Medical Waste
Issues, Practices and Policy
An Indian and International Perspective

by
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Srishti

for the
Seminar on Health and the Environment
Centre for Science and Environment
July 6-9th, 1998, New Delhi
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<th>Page No:</th>
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<td>Mumbai</td>
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1.0 Background:

The evolution of a separate category of medical waste within the municipal waste stream dates back to the late 1970s, when medical wastes including syringes and bandages were washed up on US east coast beaches. The public outcry which followed led to the formulation of the US Medical Waste Tracking Act (MWTA) which finally came into force on November 1, 1988. Much of the outcry ignored the specifics of medical waste, its small quantities and its nature. (see section 2.0)

The first solutions adopted to solve this problem were to install on-site, small and unregulated medical waste incinerators in health care facilities. More than 6500 of these were installed in the US alone in less than a decade. In many ways this only aggravated the problem, since there was a belief that the problem was solved. Just burn it and it disappeared. But not quite. As later research showed, not only were these small burners created more polluting, and in fact extremely toxic chemicals than the risks posed by medical waste itself, but they also provided a license to create more and more waste, much of it disposable plastic, since it could all be easily burned (see section 4.0). Besides, the end-of-pipe solution did not even address itself to the crucial question of worker safety since nurses and wardboys continued to suffer needle stick injuries, which using the sharp or disposing them improperly. (see section 3.0).

Medical waste was put out of sight, but in many ways its dangers increased. Despite the Medical Waste Tracking Act, syringes continued to be washed up on US beaches, in fact in larger numbers. Incineration was suddenly not as magical as it had been posed to be. The community was crying for changing the practice of medical waste disposal.

In many senses new findings of dioxins (see section 5.0) catalysed this change. A 1994 report of the USEPA, published as a draft on dioxin reassessment, put medical waste incineration as the primarily source of dioxins in the US. Health concerns about this class of super toxins, which were increasingly found to be potent in extremely small, almost undetectable doses, and its connection to incineration led to USEPA’s first dioxin reassessment, which was released as a draft report. It stated that over 60% of the total TEQ load of dioxins in the US was from medical

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1 TEQ, which stands for toxic equivalent is a term to define the relative toxicity of a chemical with relation to 2,3,7,8 TCDD, which is the most potent of dioxins.
waste incinerators. When this finding was finally reflected in the US medical waste incinerators standards, released much later in September 15th 1997, the EPA document predicted that 93 to 100 percent of small incinerators, burning about 200 kg of medical waste per hour, would shut down, since it would be too expensive to retrofit them. This was the final nail in the coffin for medical waste incinerators, which over the years had seen a rapid decrease in market shares, as hospitals opted for alternative technologies and approaches (see sections 6.0 and 7.0). Many large medical waste incinerator companies started switching over to cleaner technologies. Such moves were not limited to the US. In Europe, Germany banned such burning, as did Austria and Belgium. France stiffened its dioxin regulations greatly and monitors them very closely. World-wide the small incinerator industry became redundant, and started to find markets in developing countries, where regulation was more relaxed, and dioxin too expensive to monitor.

In India, concern for medical waste was an outcome of judicial and NGO responses. Though as early as April 1995, the Government of India has issued a draft rule on the subject, yet it was, till finally notified not law. The 1995 rule itself had ignored all international findings and had in fact recommended on-site incineration as the way to go. Fortunately, Indian NGO’s such as Srishti, who had been following clean technologies world-wide and were well aware of the issues as well as its health and economic ramifications, intervened and were able to influence public policy and public opinion to help India leapfrog over the mistakes of the west.

Practices in medical waste managemnt in India need a lot of improvement, and not enough is being done. Currently the issuance of a tender by the Government of the NCT of Delhi to procure seven waste autoclaves shows the move towards cleaner technologies and is a far cry from its 1996 direction to all hospitals to install incinerators or close shop. Also the national rules which will govern medial waste disposal country-wide are due of final notification and these allow for cleaner technologies. As should be, public opinion, supported by NGOs campaigning and providing credible information, is leading the debate. However there continues to be a strong push by incinerator companies world-wide to open new markets in India. Similar trends can be observed in other South Asian and South East Asian countries.

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2 USEPA. “Estimating Exposure to Dioxin-Like Compounds”. 1994
Much ground work needs to be done next. (see section 11.0). Capacity building in the health care sector, training and awareness, involvement of all agencies such as the Ministry of health and the state health departments, the WHO, and better enforcement of regulation with greater polluter accountability have to be addressed. These are especially of importance to countries such as India where the health care sector has to cope with a resource crunch and poor quality health care. In fact, solutions to the medical waste management will need careful and precise interventions

2.0 Defining Medical Waste

Very broadly medical waste is defined as "any solid or liquid waste that is generated in the diagnosis, treatment or immunisation of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals."4

Definitions of medical waste have evolved with a view to aid in regulating it. Given the fact that the medical waste stream is an extremely complex one, and which includes chemicals which could be hazardous, as also normal kitchen or office waste which are akin to municipal solid waste, the definition of regulated medical waste becomes important. Broadly medical wastes include all types of wastes produced by hospitals, clinics, doctors' offices and other medical and research facilities, these wastes include infectious, hazardous, radioactive and other general wastes.

While a term like 'hospital waste' would encompass all wastes which emanate from a health care facility, 'medical waste' can be generated in small clinics or outfits without kitchens or offices. The definition used must also keep in mind that only a small portion of the total hospital waste is infection, which could range from 10 to 25%. No matter which definition is used, it should enable an identification of infectious or potentially infectious waste in any health related waste stream. Over time various narrower descriptions have been used in various regulations around the world.

In India, the term used for regulated medical waste is 'bio-medical wastes,' and the rules pertaining to them are named accordingly. The definition is identical to that of medical waste above.

________________________
4 Ibid
2.1 Quantity of Medical Waste

Hospital waste is a small fraction of urban municipal waste. Estimates of it can be made from the number of beds in any city and an average amount of waste created per bed. The range varies widely depending on the per bed waste generation and the method of estimation used. In India, normally 1 to 2 kg of waste per bed have been measured. For example, in a city like Delhi, with about 40,000 beds, this translates to 60 mt per day. There have been various estimates for developing countries, including India. However, estimates range from 1.00 to 4.5 kg per bed per day.

Some of these are estimates are:

**World Bank**

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Solid Waste</th>
<th>Medical Waste</th>
<th>Infectious</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mumbai</td>
<td>5,000</td>
<td>75.0</td>
<td>37.5</td>
</tr>
<tr>
<td>Delhi</td>
<td>4,600</td>
<td>69.0</td>
<td>34.5</td>
</tr>
<tr>
<td>Chennai</td>
<td>3,500</td>
<td>52.5</td>
<td>26.3</td>
</tr>
<tr>
<td>Total</td>
<td>13,100</td>
<td>196.5</td>
<td>98.3</td>
</tr>
</tbody>
</table>

Note: “The 50% contamination estimate used in this exercise was based on discussions with hospital authorities and observation of disposal from twelve government, municipal and private hospitals.” (This is probably an overestimate - author’s note)

**As per WHO, figures for Latin America are**:

<table>
<thead>
<tr>
<th>Country</th>
<th>Year of Study</th>
<th>Generation (kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Median</td>
</tr>
<tr>
<td>Chile</td>
<td>1973</td>
<td>0.97</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1976</td>
<td>2.56</td>
</tr>
<tr>
<td>Brazil</td>
<td>1978</td>
<td>1.20</td>
</tr>
<tr>
<td>Argentina</td>
<td>1982</td>
<td>0.82</td>
</tr>
<tr>
<td>Peru</td>
<td>1987</td>
<td>1.60</td>
</tr>
<tr>
<td>Argentina</td>
<td>1988</td>
<td>1.85</td>
</tr>
<tr>
<td>Paraguay</td>
<td>1989</td>
<td>3.0</td>
</tr>
</tbody>
</table>

In a country like the US, almost 6670 tons of hospital waste is generated per day, or about 1% of the 158 mt of municipal solid waste produced annually.

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5 India’s Environment, Taking Stock of Plans, Programs and Priorities, South Asia Regional Office, January 1996
It is important to keep in mind that the above figures do not include wastes from non-hospital and private health care facilities. The waste created here could be as significant as “...about 2 million diabetics who generate insulin-type syringes and about 1.2 million interveneous drug users nation-wide (US) who generate over 1 billion insulin type syringes, but are not regulated.”

A Response from Pakistan:
According to a study carried out in Karachi, Pakistan, the situation there mirrors that of other developing countries, including India. The hospital study, produced 427 kg of waste per bed annually or less than 1.5 kg per day. About 20% of the waste was found to be potentially infectious or hazardous.

Responses of some South East Asian Countries:

<table>
<thead>
<tr>
<th>SN</th>
<th>Country</th>
<th>Medical Facilities/ Medical Waste (Mtd)</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Taiwan</td>
<td>50 mtd</td>
<td>40 nos. incinerators</td>
</tr>
<tr>
<td>02</td>
<td>Indonesia</td>
<td>113,000 beds in 982 hospitals 340 Mtd</td>
<td>Legislates that all hospitals install on-site incinerator</td>
</tr>
<tr>
<td>03</td>
<td>Hong Kong</td>
<td>NA</td>
<td>Centralised Incinerator Guidelines by the Hong Kong Medical Association</td>
</tr>
<tr>
<td>04</td>
<td>Japan</td>
<td>NA</td>
<td>Waste Disposal Law, 1970</td>
</tr>
<tr>
<td>05</td>
<td>Malaysia</td>
<td>20% of Municipal Waste</td>
<td>Ministry of Health Guidelines. Centralised or on-site facilities</td>
</tr>
<tr>
<td>06</td>
<td>Philippines</td>
<td>77mt in Metro Manila</td>
<td>No specific law, part of licensing of hospital by Department of Health. 5 on-site incinerators in Metro Manila</td>
</tr>
<tr>
<td>07</td>
<td>Singapore</td>
<td>NA</td>
<td>Guidelines issued by the Singapore Medical Association with the assistance of the Ministry of Environment, Quarantine and Epidemiology,</td>
</tr>
</tbody>
</table>

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8 ibid
9 Hospital Waste Management, SCOPE, Environmental Management Research and Information Centre, B-130 Block 13 D/@, Gulsiran-e-Iqbal, Karachi - 75300 (Pakistan)
2.2 Nature of Medical Waste:
There seems to be a greater consensus on how much of the waste generated is actually infectious or hazardous. WHO states that “…85% (of hospital wastes) are actually non-hazardous, around 10% are infectious wastes, and around 5% are non-infectious but hazardous wastes. In the US for example, about 15% of hospital waste is regulated as infectious waste. In India this could range from 15 to 35% depending on the total amount of waste generated.

