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*Original Research Article*

# A Study on Waste Treating Technologies Used For Disinfecting the Bio-Medical Waste in Greater Mumbai

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## ABSTRACT

Management of health care waste has become an integral part of an infection control and hygiene program in health care settings as they are the major contributors of community acquired diseases such as HIV, Hepatitis B and Tuberculosis to name a few. These healthcare organizations generate a large amount of bio-medical waste daily that has to be disposed off safely by disinfecting it before it is sent to the dumping ground so as to protect the community from these dreadful diseases.
The present study has made an attempt to study the three bio-medical waste treating technologies used by Bombay Municipal Corporation (BMC) for disinfecting the healthcare waste generated in hospitals of Greater Mumbai. The main objective of the study is to compare the three technologies mainly Autoclave, Hydroclave and Incinerator on the basis of their economical, technological, social & environmental effectiveness. The economic effectiveness is assessed by calculating per unit cost of disinfecting bio-medical waste. For evaluating technological, social and environmental effectiveness, Environmental Impact Assessment is carried out.

***Key Words:*** Biomedical waste treating technology, cost effective analysis, environmental impact assessment.

## 1. INTRODUCTION

The speedy increase in incidences of killer diseases such as AIDS, Hepatitis B and Tuberculosis with exposure to discarded needles, syringes and other medical wastes, safe disposal of biomedical waste has become an important public issue. Bio-medical waste still finds its way to road side heaps of rubbish where it mixes with municipal solid waste, rendering it hazardous for the environment and the public.

Looking at the scenario, governments of various countries have formulated strict rules and regulations for disposal of biomedical waste. All the healthcare organizations are required to get their biomedical waste disinfected before its disposal to the dumping ground.
As installation of medical waste treating facility by individual health care organizations is not possible due to high investment, common treatment facility is extended by the government to all the health care organizations in each city.

With governments around the world fighting to reduce deficit spending and inflation, financial and operational issues are of great importance in selecting capital intensive medical waste treating technologies. Many more factors are to be considered in selecting the said technologies.
They include:

- Need to comply with clean air act requirement in order to avoid harmful emissions of air pollutants.
- Need to prevent possible improper disposal of untreated biomedical waste in landfills, in open dumps or by informal recyclers/scavengers.
- Need to properly disinfect biomedical waste to prevent transmission of dangerous diseases.

Thus a full economic analysis can help us to decide which option is more efficient by comparing and analyzing the cost and outcomes of the alternative courses of action.

The present study is one of the humble efforts taken in this direction, where cost effectiveness analysis of medical waste treating technologies has been undertaken. This approach is selected as these technologies render many unquantifiable benefits that are difficult to measure in monetary terms.

**2. Objectives of the study:**

- To compare the three waste treating technologies on the basis their economical, technological, social and environmental effectiveness.
- To assess the economic effectiveness of the technologies by calculating unit cost of the treated infectious waste.
- To evaluate the technological effectiveness and social and environmental effectiveness of the three waste treating technologies by using Environmental impact assessment (EIA).

## 3. REVIEW OF LITERATURE

Though many researches have been undertaken by research scholars, some the related studies are cited below:

Many extensive studies are undertaken regarding use of incinerator in our country by eminent researchers. Chaturvedi Bharti, Agarwal Ravi (1996), Tomar Shipha, NSS unit of St. Xaviers College, Mumbai (2000), TomarShipha, GoelAnu (2000), Sabhapathy A. K. (2002), Vijya. K (2002), Upendra Tripathy, Times News Network (2002), DeepikaD'souza, Ayushman, Ratna Singh, Shikha, Megha and Ravi Agarwal (2002), Srinivas Chary V. (2002), Chitnis V, Chitnis. D.S, Patil.S, Chitnis. S (2002, According to Times News Network (2003), Dogra Sapna (2004), Ravi Agarwal of NGO Toxics Link, Kamdar Seema (2004) have investigated the status of incineration in big cities like Mumbai, Delhi, Pune and Nagpur. All these studies show that incinerators do not comply with bio-medical waste management rules

