyclinics</th>
<th>Dispensaries</th>
<th>Blood Banks</th>
<th>Total</th>
<th>Percentages</th>
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<tbody>
<tr>
<td>1</td>
<td>Treatment:</td>
<td></td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>16</td>
<td>31.4</td>
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<td></td>
<td>15</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>16</td>
<td>31.4</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td></td>
<td>15</td>
<td>6</td>
<td>12</td>
<td>2</td>
<td>0</td>
<td>35</td>
<td>68.6</td>
</tr>
<tr>
<td>2</td>
<td>Type of treatment</td>
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<td>0</td>
<td>1</td>
<td>16</td>
<td>31.4</td>
</tr>
<tr>
<td></td>
<td>Incineration</td>
<td></td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>Others</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>According to operation</td>
<td></td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td>33.5</td>
</tr>
<tr>
<td></td>
<td>of incinerator:</td>
<td></td>
<td>4</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>7.8</td>
</tr>
<tr>
<td>4</td>
<td>If no, waste is</td>
<td></td>
<td>12</td>
<td>3</td>
<td>12</td>
<td>2</td>
<td>0</td>
<td>29</td>
<td>56.9</td>
</tr>
<tr>
<td></td>
<td>transported into:</td>
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<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>7.8</td>
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<tr>
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<td>Nearest incinerator</td>
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<td>0</td>
<td>1</td>
<td>2</td>
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<td>Waste collection areas</td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Figure (1): Maximum and Minimum Values of Moisture Percentages of Raw Medical Wastes.
and oxygen in the combustion air was not adequate due to infrequent stirring and/or poor design. In the present study, it was found that the temperature did not reach to the right range needed for complete combustion, and there was no air fan-induced draft in some of the medical incinerators, which led to incomplete combustion. Polycyclic aromatic hydrocarbons (PAHs) and their derivatives are harmful compounds generated by incomplete combustion of organic materials. They cause health problems for animals and humans as they are genotoxic, carcinogenic, and known as they are mutagenic compounds.

Table (2) and figure (3) show that the volatile solids of ash ranged between 0.22 - 3.9 %. The medical wastes ash should not contain more than 1.2 %,(20) and some of the ash samples had more than this percentage, which is related to incomplete combustion.

Table (2) and figures (4 and 5) show that Pb ranged between 0.01 – 474.47 mg/Kg and Cd ranged between 0.01–11.66 mg/Kg. The maximum allowable values of lead and cadmium are 33.97 mg/kg and 4.59 mg/kg, respectively.(22) The effect of heavy metals in the heavily polluted areas cause damage to respiratory system, allergic morbidity, and serious toxicity. (23, 24)

The inhalation of metals has been found to have greater effect on the human body than receiving the same metals by ingestion.(24,25) Exposure to cadmium emission leads to bioaccumulation of cadmium in the human body, and may cause acute disease in humans. This acute effect is very serious and causes hypertension, kidney damage, destruction of testicular tissue, destruction of red blood cells, hypertension, and damage of bones and joints. (25,26)

Lead causes dysfunction in the hematological system and central nervous system, which decreases intelligence and behavior.(2)
Table (2): Some Chemical and Bacteriological Parameters of Raw Medical Waste and Ash.

<table>
<thead>
<tr>
<th>M.E No.</th>
<th>Measurements</th>
<th>Raw</th>
<th>Ash</th>
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<tr>
<td></td>
<td></td>
<td>Moisture</td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20ºC</td>
<td>37ºC</td>
</tr>
<tr>
<td>1</td>
<td>Minimum</td>
<td>8.06</td>
<td>6.64</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>31.89</td>
<td>8.62</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>20.67</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>Standard deviation</td>
<td>9.12</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Minimum</td>
<td>5.5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>22.1</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>13.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standard deviation</td>
<td>11.74</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Minimum</td>
<td>5.54</td>
<td>5.02</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>25</td>
<td>6.53</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>15.56</td>
<td></td>
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<tr>
<td></td>
<td>Standard deviation</td>
<td>8.48</td>
<td></td>
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<tr>
<td>4</td>
<td>Minimum</td>
<td>10.1</td>
<td>6.88</td>
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<td></td>
<td>Maximum</td>
<td>24.46</td>
<td>8.44</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>15.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standard deviation</td>
<td>6.99</td>
<td></td>
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<td>5</td>
<td>Minimum</td>
<td>8.04</td>
<td>7.2</td>
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<tr>
<td></td>
<td>Maximum</td>
<td>22.2</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>13.63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standard deviation</td>
<td>6.05</td>
<td></td>
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</table>
Figure (2): Maximum and Minimum of pH Values of Raw Medical Wastes.

Figure (3): Maximum and Minimum of Volatile Solids Percentages of Medical Wastes ash.
Figure (4): Maximum and Minimum of Lead Concentration (gm/kg) of Medical Wastes Ash.

Figure (5): Maximum and Minimum of Cadmium Concentrations (mg/kg) of Medical Wastes Ash.
This metal is inhaled or ingested and accumulates in the body causing headache, anemia, birth defects, central nervous system damage, damage to kidney, reproductive system, and death. Elevation of blood lead in children (40-60 Ug/dl) causes deficiency of red blood cells (RBC) and anaemia. This anaemia occurs when blood levels of lead increase to 60-120 Ug/100 g of whole blood. Greater than 120 Ug/100g of blood causes acute brain damage.

CONCLUSIONS AND RECOMMENDATIONS

- From the previous results, it is concluded that their medical waste incinerators conditions in the studied medical establishments there are poor and is incomplete combustion of medical waste in all studied incinerators.

- Only 31.4% of total ME have their own incinerators to treat their medical waste.

- Most of the operating incinerators have optimum combustion conditions. The incomplete combustion results in health hazards impacts.

- So, the following is recommended:

  1) Handling of the collection, treatment, and disposal of all medical wastes of ME in Alexandria by the company that is responsible now for management of domestic solid wastes of the city.

  2) Rehabilitation of medical waste incinerators.
REFERENCES


