CONSTRUCTION OF A LOW COST MEDICAL WASTE INCINERATOR

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Abstract:
This project trial reveals a description on how a low cost medical waste incinerator was constructed at The Federal Polytechnic Bida Niger State Nigeria. The medical waste incinerator was made from basic standard size refractory bricks and ordinary building bricks all to a number of about 380 pieces. Other materials used were mild steel angle bar, sheets and pipes. The features of this incinerator model comprised a simple dual compartment burning zones, natural-draught air inlet opening, a chimney, top-loading and ash removal doors. This model was designed to be operated at temperatures of 800°C and higher. The performance of the incinerator varied and depended on the moisture content of the medical waste (load) but a throughput of up to 12kg/hour was achieved.

The foundation was the first part made on the ground. It was made with normal cement aggregate casted on a 3inch foundation trench. The size was 9 inches slightly larger than the incinerator outer wall body all round with a thickness of 150mm (6inches). A standard concrete mix (3:2:1) aggregate of sand, cement and stones were used.

The body of the incinerator was put in place starting with the inner wall, using the fire bricks arranged in line into a three by six bricks matrixes without spacing for mortar. This arrangement was built up to five layers making openings for the position of top loading door access, ash removal door and chimney channels. The outer wall was erected with ordinary building bricks, held in place with cement mortar leaving 5-inches (125mm) air spacing all round the inner wall. The thickness of the fire bricks and that of the outer wall ordinary building bricks, together with the air spacing sufficiently provides resistance to heat loss from the incinerator during operation.

The incinerator top was made of 2.5mm steel sheet, prefabricated in a metal workshop, which had openings for the loading door and stack (chimney). It was put in place as an incinerator top covering leaving opening for top-loading door together with a spigot for the flue stack (chimney).

The stack was fitted over the top of the incinerator and clamped in position by an angle iron frame and angle iron strips fitted to the outer wall.
The loading door, made from angle iron and small piece of sheet metal, was fitted with a door-frame welded to the top plate. Also welded to the top plate were a number of lengths of angle iron that helped to hold down the top plate and form a box around the stack opening.

Air supply channels were pre-fabricated in the metal workshop from 2-inch square pipes cut in lengths of 150mm. This was welded on top of the 220 by 228mm square main frame of the ash door. The air inlet cross-sectional area was designed and measured to be approximately 8200mm².

The medical waste incinerator was tested in the presence some academic staff and technologist of the department of Chemical Engineering of The Federal Polytechnic Bida. Charcoal, kerosene and papers were used to initiate combustion inside the Primary burning chamber. After burning had progressed for about 30mins the load which consisted of mixed medical waste, from the Federal Polytechnic medical Centre was added. The main observations were that for most of the running time there was no visible smoke emission. Hardly did the smoke level exceed that which is considered acceptable as compared with that of a diesel engine electric power generator. However, the temperatures of the burning chamber could not be measured but visuals of flames inside the chamber and that of a clean smoke from chimney indicated that temperatures have exceeding 800°C and complete combustion was experienced.

The flue gas was not smoky and there were no offensive smell being emitted. The open field air current dispersed the flue gas well enough that one could hardly notice the presence of smoke. After ninety minutes of burning the incinerator was allowed to cool and the ash formed was seen to have reduced to one-eighth of its original volume. The ash was dark in colour and the medical waste was completely burned and destroyed beyond recognition.

**Key Words:** Medical waste incinerator, Incinerator model

The main features and procedures through which the incinerator was built are the foundation, the body of the incinerator, the incinerator top, the stack, the loading door and air supply channels.