**SKM Rao, RK Ranyal, SS Bhatia, and VR Sharma (2004**) carried out a survey of hospitals from various sectors like Govt, Private, Charitable institutions etc. to assess the infrastructural requirement for BMW Mgt. Cost was worked out for a hospital where all the infrastructure as per each and every requirement of BMW rules had been implemented and then it was compared with other hospitals where hospitals have made compromises on each stage of BMW Management. They found that a benchmarked hospital of 1047 beds incurred Capital cost about Rs.3 lakh 59 thousand which excluded the cost of incinerator and hospital incurred Rs. 656/- per day as recurring expenditure. Pune city had common regional facility for BMW final disposal. Facility charged Rs.20 per kg of infectious waste. As on Dec 2001 there were 400 institutions including nursing homes, labs and blood banks which were registered. After analyzing the results of study it was felt that there is an urgent need to standardize the infrastructural requirement so that hospitals following BMW rules strictly do not suffer additional costs.

**According to Gautam V, Thapar R, Sharma M. (2010)** most medical waste is incinerated, a practice that is short-lived because of environmental considerations. Medical waste incinerators pollute the environment by emitting toxic air pollutants in the air and sending the toxic ash residues to landfills for disposal that have the potential to leach into groundwater. Medical waste has been identified by US Environmental Agency as the third largest

known source of dioxin air emission that affects the local environment.

International Agency for Research on Cancer (IARC), an arm of WHO, acknowledged dioxins cancer causing potential and classified it as human carcinogen.

They highlighted the public concerns about incinerator emissions, and the creation of federal regulations for medical waste incinerators and suggested healthcare authorities to rethink about their choices for medical waste treatment and as stated by Health Care Without Harm go for non-incineration treatment technologies.

The BMW (Management and Handling) Rules, 2000 recommend autoclaving for disposables, microbiological waste and sharps. They also made it very clear that before assessing any technology one should be very careful about development of waste management policies, careful waste segregation and training programs, as well as attention to materials purchases that are very essential for minimizing the environmental and health impacts of any technology.

**Anurag V. Tiwari Å, and Prashant A. Kadu B (2013)** studied the classification, legislation and management practices in relation with biomedical waste in India. They concluded that incineration of biomedical waste is one of the most commonly adopted methods of treatment in India as it has low cost but impacts environmental adversely. Other than incineration the methods such as autoclave treatment, microwave treatment, dielectric heating, Depolymerization, Pyrolysis-Oxidation, etc are used by some of the hospitals in some cities of India.

**Kirti Mishra, Anurag Sharma, Sarita, Shahnaz Ayub, (2016)** carried out an analytical study of various techniques used for biomedical waste management along with the knowledge and attitude of people and healthcare workers. They found that many primary care, secondary care and tertiary facilities are in RED category and there for a lot of efforts are necessary to improve the biomedical waste management across all over country.

The state of BMW Management at primary care health facilities indicates requirements of major inputs for improvement. The situation was worst in rural areas. Public sector providers in rural areas had better BMW Management system then counterparts in urban areas. In contrast, there was almost complete lack of biomedical waste management system in private sectors in rural areas. They concluded by stating that each and every healthcare facilities which generates biomedical waste, needs to set up requisite treatment facilities to ensure proper treatment of wastes and its disposal so as to minimise risk of exposure to staff, patients, doctors and the community from biomedical hazards.

## 4. METHODOLOGY

The data regarding the three technologies was collected by using Interview and observation methods. A structured interview schedule was personally filled in by the investigator by interviewing the in-charge administrators and helpers operating these plants. The investigator recorded the data regarding functioning and the process of the three technologies by visiting and observing the plant process. Technical information was secured by interviewing the manufacturers of the technologies informally. Even public perception regarding the effect of the technologies on human lives and their surroundings was recorded by conducting informal interviews of the people residing near the plant sites.

## 5. Analysis of the data:

For assessing economic effectiveness of the three biomedical waste treating technologies, per unit cost for disinfecting the infectious waste is calculated by taking non-recurrent and recurrent costs into consideration.

For identifying and measuring technological effectiveness, social effectiveness and environmental

effectiveness, environmental impact assessment is carried out. Weighting-rating approach is used for evaluation and comparison of the selected waste treating technologies. The weighting rating method refers to methodology that embodies the assignment of relative importance weights to each decision factor and rating them in terms of impact of these decision criteria on each technical and environmental factor. The rating for various alternative technological and environmental factors is modified into "aspect sensitivity index" as the costs and benefits of these technologies are not known with certainty.