As per data collected by Srishti in a waste audit in a 40 bedded hospital

<table>
<thead>
<tr>
<th>S.No</th>
<th>Infectious waste (in kg)</th>
<th>Percentage of infectious waste</th>
<th>Plastic waste (in kg)</th>
<th>percentage of plastic waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.350</td>
<td>9.5%</td>
<td>0.450</td>
<td>3.1%</td>
</tr>
<tr>
<td>2.</td>
<td>2.250</td>
<td>16.85%</td>
<td>3.30</td>
<td>24.7</td>
</tr>
<tr>
<td>3.</td>
<td>3.550</td>
<td>22.4%</td>
<td>2.5</td>
<td>15.8%</td>
</tr>
<tr>
<td>4.</td>
<td>3.95</td>
<td>27.7%</td>
<td>3.0</td>
<td>21%</td>
</tr>
<tr>
<td>5.</td>
<td>3.050</td>
<td>23.19%</td>
<td>2.250</td>
<td>17%</td>
</tr>
<tr>
<td>6.</td>
<td>1.300</td>
<td>8.7%</td>
<td>3.30</td>
<td>22.2%</td>
</tr>
<tr>
<td>Average</td>
<td><strong>15.45</strong></td>
<td><strong>18.05%</strong></td>
<td><strong>14.8</strong></td>
<td><strong>17.3%</strong></td>
</tr>
</tbody>
</table>

Total percentage of waste which is infectious in nature including plastic waste is 35.5%

Categorisation
It has been well established that an extremely important aspect of managing the medical waste stream is its categorisation of the types of waste. The number and types of categories directly relates to the system that will eventually manage them. The World Health Organisation (WHO), has classified medical waste into eight categories:
1. general waste
2. pathological waste
3. radioactive waste
4. chemical waste
5. infectious waste and potentially infectious waste
6. sharps
7. pharmaceutical waste and
8. pressurised containers

10 Op. cit 10
The US has five classifications instead of eight, to limit the number of separate waste collection and storage channels that must be set up within a medical establishment. For developing counties WHO has recommended that hospitals use a simplified classification for practical purposes. This includes,
1. general non-hazardous wastes
2. sharps
3. chemical and pharmaceutical wastes
4. Infectious wastes
5. Other hazardous medical wastes

3.0 Risks associated with Infectious wastes:

Infected hospital waste can transmit diseases, especially if it finds portals of entry. "There is strong epidemiological evidence from Canada, Japan and the USA, that the main concern of infectious hospital waste is the transmission of HIV/ AIDS virus and, more often of Hepatitis B or C virus (HBV) through injuries caused by syringes contaminated by human blood."\(^{11}\) Concern about these two diseases was sufficiently great for the US Department of Labour (DOL) and the U.S. department of Health and Human Services (DHHS) to issue a Joint Advisory Notice on the prevention of occupational exposures to these two viruses. Statistics for illness amongst health care workers support these concerns. The Centre for Disease Control estimates that as many as 18,000 health care workers per year may be infected by HBV and that nearly 10% of these become long term carriers of the virus. As many as 300 may die annually as a result of hepatitis B infections or complications.\(^{12}\)

3.1 To the Community

It is pertinent to note, that despite the public concern over medical waste there are almost no documented instances of public illness caused by such exposures. "It is considered exceptional that victims include patents or the general public."\(^{13}\) However, these concerns, i.e. from the general public, led to the adoption of largely end-of pipe solutions such as high cost and...

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\(^{11}\) Op. cit 7
inefficient on-site medical waste incinerators. Yet it must be kept in mind that data from developing countries is scarce, and often medical waste is dumped openly along with municipal wastes, and technical education of personnel in charge is generally low.

3.2 To the Worker

Environmental workers, including ward boys, janitors, municipal workers and ragpickers, along with nurses are the group most at risk from infected medical waste. However, there is a lack of priority on basic worker training and safety when dealing with wastes within health care facilities, and installing end-of-pipe disposal technologies does little to minimise their risk.

Sharps, which include syringes and needles, have the highest disease transmission potential amongst all categories of medical waste. Almost 85% of sharp injuries are caused between their usage and subsequent disposal. More than 20% of those who handle them encounter ‘stick’ injuries, as studies show. It is of less importance if the sharp is later incinerated or autoclaved, if it has already transmitted disease.

"The workers most frequently injured … are nurse’s aides, registered nurses, housekeeping and maintain personnel and food preparation workers. The annual injury rates for these occupations vary from 10 to 20 per 1000 workers.”

In a study carried out in Jordan the risk to hospital workers was highlighted. The 3 year study, based on reports workers were asked to file on stick injuries included an immediate blood test from patients and the health care worker, and another sample from the health care worker 6 months later for hepatitis B virus, hepatitis C virus and HIV testing. The study found that of the 1000 odd persons involved in patient related activities, 248 health care workers had needle stick injuries, of which 34.6% were staff nurses, 19% environmental workers, 15.7% interns, 11.7% residents, 8.5% practical nurses and 6% technicians. The incidence density was highest for the interns followed by staff nurses and environmental workers. 22.6% incidents occurred during blood drawing, 11.3% during recapping the needle, 10.5% during needle disposal, 12.5% during garbage collection, and 5% by a neglected needle. The study concluded that needlestick and sharp injuries occur frequently in developing countries.

14 Managing Medical Wastes in developing Countries, WHO, 1994
15 “Epidemiology of needlestick and sharp injuries at a university hospital in a developing country: A 3 year prospective study at the Jordan University Hospital 1993 through 1995”, Najwa A. Khuri-Bulos et.al, AJIC, Volume 25, Number 4: 322-329
and that safer disposal facilities and routine hepatitis B vaccine should be adopted.

### Incidence of Needle Stick and Sharp Injuries

<table>
<thead>
<tr>
<th>Nu</th>
<th>Te</th>
</tr>
</thead>
<tbody>
<tr>
<td>14%</td>
<td>31</td>
</tr>
<tr>
<td>45%</td>
<td>3E</td>
</tr>
<tr>
<td>10%</td>
<td>2I</td>
</tr>
</tbody>
</table>

#### 3.3 Hazardous Waste Risks

Largely ignored, this class of hospital waste, which consists mainly of chemicals and discarded cytotoxic drugs, poses risk scenarios to hospital workers. WHO consultant Professor Shiro Shiraqto, who is the chairman of the Japanese Society for Research on Medical waste has recorded more than 500 cases of injury or poisoning with chemical waste from hospitals, and more than 400 cases of bio-hazards from cytotoxic drugs improperly disposed.

Some common hazardous chemicals, some of which are probable carcinogens or pose other health risks include:

- Chemotherapy and Antineoplastic chemicals, which are the largest volume of hazardous chemicals.
- Formaldehyde, which is normally used in pathology, autopsy, embalming etc.
- Photographic chemicals such as fixer, developer which has 45% glutaraldehyde etc.
- Solvents such as methyl chloride, chloroform, freons, trichloroethylene etc.
- Mercury
- Ethylene Oxide used as sterilizers.

#### 4.0 Problems with Medical Waste Incinerators:
Most medical administrations have focused on installing disposal technologies such as incinerators and not on implementing a ‘practice’ of waste management within the hospital. Over 6500 incinerators were installed in the US alone in the 1980s. Chronic problems both relating to very high toxic levels as well as difficulties in operating a sophisticated engineering technology in a medical setting have given rise to a debate which attempts to define a clean technology for medical waste disposal.

Medical waste incinerators are one of the largest sources of dioxin and mercury pollution in the United States. According to the United States Environmental Protection Agency (EPA), dioxin from medical waste incineration ends up in dairy foods and meat and both mercury and dioxin are taken up by fish and shellfish. When one eats these foods, one adds to existing dioxin and mercury body burdens.

EPA’s current draft assessment of dioxin shows that the average American adult consumes 300 to 600 times the "safe" dose of dioxin every day. Nursing infants take in 50 times the average adult dose. Dioxin and mercury are linked to many human health problems including cancer, immune system depression, nervous system disorders, birth defects and infertility.

It is important to visit these problems which have made incinerators so very unpopular, and expensive.

**Operational Problems:** Medical waste incinerators, particularly in developing and poorer countries, often operate under sub-optimal conditions. ‘Batch processing’ where waste is fed on an ‘as arrives basis’, low operational temperatures, give rise to poor performance, and high emissions.

This seems to be generally more true in developing countries. Most hospitals in the Delhi were found to be operating incinerators at 400 to 500 deg. C whereas they were rated at about 1200 deg. C. The percentage of incinerators that were functioning poorly or not operational in some other developing countries are as below:

<table>
<thead>
<tr>
<th>Country</th>
<th>Year of Study</th>
<th>Total Studied (Number)</th>
<th>Number of incinerators functioning poorly or not at all</th>
</tr>
</thead>
</table>

### Table: Hospital Waste

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>(Number)</th>
<th>(Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina 1982</td>
<td>9</td>
<td>7</td>
<td>78</td>
</tr>
<tr>
<td>Brazil 1985</td>
<td>14</td>
<td>8</td>
<td>57</td>
</tr>
<tr>
<td>Peru 1985</td>
<td>25</td>
<td>23</td>
<td>92</td>
</tr>
</tbody>
</table>

**Source:** Managing Medical Wastes in Developing Countries, WHO, 1994

In developed countries too, these problems are not however absent. In Britain, according to a study of 36 hospital incinerators in Wales, carried out in March 1990 only 6 of them were found operating between the 800 deg. C to 1000 deg. C, whilst the rest operated as low as 400 deg. C raising the dangers of dioxin production.17

**Absence of Pollution Control Devices:** Adequate Pollution Control Devices are not fitted to all incinerators, nor are these devices always regulated by adequate standards.18 Monitoring of pollution control devices is a sophisticated and expensive exercise and often considered an unnecessary luxury in developing countries, who may have a different set of priorities.

**Difficulty of repair and maintenance:** Incineration technology is expensive. Often and particularly in developing countries, the technology is old, and their are costs and efficiency sacrificed with maintenance problems. Not only that, there is very rarely any backup system, or any systematic waste disposal system to fall back on when the incinerator has to be shut down for maintenance, or when it breaks down entirely.