<table>
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<th>Item</th>
<th>Description</th>
<th>Size</th>
<th>Qty</th>
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<tbody>
<tr>
<td>1</td>
<td>Fire bricks</td>
<td>230 x 116 x 76mm</td>
<td>156pieces</td>
</tr>
<tr>
<td>2</td>
<td>Standard building bricks</td>
<td>230 x 116 x 76mm</td>
<td>220pieces</td>
</tr>
<tr>
<td>3</td>
<td>Cement</td>
<td>75 kg</td>
<td>1½ bag (75kg)</td>
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<tr>
<td>4</td>
<td>Gravel/Granite Stones</td>
<td>250kg (approximate)</td>
<td>6 Head Pan</td>
</tr>
<tr>
<td>5</td>
<td>Sand</td>
<td>200kg (approximate)</td>
<td>8 Head pan 300kg</td>
</tr>
<tr>
<td>6</td>
<td>Fire cement (1300°C +)</td>
<td>25kg</td>
<td>½ bag 25kg</td>
</tr>
<tr>
<td>7</td>
<td>U section (mild steel)</td>
<td>75 x 50 x 3mm meters</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>Rectangular section (mild steel)</td>
<td>75 x 40 x 3mm wall thickness</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>Angle section (mild steel)</td>
<td>50 x 50 x 3mm thick meters</td>
<td>30</td>
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<tr>
<td>10</td>
<td>Water tube (mild steel)</td>
<td>12mm inside diameter meters</td>
<td>3</td>
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<tr>
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</tr>
<tr>
<td>12</td>
<td>Flat sheet (mild steel)</td>
<td>2400 x 1200 x 1.2mm sheets</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>Washers</td>
<td>8mm diameter 24</td>
<td>NA</td>
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</table>
Note:
- The fire bricks and standard bricks should be the same size if possible,
- It is not necessary for the steel section to be exactly the size as stated for example angle iron 50 x 50 x 3mm would be an alternative for 40 x 40 x 3mm.

Introduction:

The medical waste incinerator is a simple two-chamber natural-draught incinerator designed to be operated at temperatures of 800°C and higher. The performance of the incinerator will vary depending on the moisture content of the medical waste but a throughput of up to 12kg/hour can be achieved. The incinerator has been designed so that it can be built on site, using standard building bricks or blocks and lined with refractory bricks. All the steel components, such
as the loading door, the ash removal door and air inlet apertures can be made using basic workshop equipment.

Wood and dry waste soaked in kerosene or diesel is required initially to start the combustion process. Once the correct temperature is reached, the medical waste is loaded into the incinerator. Much of the medical waste will have value as a fuel and will contribute towards combustion but additional wood or kerosene may be required to ensure that adequate combustion temperatures are maintained.

The initial combustion occurs in the primary chamber and then the hot gases pass into the secondary chamber where the combustion process is completed. The two-chamber design helps to ensure that the combustion time is sufficient to destroy the products of combustion and minimize any harmful emissions.

The incinerator should be situated under a simple open-sided roofed structure, such as a lean-to, away from tall buildings and in an area free from air turbulence. Although it can be operated in the open, a roof will help to protect the incinerator from rain and provides shelter for the operator.

The incinerator is capable of incinerating most types of medical waste including textiles, plastics and packaging. It can also incinerate most types of drugs, medicines, vaccines and sharps, as long as they are mixed with other wastes. However, grease-based products, such as ointments, creams and vaseline create large quantities of dense black smoke when burned, they are best disposed of by other means.

It was also evident that environmental, legal and economic considerations were part of the design parameter.

**Background theory survey/literature**

Incinerator is designed to retain a suitable interior temperature of the combustion chambers. To this end, suitable materials are used for the inside wall of incinerator. The material should have high resistance to heat flow and should be able to withstand high temperatures of 800°C temperature and higher. Sometimes the incinerator burning chamber temperature may be instrumented with suitable temperature controls to operate same. Clay materials made and fired into refractory bricks (fire bricks) are one of best materials suitable as lining for inside incinerator walls.

From basic principle, the conduction heat flow through a homogeneous medium, the rate of heat transfer is

\[ Q = -kA \frac{dt}{dx} \]
For a plane wall of thickness \( \delta \) (in the direction of \( dx \)), conductivity \( k \) and area \( A \), with thermal resistance \( R_t \) and temperature gradient \( dt \), the thermal resistance again may be expressed as

\[
R_t = \frac{\delta}{kA}
\]

Since fire brick is poor conductor of heat i.e. (high thermal resistance), the heat transfer rate can be expressed again as

\[
Q = -\frac{\delta}{R_t} \frac{dt}{dx}
\]

The interior of the incinerator retains heat at a temperature of 800\(^0\)C and above by means of adding the combustible materials. In addition, the entire wall thickness of 348mm helps support the maintenance of the inside temperature at 800\(^0\)C and outside at ambient temperature.