The importance weights for each decision factor is thus multiplied by the rating of each alternative and the resulting products (scores) for each alternative are then totaled to develop an overall composite index or final score for each medical waste treating technology.

Mathematically the composite index is represented as:

$$\text{Composite index} = \sum_{i=1}^{n} W_i * "ASI_i"$$

Where "Composite index" shows the technological/ social & environmental effectiveness for comparing the technologies.

"$W_i$" is the importance weight of the decision factor

"$ASI_i$" is the Aspect Sensitivity Index.

The decision factors considered for estimation of technological effectiveness are:

- Process capacity
- Waste exclusion
- Waste limitation
- Waste change
- Volume change
- Disfigurement and dryness
- Decontamination
- Performance data
- Process complexity and
- Operator training.

The decision factors considered for social and environmental effectiveness are:

- Air emission
- Liquid effluents
- Treated residue
- Permeability
- Public perception and
- Occupational health and safety issues.

Economic, Technological, Social and Environmental effectiveness was thus calculated for all the three medical waste treating technologies namely the Autoclave, the Hydro-clave and the Incinerator. The table given below shows the technological effectiveness analysis of Bio-medical waste treating technologies.

**Table: 5.1 Preference Matrix for Technological effectiveness of Biomedical Waste Treating Technologies**
**W** = Importance Weight age **ASI** = Aspect Sensitivity Index **Score** = W X ASI

| | **Auto clave** | | | **Hydro clave** | | | **Incinerator** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Technological aspects** | **W** | **ASI** | **Score** | **W** | **ASI** | **Score** | **W** | **ASI** | **Score** |
| a) Process Capacity | 70 | 0.25 | 17.50 | 70 | 0.75 | 52.5 | 70 | 0.50 | 35 |
| b) Waste Exclusion | 100 | 0.50 | 50 | 100 | 0.50 | 50 | 100 | 0.25 | 25 |
| c) Waste Size Limitation | 80 | 0.50 | 40 | 80 | 0.25 | 20 | 80 | 0.25 | 20 |
| d)Waste hange (reduction) | 100 | 1 | 100 | 100 | 0.25 | 25 | 100 | 0.25 | 25 |
| e) Volume Change (reduction) | 100 | 1 | 100 | 100 | 0.25 | 25 | 100 | 0.25 | 25 |
| f) Disfigurement & dryness | 130 | 0.75 | 97.5 | 130 | 0.25 | 32.5 | 130 | 0.25 | 32.5 |
| g) Decontamination | 180 | 0.50 | 90 | 180 | 0.25 | 45 | 180 | 0.25 | 45 |
| h) Performance Data | 80 | 0.25 | 20 | 80 | 0.25 | 20 | 80 | 1 | 80 |
| i) Process Complexity | 80 | 0.50 | 40 | 80 | 0.25 | 20 | 80 | 1 | 60 |
| j)Operator Training | 80 | 0.50 | 40 | 80 | 0.25 | 20 | 80 | 0.75 | 60 |
| **Total** | | | **595** | | | **310** | | | **407.5** |

Highest value of each scale is taken as impact sensitivity index for the decision factor so as to make calculations easy. The score for each decision factor is obtained by multiplying its importance weight age and the impact sensitivity index. The overall score is then obtained by summation of the scores of all the decision factors under consideration. The overall score or the composite index indicates the technological

effectiveness of all the three waste treating technologies to be compared.

Table 1 reveals the overall technological effectiveness scores as 595, 310 and 407.5 for the autoclave, Hydro-clave and the incinerator respectively. This shows that Hydro-clave is technologically superior to the incinerator and the autoclave. Though incinerator looks to be technologically better than the autoclave according to the composite index scores but it is more costly and dangerous while autoclave is eco-friendly and more acceptable to the public.