**Over sizing of incinerator, per volume of waste:** Experiences in Latin America show the tendency to install ‘oversized incinerators’. These are either not efficiently utilised or ineffective since they have to be filled with either too little waste leading to ‘batch processing’, or burning of waste which was never meant to be incinerated in the first place.

**General lack of awareness, education and training of personnel:** In large hospitals where contractors are employed to dispose waste, malpractice often occurs, particularly where waste recycling with ragpicking is a way of life. Lack of operator training is a key factor in the inefficient functioning of incinerators.

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Unresolved disposal of incinerator ash: Incinerator ash, consists of both fly ash and bottom ash. The ash is highly toxic concentration of heavy metals, dioxins and furans. Ironically, as the air pollution equipment becomes more effective in removing particulate matter, the toxicity of the fly ash increases. One of the largest hospitals in Delhi was found to have lead in its incinerator ash at levels which would classify the ash as hazardous\textsuperscript{19}. Ash is regularly dumped into a landfill where it is rarely or insufficiently covered with inert material, and ground water pollution through leaching is common.\textsuperscript{20} Besides the presence of heavy metals, etc., released especially by the burning of plastics, there is also the problem of sharps remaining in it. Landfilling the ash then poses special injury problems to ragpickers etc.

Dioxins and furans are found in incinerator ash at levels of the order of micrograms per gram of ash. Even internationally, while the law often stipulates stringent requirements on handling of the ash, there is usually no clear guidance on its disposal. Some ash is treated as hazardous waste, but much of it finds its way into ordinary domestic landfill sites. \textsuperscript{21}

4.1 Environmental and Health risks associated with medical waste incineration:

Incineration has specific health concern since it not only destroys the pathogen but also the material on which the pathogen resides. In the process they transform solid and liquid toxic wastes into gaseous emissions.

The pollutants of Medical waste incinerators, include

- Pathogens (entities with infection potential),
- Metals (e.g. cadmium, a neurotoxic chemical and thought to be a probable human carcinogen),
- Acid gases (e.g. hydrogen chloride, nitrogen oxides and sulphur dioxides), which can cause acute effects such as eye and respiratory irritation, can contribute to acid rain, and may enhance the toxic effects of heavy metals
- Particulate emissions (which can absorb heavy metals and organic and lodge in human lungs, and serve as irritants possible responsible for chronic health effects).

\textsuperscript{20} Op. cit 10
\textsuperscript{21} Op. cit 17
• Increased chlorine made material e.g. PVC, which creates dioxin, a known animal carcinogen, and considered human carcinogen.

Some studies have specifically examined health effects from medical waste incinerators;
• The California Air Resources Board (CARB)\textsuperscript{22} has observed consistently high concentrations of cadmium and lead in tests on Medical waste Incinerators. Tests of seven incinerators burning medical wastes were conducted from August 1986 to April 1988. Toxic metals such as cadmium and lead, and dioxins and furans were consistently observed to be at high levels. It stated the “high levels of chlorinated plastics can lead to generation of toxic air pollutants (including PCDD and PCDF) and may be responsible for the high level of Cd and Pb observed in the flyash”. Also that “Plastics, particularly PVC, are suspected as the major source...”. Lead was also detected in ‘red infectious bags, yellow bedpans, yellow linen bags...” etc.

• In August 1991, the Gateshead Health Authority in Britain was prosecuted by a local citizen Trevor Payne, for the death of his four year old daughter from leukaemia said to be directly caused by the hospital's incinerator.\textsuperscript{23}

• A study which examined human exposure to metals emitted from nine hazardous waste facilities resulted in tangible human exposure through non-inhalation pathways.\textsuperscript{24}

5.0 Dioxins

There has been a larger impact of dioxins on medical waste disposal than any other single factor.

What are they? Dioxins and furans present a special problem for the incineration industry. They are formed directly from chlorine and

\begin{flushright}
\textsuperscript{22} Cadmium and Lead in Bio-Medical Waste Incinerators, D.C. Hickman, D.P.Y. Chang and H. Glasser, department of Civil Engineering and Department of Mechanical Engineering, University of California, Davis, CA 95616, A paper presented at the 82\textsuperscript{nd} Annual Meeting of the Air and Waste Management Association, 1989, June 25-30\textsuperscript{th}, CA.

\textsuperscript{23} Health Care Without Harm

\textsuperscript{24} The evaluation of stack metal emissions from hazardous waste incinerators: assessing human exposure through noninhalation pathways. Environment Health Perspective, 1994 June, Supple 2: 105 -12
\end{flushright}
chlorinated products, which are present in larger volumes in medical waste than municipal waste. In medical waste, chlorinated products would typically include surgical gloves, catheters, PVC tubing, bloodbags etc. (see box.)
**Dioxins and Furans**

*Unseen but Deadly by-products of Medical Incineration*

- Dioxins and furans are polychlorinated aromatic hydrocarbons.

- According to the US Environmental Protection Agency (EPA), the tolerable daily intake of dioxins and furans is 6 thousand-million-millionth of a gram ($6 \times 10^{-15}$ grams) of TCDD (the toxicity of dioxins and furans is expressed in terms of TCDD, or 2,3,7,8-tetrachlorodibenzo-p-dioxin, which is known as the world’s most toxic synthetic chemical), equivalent per kilogram of body weight. At this rate of consumption, the EPA estimates that the risk of developing cancer is increased by one chance on a million.

- In Britain the Department of Environment (DOE) estimates that the average daily consumption is up to 500 times the EPA limit. In a 1989 study, the department reports that the daily intake is between 1 and 3 million-millionths of gram (between $1$ and $3 \times 10^{-12}$ grams) per kilogram of body weight. An European Community draft directive, published in 1990, specifies a limit of one ten-thousand-millionth of a gram ($10^{-10}$ grams) of TCDD - equivalent per cubic meter of undiluted emissions.

- If exhaust gases in medical waste incinerators are not rapidly cooled, they run the risk of elements re-forming into dioxins and furans. When their precursors, carbon, hydrogen and chlorine are present, they form simultaneously between 250 deg. C and 400 deg. C, with a peak at 300 deg. C. Low temperature incinerators can act as dioxin factories.

- A two year study conducted by the Danish National Environmental research Institute, published in 1990, found that hospitals waste contributed 30 percent of the dioxins and furans produced, even though it made up of only 1 percent of the total waste.

- In Britain, HM Inspectorate of Pollution, which the 1990 Environmental Protection Act makes responsible for regulating incinerators burning more than one tonne of waste per hour, accepts the same limit. According to a study (published in May 1991), some hospital incinerators in Britain are emitting dioxins and furans at concentrations that are hundreds or thousands of times as high as the European limit.

- Dioxins and furans are also found in incinerator ash at levels of the order of micrograms per gram of ash. Much of the ash finds its way into domestic and municipal landfills.

(extracted from *Medical Waste: A case for treatment,* Oliver Tickell and Alan Watson, *New Scientist,* 28th March, 1992)

### 5.1 Health Risks Posed by Dioxin and Dioxin-Like Chemicals

The US EPA has been involved in the assessment of dioxin and dioxin-like chemicals for more than five years. The effort to assess the health effects of dioxin has been coupled with an analysis of how best to estimate the exposures (e.g. sources of exposure, routes of ingestion into the body, expected health effects, etc.) to dioxin-like chemicals.
1. Effects on the Immune System Extensive evidence collected over 20 years shows that the immune system is a target for dioxins. This evidence was derived from numerous studies in various animal species, primarily rodents, but also guinea pigs, rabbits, monkeys, marmosets, and cattle. Epidemiological studies also provide evidence for their effects in humans.

2. Reproductive Effects The potential for dioxins and related compounds to cause reproductive and developmental toxicity has been recognised for many years. Recent laboratory studies in this area suggest that altered development may be among the most sensitive dioxin endpoints.

3. Cancer Effects There have been several long-term studies designed to determine if dioxins are carcinogen in experimental animals. All of these studies have been positive and demonstrate that dioxins are multi-site carcinogens, are carcinogenic in both sexes and in several species, is carcinogenic in sites remote from the site of treatment, and increases cancer incidence at very low doses. Several studies also indicate, that for the most part, humans appear to respond like experimental animals for biochemical and carcinogenic effects.

4. Other Effects Dioxins alter a number of other pathways involved in the regulation of cell differentiation and proliferation. The specific relationships of these effects to multistage carcinogenesis are not known, but the broad array of effects on hormone systems, growth factor pathways, cytokines, and signal transduction components is consistent with the notion that dioxins are powerful growth dysregulators.

Human exposure to dioxins has been associated with non-cancer effects in most systems. The majority of effects have been reported among occupationally exposed groups, such as chemical production workers, pesticide users, and individuals who handled or were exposed to materials treated with dioxin-contaminated pesticides, and among residents of communities contaminated with tainted waste oil (Missouri, USA) -and industrial effluent (Seveso, Italy).

5.1 Exposure sources
The principal identified sources of environmental release of dioxins and furans may be grouped into four major types: combustion and incineration sources; chemical manufacturing processing sources; industrial/municipal processes; and reservoir sources. Exposure levels to dioxins in industrialised nations are estimated to be about 0.3-0.6 pg (picograms) TCDD/ kg body weight/ day. With regard to average intake, humans are currently exposed to background levels on dioxin-like compounds on the
order of 3-6 pg-TEQ/kg body weight/day, including dioxin-like PCBs. This is more than 500-fold higher than EPA's 1983 risk-specific dose associated with a plausible upper bound, and several hundred-fold higher than revised risk-specific dose estimates. Plausible upper-bound risk estimates for general population exposures to dioxin and related compounds, therefore, may be as high as one in ten thousand to one in a thousand.

5.2 Conclusions
Research during the past decade has shown that there are two basic ways that chemicals can affect male reproduction. Chemicals can directly affect the testes, where sperm originates. The number of sperm can be diminished, or some sperm can be damaged, or sperm may eventually carry toxins directly to the egg. Alternatively, toxins can attack the male nervous system, or endocrine system, affecting the flow of hormones that act as messengers regulating the complex chemical processes that must all work well for conception to occur. No matter what the mechanism of damage may be, there is a growing body of evidence showing that male exposures to toxins can produce defective children.