![Temperature curve](Fig 1.1)

Thermal resistivity experiments indicate that sufficient wall thickness and good materials with high thermal resistance are best suitable for incinerator design applications. Clay material made into fire bricks thermal conductivity of 1.06W/m\(^0\)K as well as air space with thermal conductivity of 0.0515W/m\(^0\)K was applied in the design and construction of the medical waste incinerator owing to their properties as poor thermal conductors. The fig 1.3 shows how temperature is lowered across wall thickness from inside wall of fire brick towards outside wall of bricks.

The heat energy requirement for incinerator operation entirely depends on the combustion process. Combustion dictionary definition has it as chemical reaction of two or more substances with a characteristic liberation of heat and light; which is commonly called burning. The burning of a fuel (e.g., wood, coal, oil, or natural gas) in air is a familiar example of combustion. Not all combustion involves oxygen; e.g., hydrogen burns in chlorine to form hydrogen chloride with the liberation of heat and light characteristic of combustion. Combustion reactions involve oxidation and reduction.
Before a substance will burn, it must be heated to its ignition point, or kindling temperature. Pure substances have characteristic ignition points. Although the ignition point of a substance is essentially constant, the time needed for burning to begin depends on such factors as the form of the substance and the amount of oxygen in the air.

The application of combustion principle is either internal or external. External combustion application is found in incinerators. Other examples are burner furnaces, boiler heaters while internal applications are found in car engines, jet plane engines, power generators etc.

To start combustion for the incinerator, it is first loaded with solid dry combustible material such as papers and charcoal and wood which is still supported by kerosene or petrol to quickly start the burning. The vapors of a volatile fuel such as gasoline are more readily ignited than is the fuel itself. The rate of combustion is also affected by these factors, particularly by the amount of oxygen in the air. The design of the incinerator has air inlet holes which freely allow flow of air into the burning chamber. Also accommodated in the design is the area of air hole channels. The air aperture size is more than enough to feed the material for effective combustion. Extra heat source (Fire) from a match stick is usually needed to start the burning

\[
\text{Hydrocarbon} + O_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{HEAT}
\]

In normal operation, sufficient oxygen is served by natural induction through the air apertures where it meets with fuel and heat so that a complete combustion is experienced in the primary and secondary chambers. Oxygen starvation often leads to partial combustion of the carbon to CO rather than CO\(_2\}: \text{ Hydrogen will normally burn to } \text{H}_2\text{O}. \text{ Secondary combustion will take place if the CO and other intermediate products meet with oxygen or non-depleted air at a sufficiently high temperature for gaseous combustion to } \text{CO}_2 \text{ to take place.}

In an open fire, this secondary combustion can be observed as “flames” immediately above the burning material, as fresh air is drawn in to the zone by convection.

Since combustion effectiveness is also a function of gas residence time (defined as the ratio of total combustion chamber volume to gas volume flow), it is important that the air volume flow is not too great, otherwise the incinerator dimensions would need to be increased with consequent cost penalties.
Introduction: The following construction notes should be used in conjunction with the main drawing of the incinerator (see appendix 1). The construction procedure described are based on experience gained during the design and development of the prototype in the UK and the building.

Although these notes describe proven techniques for the successful construction of the incinerator, it should not be assumed that this is the only way of building one. Minor modifications to material sizes, types or specification may be required to suit local conditions. With the exception of the refractory bricks, all the other materials specified in the materials.

The common building bricks used for the outer wall could be replaced with cement blocks (as in Zimbabwe) or blocks, or where an angle iron of 50 x 50 x 3mm is specified, 40 x 40 x 3 could be used instead.

The actual size of the incinerator is dependent on the size of the bricks used and because the standard size of brick can be different from country to country – and even from region to region - slight differences in size of the incinerator may be expected. These variations should not affect the performance of the incinerator.

General Description of Construction

The incinerator – is a simple construction using firebricks, standard building bricks and steel (angle, sheet and tubing). It consists of two chambers - the primary combustion chamber (load chamber) and the secondary chamber (flue).

They are built from firebricks and are located within an outer wall constructed from standard building bricks. An air gap, approximately the width of one standard building brick, separates the chambers from the outer wall. A top plate, made from sheet steel, has openings in it for the loading door and stack (chimney) fittings.