The table given below shows the social & environmental effectiveness analysis of Bio-medical waste treating technologies:

**Table: 5.2 Preference Matrix for Social & Environmental Effectiveness of Biomedical Waste Treating Technologies**
**W** = Importance Weight age **ASI** = Aspect Sensitivity Index **Score** = W X ASI

| **Social & Environmental aspects** | **Autoclave** | | | **Hydro clave** | | | **Incinerator** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **W** | **ASI** | **S** | **W** | **ASI** | **S** | **W** | **ASI** | **S** |
| a) Air emissions | 280 | 0.25 | 70 | 280 | 0.25 | 70 | 280 | 1 | 280 |
| b) Liquid effluents | 220 | 0.50 | 110 | 220 | 0.25 | 55 | 220 | 0.75 | 165 |
| c) Treated Residue | 200 | 0.50 | 100 | 200 | 0.25 | 50 | 200 | 1 | 200 |
| d) Permeability | 80 | 0.25 | 20 | 80 | 0.25 | 20 | 80 | 1 | 80 |
| e) Public perception | 100 | 0.25 | 25 | 100 | 0.25 | 25 | 100 | 1 | 100 |
| f)Occupational Health & Safety issues | 120 | 0.50 | 60 | 120 | 0.25 | 30 | 120 | 0.50 | 60 |
| **Grand Total** | **1000** | | **385** | | | **250** | | | **885** |

The overall social & environment effectiveness is estimated to be 385, 250 and 885 for autoclave, Hydro-clave and the incinerator respectively and therefore it may be concluded that the most eco-friendly waste treating technology is the Hydro-clave and then the autoclave. Incinerator has many adverse effects on the environment.

The table given below shows the over-all cost effectiveness analysis of Bio-medical waste treating technologies:

**Table 5. 3 Cost Effectiveness Analysis of Bio-medical Waste Treating Technology**

| Type of Effectiveness | **Autoclave** | | | **Hydroclave** | | | **Incinerator** | | |
|---|---|---|---|---|---|---|---|---|---|
| | I.W. | ASI | Score | I.W. | ASI | Score | I.W. | ASI | Score |
| Economic Effectiveness | 300 | 0.25 | 75 | 300 | 0.25 | 75 | 300 | 0.75 | 225 |
| Technological Effectiveness | 350 | 0.60 | 210 | 350 | 0.30 | 105 | 350 | 0.50 | 175 |
| Social and Environmental Effectiveness | 350 | 0.40 | 140 | 350 | 0.20 | 70 | 350 | 0.90 | 315 |
| Total Score (1000) | | | 425 | | | 250 | | | 715 |

Where I.W.: represent Importance weights
ASI: represents the Aspect Sensitivity Index

The table clearly shows that economic effectiveness score for Autoclave, Hydro-clave and incinerator is 75, 75,225 respectively. This reveals that cost of per kg treatment is maximum for Incinerator while cost of disinfecting the waste is same for Autoclave and Hydro-clave is same.

The scores for technological effectiveness are 210, 105 and 175 for Autoclave, Hydro-clave and Incinerator respectively revealing that Hydro-clave is technologically very effective as compared to other two technologies.

The table also clearly shows that the scores for Social and Environmental effectiveness are 140, 70 and 350 for Autoclave, Hydro-clave and the Incinerator respectively indicating that Hydro-clave has maximum Social and Environmental effectiveness.

## 6. CONCLUSION

The study results reveal that Autoclave and Hydroclave as bio-medical waste treating technologies are economical, technologically sound and eco-friendly and thus are cost effective technologies. The incinerator is uneconomical, technologically complex and not eco-friendly and therefore discouraged. Many other researches in this field have also arrived at similar conclusion and therefore incinerator as Bio-medical waste treating technology is banned in some of the western countries while publicly opposed in many countries.

## 7. Suggestions:

Though Incinerator is widely used as bio-medical waste treatment technology in our country, its use should be discouraged as it releases toxic emissions if not operated efficiently and use of recently developed alternative waste treatment technologies such as Autoclave, Hydro-clave, Chemical Disinfection , Microwave Irradiation should be encouraged. The final selection of any waste treating technology should be thus made very carefully.

While selecting a waste treatment technology, following criteria should be borne in mind:

- Disinfection efficiency
- Investment, Operating and maintenance costs
- Occupational health and Safety
- Health and Environmental Impact
- Location and Surroundings of treatment site and disposal facility
- Public acceptability
- More researches should be undertaken in the field of study regarding Bio-medical waste treatment technologies.

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