A recent study in the British Medical Journal concludes that men in western countries today have sperm counts less than half as high as their grandfathers had at the same age. In addition, the occurrence of cancer in the testicles has increased 3-fold to 4-fold during the past 40 years; and various birth defects of the male reproductive system have increased 2-fold to 4-fold during the same period, including undescended testicles (a condition called cryptorchidism) and a birth defect called hypospadias in which the male urinary canal is open for a variable distance on the underside of the penis.

These findings and hypotheses add to the growing body of medical knowledge indicating that many chemicals -- especially chlorinated hydrocarbons -- mimic hormones and interfere with the endocrine systems of fish, birds, wildlife and humans. Earlier studies have linked chlorinated hydrocarbons to female breast cancer and it is worth pointing out that breast cancer in women is associated with an increased likelihood of testicular cancer in their sons. Thus breast cancer, testicular cancer, and defects of the male reproductive system, including diminished sperm count, all seem linked.

The general spread of dioxin and dioxin-like chemicals in the U.S. environment has already exposed the entire population to levels of these extremely toxic substances that are expected to cause a number of serious
These include an average risk of cancer of 100 or more per million in the entire U.S. population 100 times greater than the risk standard that has triggered EPA remedial action, for example at Times Beach in Missouri Superfund site.

The only way to reduce contaminants of food is to take comprehensive action to protect the food supply. Consumption of dairy and meat products is the primary exposure route for dioxin, and fish consumption is the major route of mercury to humans. The average adult consumes 300 to 600 times USEPA's estimated acceptable daily intake of dioxin and infants consume 50 times more dioxin than adults according to USEPA.

USEPA's best estimate is that existing levels of dioxin in the U.S. population may be sufficient to cause cancer in somewhere between one-in-every-thousand people and one-in-every-ten-thousand people each year.

### 6.0 The Technology Debate:

#### 6.1 Alternative Technologies to Incineration for Medical Waste

There is a concerted move towards non-incineration technology, particularly for medical waste. Nearly 80% of the hospitals in California use alternatives to on-site incineration. Some of the factors which have contributed to such a shift include:

- Increased awareness of the environmental and health impacts of incinerators.

- Increased cost of Incineration given increased equipment needs defined by new emission standards.

- Difficulty in finding new sites for incinerators.

- An increasing availability of non-incineration technologies.

Given the relatively low infectious content (10%) and high cost of its treatment, the first logical step in managing medical waste involves separating out infectious from non-infectious waste. The other components should be treated through implementing waste separation systems,
substituting reusable and durable products for disposable, and introducing recycling programs for plastics, paper and metal.  

Alternative Medical Waste treatment technologies have been placed into three broad categories of mechanical treatment, chemical treatment, chemical/mechanical, plasma torch, thermal deactivation, electro-thermal deactivation, autoclaving, microwaving and electron beam sterilisation.  

**Autoclaving:** Autoclaving, or steam sterilisation, has been practised for years and is typically used for reusable items such as syringes and other medical equipment. An estimated 45% of infectious medical equipment from Western hospitals is reused through autoclaving.

The process involves heating bags of medical waste at between 120 and 165 deg. C for 30 to 90 minutes in chambers into which pressurised steam is introduced. The steam (at 15-80 psi) penetration ensures destruction of bacteria and pathogenic micro-organisms. Two technologies used during autoclaving are induced vacuum where the steam is introduced into a vacuum and gravity displacement where the steam entering the chamber displaces the air. Waste is reduced by an estimated 75% of its volume and can either be landfilled directly or compacted further.

There are many advantages to autoclaving. It encourages the reuse or recycling of medical equipment. Disinfected waste can be landfilled. Autoclaves are commercially available in varying sizes from desk-top to industrial units.

It should be noted that autoclaving is not suitable for certain types of medical waste including low-level radioactive waste, organic solvents, laboratory chemicals, chemotherapy waste and pathological or anatomical remnants.

**Superheated Steam Sterilisation:** This technology comprises a heated shredder and sterilisation unit. In the shredder, organic liquids are vaporised and solids reduced to gas by 'super-heated' steam at temperatures between 500 and 700 deg. C. The sterilisation unit also employs steam at high temperatures and increased atmospheric pressure further reducing the overall weight of waste. The temperatures used (up to 1500 deg. C) exceed ordinary steam sterilisation. Medical equipment is melted into a sterile mass in under an hour. The remaining residues are

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cooled and dropped into a collection bin or ground in a heated shredder. The process employs a continuous batch-system and has been shown to reduce medical waste by 50 to 80% of its original volume.  

It is claimed that this technology can handle all waste including chlorinated plastic products and low-level radioactive waste. Timing is based on measuring carbon monoxide in the emissions from the sterilisation unit. However, the superheating of PVC plastic waste can result in the formation of hydrochloric acid (HCl). HCl can, in turn, react with the many additives present in PVC, creating even greater volumes of toxic fumes.

One prototype employing Superheated Steam Sterilisation takes the form of a 'mobile-van.' Tests have shown this technology can destroy nine live viruses.

**Wet Oxidation Technology:** This technology resembles that of a washing machine. Weighed plastic drums filled with medical waste are placed on top of a shredder. Shredded waste drops into a spinning basket in an oxidation chamber. Once full, the chamber is closed and a water based solution containing 10% sulphuric acid, an iron ion catalyst and a co-catalyst is introduced. Sulphuric acid maintains a very acidic pH value of the mixture while mechanical agitation ensures that the entire waste mass is saturated with the solution. The solution is pumped out into a rear holding tank while water is sprayed into a spinning basket to rinse any remaining solution out of the waste. Finally, the remaining waste is doused with a finishing rinse of de-ionised water. Hydrochloric acid is used to rinse the shredder and plastic drums. The process claims to oxidize most organic material at a relatively quick rate of about 225 kg per hour. The catalyst solution as well as the final rinse can be reused after treatment. Waste treated in this way can be landfilled or recycled. Tests have also shown air pollution to be lower for this type of medical waste treatment than for other methods.

**Microwave Disinfection:** Germany started using microwave disinfection in the early 1980's. The technology has since spread and has now been approved in 40 states in the USA. The equipment can be installed on or off site in stationary or mobile units. Microwave disinfection relies on treating medical waste with moist heat and conventional microwaves.

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27 'Study of Non-Burn Technologies for the Treatment of Infectious and Pathological Waste and Siting Considerations.' Minnesota Healthcare Partners Inc. (15 April 1992.)
Hospital Waste

Waste loaded from an automatic hoisting bucket into a hopper is treated with high-temperature steam from where it goes through a heap filter. The filtered residues are then shredded, high temperature steam treated and disinfected with microwave heat at 940°C. The remaining residues which have been reduced by 80% in volume can be landfilled.

Microwaving is economically competitive and versatile. Microwave equipment can be fitted in small and large facilities. The process employs continuous batch processing. Time and temperature are controlled automatically by a computer which also indicates when more waste can be fed into the unit and monitors and records progress. The internal microwave heating system is 'closed' and studies in Europe have shown virtually no emissions. Consequently, there is no need for pollution control devices. However, it is not suitable for liquid blood or hazardous chemical compounds.

**Electron Beam Gun Technology:** Medical Waste is exposed to an ionized electron beam inducing chemical and biological changes in the waste material. Decontamination occurs when nucleic acids in living cells are irradiated. The equipment emits sufficient radiation to destroy micro-organisms and change the molecular structure of materials. However, the technology produces radioactive fields that require costly shielding. Additionally, ozone is produced, but this can be destroyed using a catalyst. The volume of waste is reduced by about 20% and the disinfected remains are shredded and landfilled.

The entire sterilisation process is electronically monitored with radiation dosimeters and biological indicators. The quantity and duration of irradiation required depends on the quantity and resilience of micro-organism. Unit sizes are small, treating between 75 and 110 kg of waste per hour. Irradiation intensity or quantity can be varied by increasing the number of installed machines.

Developed in 1989 in the USA, Electron Beam Gun Technology has been approved in 12 states and is already being used for sterilisation. At present, there is only one known manufacturer. Normally, low-level radioactivity results at exposure to around 10 MeV - the maximum permissible level imposed by the US Food and Drug Administration (FDA) and Environmental Protection Agency (EPA.) Other irradiation methods which use gamma radiation to deactivate Cobalt 60 have proved more dangerous than electron beam gun technology.

**Other potential treatment technologies - Electrohydraulic disinfection and pulse power technology:** The process involves the use of pulsed plasma of
electrical discharges in water, using ultraviolet radiation, hydrogen, hydroxyl, ozone and shock waves to act as disinfectants.

6.2 Comparing Alternative Technologies:
The following sub-sections attempt to answer some commonly asked questions about alternative technologies:

Q 1. Which technology is cheaper to operate and at what scale?

Comparative Costs of Alternative Medical Waste Disposal Technologies (US): The cost per pound of waste for alternative treatment technologies depend on factors included. Costs may vary from source to source due to regional differences such as hauling and landfilling.

<table>
<thead>
<tr>
<th>Tech.</th>
<th>Price ($/lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;200 lb/hr</td>
</tr>
<tr>
<td>Autoclave</td>
<td>0.25</td>
</tr>
<tr>
<td>Microwave</td>
<td>-</td>
</tr>
<tr>
<td>Chemical</td>
<td>0.19</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
</tr>
</tbody>
</table>

(Note: Cost includes financing (10% interest rate at 15 yr. loan, labour, installation, landfill disposal costs etc.)

Q 2. Which technology is the least expensive to purchase and install? And which is the most expensive?

Capital Costs

<table>
<thead>
<tr>
<th>Treatment Technology</th>
<th>Type of Wastes</th>
<th>Volume Reduction</th>
<th>Capital (equipment and Installation ($K))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Autoclave</td>
<td>All except pathological</td>
<td>0 %</td>
<td>$100K (onsite)</td>
</tr>
<tr>
<td>Autoclave with compaction</td>
<td>All, except pathological</td>
<td>60- 80%</td>
<td>$100K</td>
</tr>
</tbody>
</table>

Hospital Waste

<table>
<thead>
<tr>
<th>Technology</th>
<th>All</th>
<th>60 - 90%</th>
<th>$ 40 - 350K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical/Chemical</td>
<td>All</td>
<td>60 - 90%</td>
<td>$ 500K</td>
</tr>
<tr>
<td>Microwave with Shredder</td>
<td>All</td>
<td>60 - 90%</td>
<td>$ 500K</td>
</tr>
<tr>
<td>Incineration</td>
<td>All</td>
<td>90 - 95%</td>
<td>$ 1300K</td>
</tr>
</tbody>
</table>


Q 3. How effective is each technology?