Chimney: The stack is fitted over the top of the incinerator and clamped in position by an angle iron frame and angle iron strips fitted to the outer wall. The loading door, made from either channel-section or angle iron, fits within a door-frame welded to the top plate. The door frame is then filled with sand to form a seal.

Also welded to the top plate are a number of lengths of angle iron that help to stiffen the top plate and form a box around the stack opening. The stack, which is made from sheet steel, fits over a spigot-plate and is supported by a simple angle iron frame bolted to the top-plate clamping frame.

Foundation: The foundations should be slightly larger than the incinerator and a guide to the actual size can be gained from laying out a course of standard bricks - six long and four wide - to represent the outer wall of the incinerator. A gap should be left between each brick to allow for the
thickness of the mortar. The length and width should be measured and then the foundations should be built one brick wider all round and 75mm deep. A standard concrete mix (3:2:1) of ballast, sand and cement should be used (see Figure 1).

**Combustion Chamber:** The combustion chamber is constructed from firebricks, without any mortar, and is clamped together to provide strength and reduce the possibility of bricks being pushed out of alignment during incineration. A standard fire brick approximately 225 x 116 x 76mm (9 x 4.5 x 3 inches) and capable of withstanding temperatures of at least 1300°C should be used. The combustion chamber is four (4) bricks long by two (2) bricks wide and eight(8) courses high (see drawing). The incinerator height can go up more to 13 or 17 courses. But the larger the chamber space the more heat requirements would be and the more chances the inner wall layer may go out of alignment. The first course forms the floor of the combustion chamber while the other seven form the walls. Particular care should be taken to ensure that the front opening and the channel between the combustion chamber and the flue outlet are built correctly.

**As Door:** The ash door and air inlet tubes must fit in the front opening. These are sealed into position using fire cement (or fire clay) during the building of the outer wall.

**Clamp frame:** The clamp frame consists of four angle iron uprights bolted together using a number of horizontal tie bars. The uprights should be slightly shorter than the outside height of the combustion chamber. The tie bars can be made in a number of ways to suit locally available materials and workshop facilities. One method is to make tie bars from angle iron with one end welded horizontally to an upright and a short length of 12mm steel pipe welded to the other end. The opposite upright has short lengths of steel pipe welded to it in alignment with those welded to the tie bars. The clamp frame can then be fitted to the combustion

**Air Aperture:** The air inlet can be made from square, rectangular or round steel pipe. The air inlet cross-sectional area should be approximately 8800mm². The inlet can be made from pipe or tube, or from a number of smaller tubes welded together. Using standard bricks and mortar build up the outer wall until it is level with, or slightly higher (5mm maximum) than the top of the combustion chamber.

It is important that there is an air gap between the combustion chamber wall and the outer wall. This gap provides insulation between the inner and outer walls, so ensuring that the outer wall never becomes too hot. It should be approximately the width of one standard brick all round. While building up the outer wall, the ash door and air inlet tubes should be fitted. Where they pass into the combustion chamber they should be fixed in position using fire cement. Where they are located in the outer wall, the ash door and air tubes should be fixed using ordinary mortar.
The air tubes should be long enough to be flush with the brickwork in the outer wall and should only protrude slightly into the combustion chamber.

*Top frame:* The top frame clamps the top plate in position. It is made from angle iron with 2.5mm sheet steel plates welded across the corners to provide increased strength. Six vertical hangers are welded to the frame, two on each of the longer sides and one on each of the shorter sides. These hangers are bolted to an angle iron rail which is fixed to the side of the outer wall using screws and wall plugs.

The top plate is made from sheet steel and has the loading-door frame welded to it, along with a number of lengths of angle iron forming a frame for the stack spigot-plate. These also provide stiffening for the top plate. The top plate itself should be cut slightly smaller than the outer wall (approximately 10mm all around) with two cut outs corresponding to, and slightly larger (again 10mm all around) than, the openings into the combustion chamber.

The top plate should be bedded onto a thin layer of fire cement on the inner chamber and ordinary cement on the outer wall, sufficient cement being used to ensure good sealing all round. The plate should then be clamped in position using the top framework described above

*Loading door frame:* The loading-door is made from channel section and should be fully welded to the top plate. The frame should be made larger than the opening in the top plate so that it can be fully welded on the inside and outside edges. The flue exit-frame is constructed from angle iron and fully welded to the top plate on the outside only. The stack spigot will fit inside the box and should be clamped in position using two lengths of angle iron bolted to the box. This enables the spigot plate to be removed and replaced as necessary.

*Loading door:* The loading door is made from channel-section frame), such that its outside edges fit inside the loading door-frame. It is covered with a fully-welded sheet steel plate. Two angle-iron hinge support brackets are welded on top of the door. A baffle plate is suspended beneath the door so that it hangs into the combustion chamber by approximately 100mm when the door is closed. This baffle plate will help prevent the door and door handle becoming too hot during operation. The sheet steel cover should be welded in position on top of the door. The door should be hinged at the front end or side of the incinerator so that it opens towards the operator. This provides protection to the operator in case blow-back occurs when air enters the combustion chamber through the open loading door.

The hinge is made from a short length of steel pipe welded to the underside of each of the support brackets and two more pieces welded to the loading door frame. A length of steel bar is used as the hinge pivot bar. The door handle can be made from steel bar and welded in position once the door has been fitted.
Stack: The stack has 150mm (6-inches) inside diameter and stands at 4m high. It can be made from rolled sheet steel or from a piece of steel or cast iron pipe. If it is being made from sheet steel, the stack can be constructed in sections to suit the capacity of the rolling machine and/or the size of sheet being used. The sections can then be welded together using either a collar welded to one end of each section or bolted flanges. Regardless of the techniques used to make the stack, it is useful to have a removable bottom section of about 1m long.

The stack is positioned over the spigot, on the spigot plate and clamped into the stack box. A simple support frame is required to hold the stack in place. This can be constructed from angle iron. A rain cap should be fitted on top of the stack and a steel-mesh guard (approximately 1m high) placed around the stack to prevent people from touching it as it heats up. The flue-exit frame should then be filled with sand of fire cement which provides an effective gas seal.

Grate: A simple ash grate can be made from angle iron or steel bar or a mixture of both. The grate should be long enough to extend across the whole of the combustion chamber and it should be easy to remove either through the ash door or the loading door.

Fuel tank: This is an optional facility. A fuel tank with a capacity of between 2 and 5 litres should be fitted to the front of the incinerator. A tank from a pressure kerosene stove is most suitable because it enables the kerosene to be added under pressure. If none is available, then the tank should be placed approximately 0.5m above the top of the incinerator to provide a head of fuel. The feed pipe enters the incinerator combustion chamber at one brick course below the top and should be sealed in position using fire cement. The tank should be fitted with an open/close valve or tap to control the flow of kerosene.

Painting: To prolong the life of the entire metal surfaces of the incinerator, application of gloss painting would be required which would help prohibit the growth of corrosion.

Operating the incinerator

Please read the following safety notes carefully:

- When opening the loading door always wear eye protection and a face mask.
- Opening the loading door on either the wood or kerosene fired version during operation will mean that additional air will enter the combustion chamber. This may cause blow-back to occur and the flame to flare up out of the loading door. The blow-back does not last long but it could cause injury to anyone standing too close to the incinerator.
- Particular care should be taken when using kerosene as atomized vaporized fuel may be present at the top of the combustion chamber which could ignite vigorously.
• Care should ensure that door normally opens towards the operator. This provides the operator with some protection from any blow-back and keeps him/her away from the opening to the combustion chamber.

• The operator should wait a few moments to allow any blow-back to die down before loading waste materials into the incinerator.

• Some waste materials such as ampoules and glass bottles containing liquid vaccines and medicines may explode during incineration causing glass and other waste materials to be blown into the atmosphere. The operator should ensure that eye protection and a facemask is worn when opening the loading door or when visually checking the combustion process through the air inlet or when removing the ash door while the incinerator is in use.

Handling waste

• Always wear heavy-duty gloves and apron while handling medical waste. If the waste is bagged hold the bag by the top and away from your body. Drop the bag through the loading door opening and if it gets stuck use a stick to push the bag into the combustion chamber.

• If the waste is loose, use a shovel to load it into the combustion chamber.

Removing ash and other solids from the combustion chamber

• Never handle the ash or other waste materials by hand. Use a stick or scraper to pull the solids out through the ash door and into a dustpan or box.