**Comparative Efficacy of Alternative Medical Waste Disposal Technologies:** Treatment may be defined as any method, technique or process designed to change the biological character or composition of any medical waste so as to reduce and/or eliminate its potential for causing disease.

Levels of microbial inactivation, as used in the table below, are commonly used to indicate efficacy of medical waste treatment processes.

Level I to Level III inactivation can be associated with disinfection ranging from low level disinfection to high level disinfection. Level IV is equivalent to sterilisation.

Level III inactivation is generally considered as an appropriate level of medical waste treatment.

**EPA Efficacy Tests: All Field Test Results**

<table>
<thead>
<tr>
<th>Waste Treatment</th>
<th>Microbial Inactivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Level 1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Steam Autoclave</td>
<td>Yes</td>
</tr>
<tr>
<td>Microwave</td>
<td>Yes</td>
</tr>
<tr>
<td>Chemical</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<sup>a</sup> Inactivation of vegetative bacteria, fungi, some viruses

<sup>b</sup> Inactivation of vegetative bacteria, fungi, all virus and mycobacteria

<sup>c</sup> Inactivation of vegetative bacteria, fungi, viruses, mycobacteria, and B.subtilis $10^4$; or B.stearothermophilus $10^4$ (chemical)

<sup>d</sup> Inactivation of vegetative bacteria, fungi, virus, mycobacteria and B stearothermophilus $10^6$ or greater
Note:
1. subtilus and B.stearothemphilus have death curves similar to human pathogen spores and are standard methods for testing level of disinfection.
2. Level IV is equivalent to sterilisation)

In the above table:
- Autoclave: Prevacum system 138 ° C, 30 psi, double door gravity system, 163 ° C, 80 psi
- Microwave treatment system (six units at 2,450 MHz each)
- Chemical / mechanical systems, sodium hypochlorite, 1000, 2000, 3000 ppm FAC

Q 4. How much electricity, steam and water does each technology require?

Energy requirement for Alternative Medical Waste Disposal Technologies: Utility consumption may vary from system to system. The values for autoclaves do not include the power required for a shredder. The values for chemical system water consumption may triple if water is not recirculated during the system operation.

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Electricity (kWh)</th>
<th>Steam (lb/hr)</th>
<th>Water (gal/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;200 lb/hr</td>
<td>200-500 lb/hr</td>
<td>&gt;500 lb/hr</td>
</tr>
<tr>
<td>Autoclave</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Microwave</td>
<td>30</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Chemical Treatment</td>
<td>10</td>
<td>25</td>
<td>60</td>
</tr>
</tbody>
</table>

Q 5. What the users say about alternatives?

Other Owner Satisfaction Factors: This is based on an EPA survey of eight hospitals, although Srishti has also received several replies to queries from various hospitals in the US. According to the EPA study, all hospitals surveyed indicated that they would recommend their alternative technology.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Autoclaves</th>
<th>Microwave</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredder Problems</td>
<td>Rare</td>
<td>Rare</td>
<td>NA</td>
</tr>
</tbody>
</table>
Hospital Waste

<table>
<thead>
<tr>
<th>Odour Problems</th>
<th>Slight in older models</th>
<th>Slight, none after HEPA filters</th>
<th>Slight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation/Repairs</td>
<td>Easier, cleaner, less maintenance than incinerators</td>
<td>Minimal</td>
<td>Easier</td>
</tr>
<tr>
<td>Costs</td>
<td>Cheaper</td>
<td>Cheaper</td>
<td>Cheaper</td>
</tr>
<tr>
<td>Overall</td>
<td>Recommended</td>
<td>Recommended</td>
<td>Recommended</td>
</tr>
</tbody>
</table>

Q.6 What are the kinds of occupational hazards that operators can face while handling alternatives?

Operator Safety:

1. General Biological, Physical and Chemical Hazards
   a) Routes: Skin Penetration/ Skin Contact / Aerogenic Route
   b) Hazard Situations: Loading of waste / Waste bags rupture / Hot walls of thermal treatment processes etc.
   c) Types of injuries: Exposure to infection / falls / cuts / burns / chemical injuries

2. Technologies which require manual loading of waste:
   Same risk as in Incinerator technologies

3. Technologies incorporating automatic loading:
   a) By proximity to moving belts or hydraulic cylinders
   b) Aerogenic exposure to biological hazard from contaminated conveyor belts, broken waste bag. In chemical treatment exposure to oxidising agents, caustics other chemicals. Falls in wet areas, exposure, exposure to radiation etc.

Exposure can be minimised by personal protective equipment such as puncture proof gloves, respirators, safety glasses and fluid resistant clothing. Hearing protection for glass scrubbers and shredder technologies. Loading tools to discourage hand-to-hand contact. Proper training is also important.

7.0 Effects of Regulation on Medical Waste Technologies:
The Clean Air Act and the Medical Waste Tracking Act dramatically changed the structure of the medical waste technology market. The US EPA estimates that as a result of its new Medical Waste Incinerator standards, up to 93% of those which burn less than 200 lb/hour and constitute a majority, will have to shut down, since the total costs for retrofitting existing sources could range from USD 59 million/year to USD 120 million/year. Before these regulatory introductions, incineration was the most popular medical waste treatment process. Incineration became either too costly to retrofit or became restricted. The medical waste treatment and processing industry responded with improvements to existing technologies and an onslaught of new technologies. The decline of incineration, therefore, was a pivotal force in opening the treatment and processing market to other treatment methods.

The EPA estimates that there are approximately 2400 MWIs operating in the U.S. burning approximately 846 thousand tonnes of medical waste annually. Most of these incinerators are located on-site in medical facilities, and most of them will have to install air pollution equipment to meet new air emission limits. Implementation of the rule for existing sources is estimated to cost between USD 60 million per year and USD 120 million per year. “For many of these facilities the economic impacts of switching to an alternative method of waste disposal are much lower than the economic impacts of choosing to install emission control equipment” based on the EPA’s studies, adding pollution control equipment, such as wet scrubbers, to existing facilities would cost between USD 160,000 and USD 380,000 per installation, plus an operating cost ranging from USD 50,000 to USD 130,000 per year. There are additional costs for annual compliance testing, about USD 55,000, operator training and qualification etc. 29

Subsequently, the medical waste service market experienced a period of radical transition and transformation in 1993. Transition included a shift from incineration and alternate technologies. Transformation included competitive pricing, consolidation of business, downsizing of technology companies and new services such as hauling medical waste to centralised facilities.

Incineration market share which was 79.2% in 1990, dropped to 43.8% in 1995, and is expected to halve at 31.2% by 2000. Comparatively market shares of other safer technologies such as steam sterilisation and autoclaving are expected to rise to 48.9% in 1996, and become dominant in 2000 (see table).

29 Health Care Without Harm, CCHW, P.O. Box 6806, Falls Church VA, 22040
Alternatives to medical waste incineration, the more acceptable of these being autoclaving and microwaving, besides chemical disinfection, are generally considered to be safer and "there appears to be no significant or substantial adverse economic, environmental, or health and safety issues associated with the increased use of the alternative waste treatment technologies."  As per the USEPA, "many facilities that currently operate onsite incinerators may find it more cost effective to dispose of their waste using... alternatives.

Representing this trend, in June this year, Browning - Ferris Industries, one of the largest US medical waste disposal companies with USD 199 revenues from medical waste disposal in 1997 alone, announced its plan to shut down most of its Incinerators over the next five years and switch Autoclaves. This included more than 12 of its 16 medical waste burners. "It is clearly on our game plan to move towards autoclaves," the company remarked. Massachusetts had roughly 150 medical waste incinerators 15 years ago, but only 15 today.

As the table will show this is having a direct influence on other technologies for medical waste, which are safer and indeed cheaper.

<table>
<thead>
<tr>
<th>Year (Revenue)</th>
<th>Incin % Share</th>
<th>Steam/Autoclav % Share</th>
<th>Mech/Chem. Microwaving % Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>79.2</td>
<td>17.2</td>
<td>2.3</td>
</tr>
<tr>
<td>1991</td>
<td>73.7</td>
<td>18.4</td>
<td>2.4</td>
</tr>
<tr>
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Source: Trends in Medical Waste Disposal Technologies, Frost and Sullivan


31 Story in the Boston Globe, 10/6/98, USA
Effect on Choice of Medical Waste Disposal Technologies owing to Stricter Regulation

- Incineration
- Steam
- Mechanical/Chemical
- Microwaving

% of Revenue (U.S.)

Year


Hospital Waste
8.0 Overview and Issues of Medical Waste Disposal in India:

8.1 History
The disposal of medical waste is a crisis management problem in India today. Municipal bins are overflowing with municipal as well as medical waste; there is a general fear of epidemics tormenting city administrations. Despite recommendations both here as well as abroad, to rectify waste management systems in an overall sense in order to manage medical waste, hospital administrations have tended to pick up only end-of-pipe solutions, such as incineration. Ignoring larger systemic practices, could act as a double edged sword. This becomes especially important in a scenario where pollution monitoring and control has a poor track record.

Even the World Bank\textsuperscript{32} recommended that “long term environmental policies, guidelines and statutes should be linked with immediate requirements to segregate and decontaminate medical waste at its source. This linkage should include appropriate technology for sustainable environmental and public health protection, rather than imported high technology incinerators that are expensive to purchase and difficult to maintain.” It is another matter however, that this has as yet not been reflected in its State Health Projects program in India.

8.2 Legislation and NGO Intervention
The first draft rules of the Indian Ministry of Environment and Forests, which were issued in June 1995, ignored all international trends and recommended that all 50 bedded hospital and above must install on-site incinerators.\textsuperscript{33} Acting on these, in a Public Interest Case of B.L.Wadhera vs. UOI, the Supreme Court of India, in March 1996, ordered that this be implemented for the city of Delhi.

Owing to a very timely and precise intervention by Indian NGOs, in particular Srishti, there has been a similar reversal of trends in India too. Srishti, had carried out an extensive study of technologies and trends on medial waste disposal world-wide, filed for a review of the order. Based on their research, Srishti asked the Supreme Court of India, for both the inclusion of alternative and safer technologies in the rules as well as a their standardisation, both of which the Court directed. Subsequently these

\textsuperscript{32} Op. cit 5

\textsuperscript{33} Bio Medial Waste Management and Handling Rules, Draft Notification, April 1995, Ministry of Environment and Forests, GOI
alternatives become a part of the forthcoming national rules on bio-medical waste.