• Do not remove the ash or other waste materials from the combustion chamber until they have cooled down. This will take about five hours. If the incinerator is in operation on a daily basis then the ashes and other waste material can be removed the following day as part of the preparation for operation.

• Dispose of the ash and other waste materials carefully by burying or placing in a skip for disposal by local authority.

General operating notes

The following notes are intended to give the operator a basic understanding of how to operate the incinerator. Optimum operation of this incinerator requires frequent attention to ensure that it performs effectively. It will take time for the operator to become familiar with the operation.

Waste Management.
Materials with high fuel values such as plastics, paper, card and dry textile will help maintain high incineration temperature. If possible a good mix of waste materials should be added with each batch. This can best be achieved by having the various types of waste material loaded into separate bags at source i.e. the wards and laboratories, and clearly labelled. It is not recommended that the operator sorts and then mixes the waste prior to incineration as this is potentially hazardous.

The operator can then judge when to place which type of waste into the incinerator at any particular time. If possible some plastic materials should be added with each batch of waste as this burns at high temperatures. However, care and judgment will be needed as too much plastic will create dense dark smoke. Wet kitchen waste should not be placed in the incinerator.

*Operating temperatures*

The incinerator does not have a temperature gauge and so adequate operating temperatures have to be judged by the operator based on experience. A visual guide is to look through the air inlet and at the colour of the smoke from the stack. If a good strong flame can be seen then the temperature should be more than 800°C at this point and so will be adequate for good incineration. If the smoke is dark grey or black then poor combustion is occurring and the temperature will be below that required.

*Starting and Operating the /Charcoal/Wood Fuelled incinerator*

- Open the loading door and ash door and remove any ash or other materials from the fire box, ensuring that the grate is clean and the entrance to the flue is not blocked.
- Before lighting the incinerator, prepare the charcoal or fire wood, ensuring that it is dry and chopped or cut into short lengths (that fit horizontally through the loading door) and not more than 75 mm (3”) in section. Place paper on the grate and cover with dry kindling and small pieces of wood and/or dry textiles.
- Light the paper through the ash door and NOT through the loading door. (This prevents the operator being burnt if paper and kindling material flare up unexpectedly).
- Once the fire is established and burning well, start adding the fire wood in small amounts.
- The loading door can be closed after about 5 minutes from lighting and once the fire is being drawn from the primary combustion chamber into the secondary chamber and up the stack.
- The ash door can be closed once the fire is well established. A well established fire will roar and will be audible through the air inlet tubes. Practice will enable the operator to judge when the fire is established.
- Fire wood and/or dry waste is added at intervals until the incinerator is operating at the right temperature. The operating temperature will be achieved between half and one hour from
lighting, depending on the ambient temperature, moisture content of the wood and the type of wood being used (i.e. hard, soft etc.)

- Once up to operating temperature, start to add the general waste material on small batches at regular intervals. The level of material in the incinerator should be such that the incinerator is always above half full.
- If the waste is predominately unwanted drugs, straw or wood may be placed in the incinerator before the drugs to hold the boxes in position for a longer period in order to prevent pills falling through the incinerator without burning.
- Sharps, including hypodermics, should be mixed with other waste to prevent them falling through the incinerator without being destroyed.
- If the waste material has a high moisture content or has a low fuel value, wood can be added to help maintain the correct operating temperature.
- The grate and flue entry should be checked every 15 minutes and raked clear of any obstruction. This is to ensure that the airways are kept clear.
- At the end of the operating session and all the waste has been placed in the incinerator, add more wood to ensure that any waste residue has been completely burned.

Results and discussion

The Federal Polytechnic Bida low cost Medical Waste Incinerator was described and constructed as a trial unit following the instructions of the original author and other supervising School Staff.

Essentially, the project fulfilled its primary objective very satisfactorily in that it successfully destroyed medical waste rendering it useless as well as reducing large quantities of general hospital waste by 80% of its original volume to ash at 800°C and above. The weight and volume loss is accounted for and seen as smoke from stack. As the sharps boxes burned, syringes could and did, drop to the floor of the incinerator.

When the incinerator reached a steady state burning temperature of 800°C, about 10 to 12kg/hr of medical waste was the achievable throughput.