The latest and forthcoming Indian legislation also reflects this in the recently amended October 1997 draft Rules which are to be finally notified soon, which has a much more rational, yet mainly a technology mix including off-site and centralised facilities.

The rationale for pushing for such a change was very simple. The regulation must not restrict technology, but such options should be commercially driven. Regulation should limit itself to emission and performance parameters, leaving options for the user.

8.3 Medical Waste Disposal Technology Markets:
As a result, the medical waste technology market is seeing a steady influx of alternate technologies. There are already a number of autoclave, hydroclave and microwave technologies which are available. The first waste autoclave in India was installed in a medium sized Delhi hospital, while the Government of Delhi has tendered for 7 more. The first centralised microwave technology was granted approval by the Central Pollution Control Board in September 1996, and is awaiting installation. This was a dramatic shift from a scenario, just a couple of years ago where incinerators were the only option available and allowed.

Centralised and shared waste treatment facilities are now being allowed within legislation, also because of NGO pushes. Centralised facilities allow not only for more state-of-the-art facilities to be installed, but also help in ensuring that these adhere to regulatory norms. Instead of resource strapped pollution control bodies monitoring individual stacks in hospitals, centralised facilities reduce this to a few in the city. Economies of scale allow for more cost effective technologies and capacities, besides to run in a scientific manner through trained staff. Considering that a small percentage of hospital waste, consisting of mostly pathological wastes and body parts, needs to be incinerated, this can be carried out by sharing the many existing incinerators in say a city like Delhi. A zonal or centralised autoclave or microwave disuniting unit can then take care of the rest of the waste. Of course key to the success of such facilities is segregation as well as a safe and reliable transport system.

8.4 National Cost:
On the other hand, top down and ineffective technology centric solutions do not come cheap. If only thirty percent of healthcare facilities in the four
major metros install on-site disposal technologies, the investment would exceed over Rs 300 crores. For less than a combined 50 tonnes of infectious waste per day this amounts to Rs 6 crores per tonne, besides operating costs; an investment not made in any other waste stream, municipal or hazardous! Centralised of zonal facilities, on the other hand can be installed for less than one third that amount, including transport cost for handling that waste.

Also India has roughly 21000 primary health centres, and about 1000 district hospitals. If all of them invest even Rs 5 lakhs each in medical waste disposal technologies, then the overall cost will exceed Rs 1000 crores. Hence there is a great need to come up with systematic and simple approaches, besides staggering investment over a period of time.

### 8.5 Worker Safety
Medical waste regulation has never focused on the immediate and extremely high risk faced by hospital workers and waste handlers. From the late seventies, when syringes and bandages were washed on the shores of five west coast beaches in the US, to now, when the Supreme Court of India ordered all Delhi hospitals to install on-site incinerators or alternative technologies, medical waste has been considered as only a threat to the community, and accordingly end-of-pipe solutions have been emphasised. There was no mention of worker safety procedures, setting up of hospital committees, training of operators, or monitoring, as is also lacking in forthcoming legislation.

Some of the questions commonly argued in the context of Medical Waste Disposal are:

- Can we, a relatively poor developing country, without adequate resources for even basic health care, afford to follow sophisticated and systematic approaches to waste management in health care institutions?
- Is waste really an important focus, when attention should be paid on training medical personnel?
- Is it not better to make the garbage “disappear” through incineration, rather than have it polluting our neighbourhood and spreading disease?
- Can we afford to be finicky about the ‘marginal’ increase in pollution caused by technologies such as incineration, when there is already so much pollution anyway?

### 9.0 Prevalent Practices of Medical Waste Disposal in India
Over the past two years various agencies and NGO documents have illustrated the lack of proper medical waste disposal in India. A World Bank report\textsuperscript{34} cites that in a study conducted in Mumbai, New Delhi and Chennai, there was found to be no segregation of wastes, and that all wastes were dumped into wastes sites. Hazardous, uncollected waste was observed in each of the three cities, with sharps and other materials irrespective of whether an incinerator was available or not. Workers, though aware of potential dangers, did not follow safe practices or wear protective gloves. Also there was inadequate protective gear available, since budgets for procuring them were inadequate. Budgets for training of Class IV employees were non-existent.

In a study carried out by Srishti in December 1995, hospitals were found to be dumping waste in municipal dumps. Ragpickers regularly scavenged intact needles, sometimes with body fluids in them, for recycling and possible reuse. All major hospitals were found to have adjacent slums, where hospital waste was collected and sold. In one particular slum, used bandages were washed and sold to those who made cotton mats or ‘durries’ form them.

\textbf{9.1 Delhi}

In another more recent survey, also carried out by Srishti, in February 1998, the situation was not found to have improved much. The survey\textsuperscript{35} was conducted over a period of three weeks mainly during the morning hours, since it was then that waste collection and disposal took place in hospitals.

\textbf{Some of the findings were: -}

- Of the hospitals with incinerators, only 14.2\% of the incinerators were operating at temperatures prescribed by CPCB.
- 50\% of the hospitals surveyed had given their waste disposal work to a contractor. Also 33.3\% of the hospitals had their incinerators run by contractors.
- Ram Manohar Lohia hospital was the only hospital that had a shredder installed for plastic waste.
- Plastic material from the hospitals were being collected for recycling.
- Many incinerator operators and waste collectors had no idea of the hazards of waste nor were they given any protective gear.

\textsuperscript{34} India - A Review of Medical Waste Management, Population and Human Resources Division, SAII, September 1996.
• A lot of infectious waste was being directed towards bins even in hospitals with incinerators.
• Ragpickers stated that they were regularly pricked by needles.
• Waste reaching the kabari is usually dirty and blood stained.
• Segregation is done by hand by employees of the kabari.
• There is every chance of spread of disease because unwanted recyclable medical waste is dumped within these slums or in nearby drains.

Some prevalent systems of waste disposal included:

**The Contractor System:** A contractor for waste collection in a hospital has the responsibility of removing the waste from the hospital premises. What is done to the waste, or where it is disposed is not normally checked by hospital authorities. Hospitals either segregate their waste or can dispose all the waste in one category. If the waste is disposed off in one category then the contractor may take the waste to a municipal bin and segregate it there. The waste which will be removed will be - Syringe barrels, tubes, gloves, I.V bottles and other material made of plastic and glass. If the waste comes segregated the contractor takes the bag containing biodegradable waste to the bin and the other waste his house which acts like a sorting area and godown.

In some cases the sorting is done within the bin at the hospital itself. The contractor employees ragpickers to sort through waste at the bin and to transport it to the godown. The contractor earns in two ways - the hospital pays him to remove the garbage and the contractor also earns by selling all the recyclables.

**Ragpickers:** Ragpickers can only sort out the waste if the hospital bin is on the road or if it is close to the road. A ragpicker sorts through the waste thrown out of a hospital. In most cases, s/ he is between 10 - 18, there are adults too. The ragpicker at the bin separates the waste using his bare hands. The types of waste they collect are -

Mojammi which also includes rubber gloves. This is sold at Rs 2/- per kg
Guddi, which is all plastic items including tubes. This is sold at Rs 10/- per kg. Syringes without needles are sold at Rs 9/- per kg. This is then taken to a kabari who then sells it.

Ragpickers state that they are pricked by needles 3-4 times when they are sorting through the garbage. They also state that they take an anti-tetanus injection every 3 months.

**9.2 Mumbai:**
The Mumbai MedWaste Action Group as well as the All India Institute of Local Self Governance (AIILSG) have generated data here.

The AIILSG report was based on primary data collection from 111 responses to a questionnaire sent out. The findings are as below:

The total waste generated per patient was:

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Total waste per kg per patient per day</th>
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<tr>
<td>Private (upto 20 beds)</td>
<td>0.25</td>
</tr>
<tr>
<td>Private (21-50 beds)</td>
<td>0.19</td>
</tr>
<tr>
<td>Private (&gt; 50 beds)</td>
<td>0.98</td>
</tr>
<tr>
<td>Municipal</td>
<td>1.08</td>
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<tr>
<td>Government</td>
<td>0.7</td>
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</table>

- Although 45% of private hospitals claimed to segregate their waste, most did not use colour coded bags.
- In most hospitals, especially in small and medium sized hospitals, segregation is done by nurses, ayahs, wardboys and sweepers. This is more for retrieving useful items like plastic bottles and cardboard boxes, but not with colour coding.
- 2 municipal and 4 major private hospitals were carrying out relatively systematic colour coding.
- 50% of municipal and government hospitals disinfected wastes using hypochlorite. However sharps and cultures are not disinfected.
- Liquid wastes are flushed without treatment.
- Only 19% of large private hospitals had incinerators. Large hospitals used municipal crematoria for organs, tissues etc.
- 58 to 100% of the sample wanted guidelines and help in developing waste management systems.
- Common waste treatment facilities was the preferred option.

9.3 Bangalore

Another survey carried out by the Department of Community Medicine, M.S. Ramaiah Medical College, in Bangalore, on 10 dispensaries, 8 maternity homes, 10 private hospitals and nursing homes and 31 general practitioners had the following to report: It confirmed that the trend was common across the country.

- Health care waste is likely to be 5 kg for a hospital of 15 beds.

36 Health Care waste Disposal - department of Community Medicine, M.S. Ramaiah Medical College, Bangalore - 560054, 1997.
- Health care waste is casually managed and thrown into dustbins. It is regularly mixers with general waste.
- Gloves and masks were not found to be used by `pourakarmikas' (ragpikers). Many wore just slippers with no other protective gear.
- Disposal syringes were sold at Rs 10 per kg and glass bottles for Re1 to Rs 2 per bottle.
- These is no segregation of waste in health care facilities
- Only 33.33 % of hospital bins had lids
- 79.1% of hospitals threw waste sharps casually in dustbins.
- 95.6% of the facilities had no primary treatment before liquid waste was discharged into sewers.
- Waste handlers in 76.47% of hospitals used no protective gear.
- Only 8.82% of the facilities immunised its workers against hepatitis B.

9.4 Calcutta:
A study carried out in 4 large hospitals in Calcutta was carried out. It had the following observations to make:

- There was no specific modernisation plan for waste management in any of the 4 facilities.
- It was common for bio-medical waste to be mixed with general waste.
- Two of the four facilities studied had incinerators, but both were non-functional.
- Workers did not use any protective gear such as gloves, aprons etc.
- There was a general lack of awareness about waste disposal and safety amongst workers.
- Three of the four medical centres produced a total of 2,67,000 gallons of liquid waste per day. Liquid waste was directly dumped in sewers.
- There was no colour coded waste segregation followed in any of them.
- Plastic items were separated and sold in each of the centres.

9.5 Worker Safety Practices
The workers in the health care facility do not take care of the hazards associated with medical waste. Workers are not provided with protective gears like gloves, face masks and boots in most of the health care facilities, and in the rest where they are provided with workers do not use the protective equipment as it impedes their work and is not comfortable. It is not considered a necessity as they were not aware of how the infection spreads through the waste. The workers do get needle stick injuries very often and in institutions including Safdarjang, Charat Palika NDMC.

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Hospital, Ganga Ram, they have to tell the higher authorities and get a Tetanus injection, they are given Tetanus inoculations every 6 months. None of the workers operating incinerators were aware of the Hepatitis B vaccination even if it was available in their institution.

The incinerator operators at Safdarjang, NDMC Charat Palika, Batra and Sir Ganga Ram hospital were given operating instructions. Here the workers were aware of the temperature at which the waste had to be fed. The incineration of waste in all the institutions was in batches. Appropriate time for feeding would be determined by opening the mouth of the incinerator and looking if the previous waste was burnt.

The method of feeding which was by lifting the plastic bags by hand and flinging them into the mouth of the incinerator with no protective devices. During this process there was every chance of the bag tearing and its contents spilling on the ground and on any one standing nearby. Any spillage was put into the incinerator by long spades, these shovels were also used to push the bags into the centre of the fire with no protective devices on. Non of workers in any of the institutions were wearing heavy duty plastic face shields, hand gloves and boots. The workers at the Safdarjung hospital incinerator wore boots and gloves.

**Safety of Ragpickers and those involved in the segregation of Waste**

66% of the ragpickers Srishti spoke to were able to recount or show a definite instance of an injury or cut got while dealing with Medical waste. Most of these were from glass and a few from needles and metal in the waste, and were not necessarily the items they were looking for. The rest claimed that they did get injured, but could not provide any definitive evidence or instance.

Srishti has never observed any ragpicker or any other worker rummaging through Medical waste using either gloves, or even the more common stick. In fact they usually use bare hands.

In Moolchand (Delhi Hospital) a ragpicker showed his hands which were suppurated and pus was oozing out of them as he had cut them on a vial during segregation. A ragpicker at Sucheta Kriplani (another Delhi hospital), who now no longer collects there, complained of persistent fever and swollen hands from the bins where he rummaged for five years.

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38 Be Careful with that Cure, A critical look at Incineration as a medical waste disposal method, Srishti, R. Agarwal and B. Chaturvedi, March 1996, Delhi
In LNJP (a Delhi hospital), the municipal dump within the premises receives waste that is manually loaded in baskets by workers who throw it into a truck. They have neither masks nor gloves, and occasionally sustain injuries from the waste they lift.

Cows that ingest infectious waste, or food which is contaminated, as seen on occasions in Safdarjung hospital, as well as many other hospitals where waste is thrown into municipal dumps, could carry diseases like typhoid through their milk.

Nearly 93% of the hospitals and nursing homes surveyed use the Municipality bin to dispose off their garbage, and have no disposal system of their own.”

10.0 Sector Wise Responses:

There has been a variety or responses from various sectors:

10.1 The Government Response:
The Government has had a range of responses to the issue. However, it seems that continuous attentions and a push towards more sensible approaches is finally paying off. This is exemplified in a tender issued by the Government of Delhi, in May 1998, for the purchase of 7 waste autoclaves for their main hospitals. This is a far cry from similar tenders issued less than an year ago for incinerators. This is not necessarily true across the board. The Health Ministry of UP recently issued a requirement of 51 electric incinerators for its district hospitals, despite there being an erratic electrical supply, and the large information available against small on-site incinerators. There is still a need though for capacity building pushes through incorporating training modules in nurses and medical curricula.

On the legislation front, the Government has been slow to move. After procrastination for two land years, much after the Central Pollution Control Board gave its recommendations on the subject to the Ministry of Environment and Forests in June 1996, a second draft notification of the Bio Medical Waste Handling and Management Rules was issued in October 1997. Currently the MOEF has evidently finalised the notification which is due for release any time.

Meanwhile there have been reports of various State Pollution Control Boards having issued notices to hospitals to install incinerators or close
shop. But the tide is turning against a pure technology approach, and the public and media pressure is guiding towards more viable solutions.

10.2 Other Institutional Responses:

Many external pushes are forcing such approaches on a funds starved health care sector. Amongst these is the World Bank. A World Bank document entitled ‘Staff Appraisal Report, India, State Health Systems Development Project II, February 20, 1996. South Asia Country Department II (Bhutan, India, Nepal) Population and Human Resources Operations Division’ recommend the setting up of on-site incinerators in its State Health Systems Development Project II for Karnataka, Punjab and West Bengal. Intervention by NGOs stalled this move and there is evidently a change in policy, but the promised review is yet to be seen. The program has till now, no clear cut policy for medical waste disposal. The States themselves have asked for the setting up of on-site incinerators for all large hospitals, puralotors (type of incineration) for small hospitals and burial in wells for primary care facilities. There is not mention either of cleaner technologies or of worker safety, segregation, training or basic disinfection, inspite of world-wide trends.

Municipalities have been issuing notices to health care facilities to install incinerators or close shop. Lucknow, Baroda, Bhopal, and Hyderabad, are some such cities documented by the Medwaste Action Network (MAN), a loosely bound national group of NGOs, medical practitioners and concerned citizens advocating sensible solutions to medical waste. International incinerator salespersons are touting technologies obsolete in their host countries, with arguments like “Indians do not need to follow the same health standards as those in the West.” Voices of reason, such as that of the World Health Organisation, which recognises worker safety issues and supports systemic low-cost India specific solutions, are lost in the commercial din, since they are not funding agencies.

10.3 Industry Responses:

International Industry: The International Medical Waste disposal technology industry has probably welcomed new markets being opened up in India. Some of the largest incinerators manufacturer and consultants from the US, the UK, and Australia have been scouting the market for business. Often they have been part of Governmental Trade platforms such as the USAEP or AusAid. Many of them do not have markets for small low cost devices in their home countries any more, and find it hard to justify

39 Op. cit 34
dumping technology here. Very reactionary statements such as “Indians can afford lower health standards than the west,” etc., have not shown them in very good light, and there has been strong public reaction to these. On the other hand, cleaner technology sellers have also been trying to find a foothold in the potentially large markets. Two microwave disinfection companies and one autoclave and a hydroclave disinfection company have been doing their rounds over the past few months, trying to prise the market open.

**Indian Industry:** The Indian Industry has had many new entrants in the technology market, but mainly those who are dealing in incinerators. Owing a lack of BIS standards, an incinerator of say 20 kg per hour can cost between Rs 3 lakhs to Rs 10 lakhs. Many such entrants have either little or no experience in combustion technologies, and it is unlikely that their devices will meet the mandatory pollution norms also. For example though the recommendation is to have a minimum chimney stack height of 30 m for an incinerators, some vendors have been touting product with less than 10 m high stacks, or even portable incinerators with no stacks at all. Since laws have not been finally notified as yet, the Pollution Control Boards claim to be helpless in the matter, though NGOs have been protesting. It is expected that with the issuance of regulations, the market will become more sophisticated. This will also be pushed along by alternative technology vendors gaining ground in the market, and through competition providing the user with a better and more informed choice.

**10.4 NGO and People's Responses:**

Many NGOs have begun to respond to the issue. Srishti, first started campaigning against dioxins production through medical waste incineration, and in two short years the word has become part of the environmental vocabulary. Srishti also carried out a year long project along with a 40 bedded hospital to implement a hospital waste management system, the outcome of which was a first Indian manual on hospital waste management. Currently Srishti is working on two more pilot projects, one with a 300 bedded hospital, besides being a focal point for information dissemination on the issue to 200 addresses. Besides it constantly interacts with medical associations, nurses association and regulatory bodies to keep the pressure up.

NGOs have begun work in Calcutta - DISHA, Mumbai - Mumbai Medical Waste Action Network (MMAG), Bangalore - CEE and TERI, Chennai - Exnora, Baroda, Nagpur, Bhopal, Lucknow, Himachal Pradesh, to name a few, are actively working towards change. Srishti constantly provides
information and collaborates with many of them. MMAG for example has carried out extensive documentation of hospital waste in Mumbai, including examining the recycling trade. The Indian Institute of Rural development (IIRD) of Jaipur, FASCETS of Hyderabad, have held joint workshops with Srishti. The issue has truly become a public concern, and has a fair degree of public involvement.

Medical Associations: Many medical associations have been holding seminars, and meetings on the subject. In fact some of them, like the Baroda Management Association, has produced and distributed information booklets on the subject to its members. The Delhi Medical Association has circulated guidelines amongst itself, and the Indian Medical Association is also planning to take an interest in the issue.

11.0 Policy and other Initiatives needed

Basically comprehensive solutions to medical waste management lie solely in implementing systems of waste segregation, disinfection and treatment through the co-operation of hospital staff, and the medical personnel. Often, such solutions are resisted by hospitals, since they either think the issue is not important enough, or too difficult. All that is needed is some guidance, and the will to manage medical waste responsibly. Areas of interventions include training, segregation, disinfection, and raising awareness, all co-ordinated within a reporting and monitoring program involving a senior person.

The importance of worker participation: Hardly any hospital has a worker involvement perspective in their waste disposal schemes, contributing to their failure. The Central Pollution Control Board inspected 32 Delhi hospitals in August 1997 and found only 16 which practised any kind of segregation at all. Untrained Incinerators operators worked without gloves or aprons, regularly handling blood soaked waste and sharps sticking out of disposal bags, completely unaware of the grave dangers they faced. They ran Incinerators at temperatures between 300 to 500 deg. C, burning mixed waste containing plastics banned for incineration, and optimising dioxin production. Such trends are disturbing after two years of information dissemination and media attention on the issue with even a ‘step-by-step, how-to’ guide having being prepared and distributed.