The fuel consumption has proved to be almost zero. Users of the incinerator have seen several good reasons to build one; it is cheap to build, it uses locally available materials and labour thus saving hard currency does not require electricity to operate, it is easy to use and it requires small land space and can be operated in the rain.

It has however been criticized for the production of high levels of smoke but it not always the case.
The incinerator was tested by Nwadukwe C.J. and Oyawuye O. S of The Polytechnic Bida in the presence of supervising academic staff, technologist and the head of department of Chemical Engineering Bida, Niger state Nigeria, West Africa, in April 2001.

The main observations were that for most of the running time there was no visible smoke emission. Hardly did the smoke level exceed that which is considered acceptable as may be compared with that of a diesel engine electric power generator. However, the temperatures of the burning chamber could not be measured but visuals of flames inside the chamber and that of a clear smoking chimney indicated that temperatures have exceeding 800°C.

Emissions and destruction efficiencies were observed, and the principal findings were that the medical waste materials were rendered non-infectious, the syringes were destroyed and the needles were rendered unsuitable for use.

The material cost and labour cost for this type of low cost medical waste incinerator ranges between N200,000 and N280,000. It can be built by two to four persons within 5 to 8 days with all the materials on ground.

The common practices of medical waste disposal which include open fires, open pit with occasional burning, shallow burial, storage – but no treatment, open drum-incineration, disposal with general waste, dumping in isolated areas, throwing into a river or re-cycling without sterilization etc. All these practices are undesirable and need redress and practical campaign by appropriate authorities.

Human and Resource Problems Encountered

1. Lack of awareness of any problem and the need for adequate incineration of medical waste.
2. Difficulty in sorting out waste in the order of most combustible matter to least combustible matter.
3. Lack of knowledge of dangers posed by in appropriate disposal of medical waste.
4. Lack of resources at many rural hospitals i.e. very little money and few skilled people available.
5. In Nigeria we have inappropriate legislation and weak enforcement of environmental laws by Environmental agencies concerned.
6. Operators are often not trained to use the incinerator properly.
7. Operators are often not allowed the time to operate the incinerator properly.
8. Wrong location for incinerator equipment (too near to hospital wards or housing).
Conclusion:

The sole purpose of this paper is to describe briefly how a low cost medical waste incinerator was made using readily affordable available resources.

The medical waste incinerator was built on site with basically fire bricks, building bricks, fire cement and other metallic parts and fittings. See appendix below. In as much as it is desired that medical waste be incinerated, not all hospital can afford sophisticated incinerators. It is therefore advisable that a low cost medical incinerator like the one described here be put into consideration other than using other inadequate disposal means and let our health exposed to danger of infection.

More complete combustion could be achieved in a more sophisticated incinerator, but its price and power supply demands would then put it beyond the reach of the hospitals and clinics that need it.

It is the responsibility of those environmental protection Agencies to find and adopt lasting solutions that would be acceptable and economically possible.

The performance test carried out here were mere physical observations only. For example the temperatures of the burning chamber could not be measured but visuals of flames inside the chamber, absent offensive smell and that of a clean smoke of chimney indicated that temperatures have exceeding 800°C and with complete combustion.

The operating instructions for the incinerator need to be clarified to explain the differences between burning general medical waste for which it was designed, and for a load consisting of very wet or house hold waste which is meant to be disposed separately.

Operation manual should be studied and all safety procedures described be followed.

The medical waste incinerator unit described here is recommended for small scale hospitals, clinics, medical lab or any type of health centre with hospital bed capacity of 9 to 45 beds. More units may be needed for hospitals with larger capacity.

Research has shown the common practices of medical waste disposal include open fires, open pit with occasional burning, shallow burial, storage – but no treatment, open drum-incineration, disposal with general waste, dumping in isolated areas, throwing into a river or recycling without sterilization. All these practices are undesirable and need redress and practical campaign by appropriate authorities.

Improvements on design can be made in various ways: such the size of Incinerator through changing the dimensions of the building bricks; connecting thermocouple lines along with digital monitors for temperature readings; building the incinerator on a cart to make it mobile model;
connecting gas burner nozzles that can be used to initiate burning and to raise temperatures; use of induced air circulation to enhance burning efficiency and smoke reduction. However, one must note the cost implication of sophisticated of incinerators as it may be not easily affordable

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