Looking it from a worker view point can lead to effective and cost effective solutions for managing medical waste. Basic approaches to involve workers are important in the context of the complex Indian health care
system with government hospitals, private nursing homes, district, primary and rural facilities, and a host of clinics, labs and blood banks. Training of nurses and environmental workers to establish handling procedures will help segregation and red bagging and containment of sharps. A simultaneous ensuring of a supply of different coloured bags and bins and preventing the reuse of plastics through shredding, are low cost but high return areas. The setting up of a waste management committee, with representatives of all sections of hospital workers is essential so that the scheme does not become an unwanted burden.

11.1 What needs to be done

1. Focus On Segregation First:

The current waste management practice observed at many Indian hospitals is that all wastes, potentially infectious, office, general, food, construction debris, and hazardous chemical materials are all mixed together as they are generated, collected, transported and finally disposed of. As a result of this failure to establish and follow segregation protocols and infrastructure, the waste leaving hospitals in India, as a whole is both potentially infectious and potentially hazardous (chemical). The risk occurs in three ways: (1) accidental exposure from contact with wastes at municipal disposal bins; (2) exposure to chemical or biological contaminants in water; (3) exposure to chemical pollutants (e.g., mercury, dioxin) from incineration of the wastes.

It is critical that wastes are segregated prior to treatment and disposal. This most important step must be taken to safeguard the occupational health of health care workers. The wastes contain mercury and other heavy metals, chemical solvents and preservatives (e.g., formaldehyde) which are know carcinogens, and plastics (e.g., PVC) which when combusted produce dioxins and other pollutants which pose serious human health risks not only to workers but to the general public through food supplies.

Imposing segregation practices within hospitals to separate biological and chemical hazardous wastes will result in a clean solid waste stream (90%) which can be easily, safely and cost-effectively managed through recycling, composting and landfilling the residues. This resulting waste stream has a high proportion of organic wastes (food) and recyclable wastes (paper, plastic, metal) and actually very little that is truly disposable, especially

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40 In association with Hollie Shaner, R.N. and Glenn McRae of CGH Environmental Strategies
given the high percentage of reprocessing and reuse of materials which exists in the Indian health care system. Training, proper containers, signs, and protective gear for workers are all necessary components of this process to assure that segregation takes place and is maintained.

Similarly liquid wastes need to be treated before being discharged into the sewer.

2. **Institute A Sharps Management System :**
The most immediate threat to human health (patients, workers, public) is the indiscriminate disposal of sharps (needles, syringes, lancets, and other invasive tools). Proper segregation of these materials in rigid, puncture proof containers which are then monitored for safe treatment and disposal is the highest priority for any health care institution. If proper sharps management were instituted in all health care facilities throughout India most of the risk of disease transmission from medical waste would be solved. This would include proper equipment and containers distributed everywhere that sharps are generated (needle cutters and needle boxes), a secure accounting and collection system for transporting the contaminated sharps for treatment and final disposal, and proper training of all hospital personnel on handling and management of sharps and personal protection.

3. **Keep Focused On Reduction :**
Establishing clear guidelines for product purchasing that emphasized waste reduction will keep waste management problems in focus. New emphasis needs to be put on waste reduction of hazardous materials. For example, hospital waste management would benefit from a policy of a phase out of mercury-based products and technologies. Digital and electronic technology is available to replace mercury-based diagnostic tools. This is a purchasing and investment decision. Since there is no capacity in India to safely manage mercury wastes, this reduction policy will make a serious contribution to cleaning up the hospital waste stream. This is one example of reduction strategies which could be identified and implemented in India. Practicing pollution prevention is the most cost effective way of securing public health.

4. **Education, Training And Proper Personal Protective Equipment :**
Workers who handle hospital wastes are at greatest risk from exposure to the potentially infectious wastes and chemical hazardous wastes. This process starts with the clinical workers who generate the wastes without proper knowledge of the exposure risks or access to necessary protective gear, and includes the workers who collect and transport the wastes
through the hospital, the staff who operates a hospital incinerator or who take the waste to municipal bins, the municipal workers who collect wastes at the municipal bins and transport it to city dumping sites, and ragpickers, who represent the informal waste management sector, but play an important role in reducing the amount of waste destined for ultimate disposal. Whether rag pickers are considered as part of the formal system or not, they are integrally involved in waste management and their unique role and personal needs must be considered.

Proper education and training must be offered to all workers from doctors to ward boys, to rag pickers to ensure an understanding of the risks that wastes pose, how to protect themselves, and how to manage wastes (especially how to properly segregate). Education and training programs must be developed which speak to each population in a way that will best meet the needs and build understanding and change behavior in that population. There is no “one” way to educate all workers.

75. Collection And Transportation :
If the benefits of segregation are to be realized then there must be secure internal and external collection and transportation systems for waste. If waste is segregated at the point of generation only to be mixed together or if a hospital has segregated its waste and secured it in separate containers for ultimate disposal only to have municipal workers mix it together upon a single collection, then the ultimate value is lost. While worker safety may have been enhanced, the ultimate cost to the environment and the general public is still the same.

In addition the very real concern of hospital administrators and municipal officials to prevent the reuse of medical devices, containers and equipment after disposal should be taken into account in any management scheme. One has only to walk by street vendors selling latex gloves, or using cidex (a disinfectant regulated as a pesticide in the US) containers to hold water for making tea, to understand the risk that unsecured waste disposal systems have. In addition, the practice of cleaning and reselling syringes, needles, medicine vials and bottles is not well documented but appears to have enough informal evidence to indicate that it is a serious concern. Items that could potentially be reused illegitimately must be either rendered unusable after their use (cutting needles, puncturing IV bags, etc.) or secured for legitimate recycling by a vendor or system that can be monitored for compliance.

6. Plans And Policies:
To ensure continuity and clarity in these management practices, health care
institutions should develop clear plans and policies for the proper management and disposal of wastes. They need to be integrated into routine employee training, continuing education, and hospital management evaluation processes for systems and personnel. In the U.S. the Joint Commission for the Accreditation of Health Care Organizations has been developing a set of standards on the “Environment of Care” which includes plans and policies for the proper management of hazardous materials and workers’ safety, without which a hospital cannot be accredited. The USEPA’s new MACT rule now requires that hospitals develop waste management plans, a requirement that many states have had on the books for several years. Municipal governments or state governments here could require waste management plans from all hospitals as a condition for operating.

7. **Training And Equipment For Reprocessing Of Supplies:**
The science of the reprocessing of equipment and materials for reuse in medical facilities is well established in India and should be supported. The Hospital Infection Society of India firmly supports judicious reuse of materials, and should begin to set standards for reprocessing. Maintenance of this effort within hospitals will provide quality products and thwart efforts to increase reliance on disposables. Disposables are costly, increase waste generation, and do not necessarily provide for decreases in infection rates in hospitals. A reprocessing industry must however be supported with investment in proper equipment and training so that it is carried on in a safe and efficient manner.

8. **Environmentally Sound & Cost Effective Medical Waste Treatment And Disposal Technologies:**
The rush to incinerate medical waste in India as an ultimate solution to a problem without definition is of concern to public health, and the environment. The mass incineration of hospital waste given current practices of waste disposal will not reduce risk to workers (this is where the greatest risk of disease transmission or chemical exposure exists) and will actually create a greater threat to the general public as mercury and other heavy metals are spewed out into the general air of India’s cities, or dioxins and furans are created from the combustion of plastics such as PVC which is growing in use in medical packaging in India. Additionally the ash generated from incineration of medical waste is also tainted with heavy metals and other toxic residues. Lesser risks are associated with the treatment of unsegregated wastes through other treatment technologies such as autoclaving, hydroclaving, microwaving and chemical disinfection, which affect workers more than the general public, and contaminate water
Choices of treatment technologies should be made in line with a clear knowledge of the waste stream to be managed and the goal to be achieved through treatment. If the technology is to be environmentally sound, the waste stream should be able to be treated (disinfected) without creating other hazardous by-products.

If the overall goal of waste management is to prevent disease transmission from waste products, then the emphasis should be placed on the “management” aspect of the process and not on the “technological fix” which time and again has proven to be an expensive diversion rather than an effective solution. Technology should fit the situation and work in the management system to achieve the final goal as part of the overall system, not as a replacement for the system. Technology choices will be made to meet local needs and conditions and cannot be uniformly applied throughout a state or country. National standards for operating acceptable treatment technologies should be set, and there is no reason for India to have standards any less stringent than those being modeled in the U.S. or Europe.

9. Infrastructure For The Safe Disposal And Recycling For Hazardous Materials:
There is little or no capacity for the management, treatment, recycling or final disposal of hazardous wastes in India (e.g. chemicals, mercury, batteries). Hospitals seeking to segregate hazardous wastes are left with little or no option for safe disposal. The development of an industry which is capable of managing hazardous waste (chemicals) is essential. On-site reprocessing technology is available for hospitals for materials such as xylene or formalin, and recovery technology for silver from developing solution. These technologies may be cost prohibitive at this time. Pollution prevention and the choice of nonhazardous or less hazardous material is the only real option left to hospitals, which should be followed regardless of the existence of a hazardous waste industry.

10. Infrastructure For Safe Disposal For Municipal Solid Waste:
Health care facilities need to be able to tie into a municipal system of proper waste management to ensure that they are meeting their mission of providing for the public health. Until such an infrastructure exists there are numerous decisions and actions that any hospital can make (listed above) to begin the process of improving their waste management
practices and ensuring public health and worker safety today.

The range of policy initiatives needed should be:
1. To ensure that the regulation is implementable, is supported by regulatory bodies, and to both provide adequate time for change as well as be punitive enough.
2. To ensure an access to clean disposal technologies and clean medical products - which do not create undesirable waste - so that the sector can benefit from them. These include a rational customs duty and excise structure.
3. Addressing worker safety issues though procedures, information and training and through involving various stakeholders such as nurses and wardboys without whom no waste system can hope to succeed.
4. An accreditation system for health care units, for the waste management system can only be as good as other systems within the hospital.
5. Helping in the development of medical waste product and technology industry to ensure their availability at a competitive local price, and a good support base.
6. Incorporating training and awareness through on-going programs and incorporating waste management focuses in course curriculum.
7. The development of safe and reliable transport and collection systems for hospital waste to support the sharing of facilities and the setting up of common treatment facilities. Also this needs to ensure basic polluter liability issues.
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