



Toxics Link  
for a toxics-free world

# Understanding and simplifying bio-medical waste management

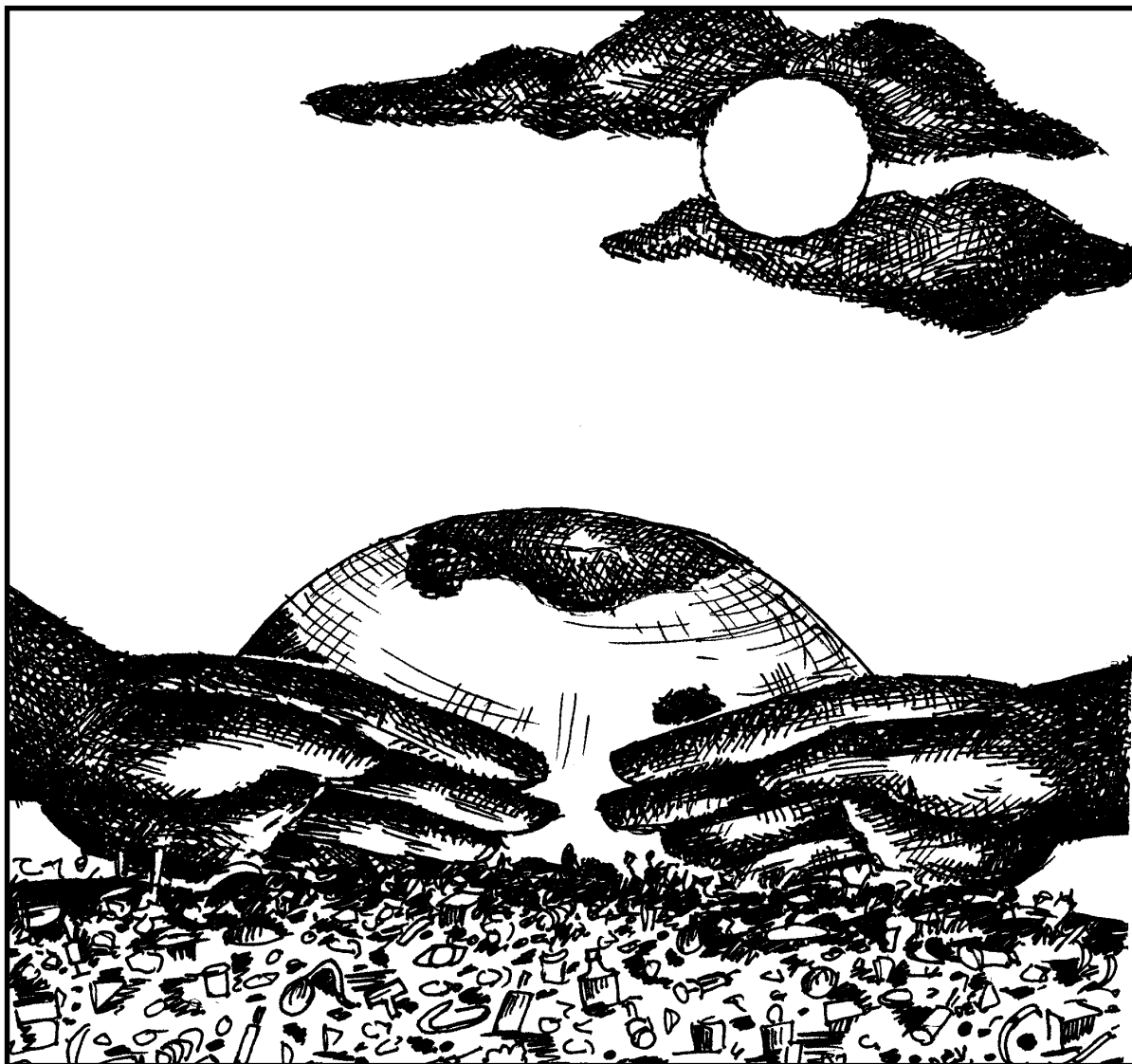
A training manual for trainers





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Toxics Link, January 2005

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## **About Toxics Link**

Toxics Link is an environmental NGO, dedicated to bringing toxics related information into the public domain, both relating to struggles and problems at the grassroots as well as global information to the local levels. We work with other groups around the country as well as internationally in an understanding that this will help bring the experience of the ground to the fore, and lead to a more meaningful articulation of issues. Toxics Link also engages in on-the ground work especially in areas of municipal, hazardous and medical waste management and food safety among others. We are also involved in a wider range of environmental issues in Delhi and outside as part of a coalition of non-governmental organisations.

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# Acknowledgements

**W**e would like to thank the various hospitals and state governments which provided us the wonderful opportunity to conduct training programmes around the country; this manual is a result of the experience and skills gathered and honed during these training programmes. Our special thanks to Dr. Glenn Mc Rae and Dr. Jorge Emmanuel of Healthcare Without Harm for reviewing specific text of this manual. And foremost to all the trainees who brought several practical issues to our notice and helped us improve the manual through their suggestions. Not to forget the entire Toxics Link family which was always supportive.

# An introduction to this manual

**T**he issue of medical waste management was first taken up in India around 1995. A lot has changed since then in the way medical waste is handled, stored, treated and disposed.

An important catalyst to this change have been the Bio-medical Waste (Management & Handling) Rules 1998. Framing the rules was one important aspect of waste management, but implementing the rules required that the medical fraternity understood the rules and adopted them into their professional environments. This was possible only through large-scale training of medical staff. Considering the geographical spread of India, and the size of its medical sector, this has been, and continues to be, a challenging task.

Srishti, a programme of Toxics Link, has played its part in training healthcare professionals regarding medical waste management and the implementation of management systems in hospitals and other medical institutions. Srishti emphasises the importance of managerial interventions and staff dedication to bring about efficient waste management practices. It works towards dispelling the belief that technology is the only solution for medical waste management.

As our work with various hospitals has progressed, the training needs have also increased. As a result, training has gradually become one of our focal areas. We have learnt from each

training session; every hospital has its unique problems and challenges. As we attempted to resolve particular problems, and respond to the queries of the hospital staff, we enhanced our understanding of the practical problems and the unique needs of healthcare institutions. This helped us evolve our training methodology as well as its content.

Apart from training hospital staff, we have also conducted various Training of Trainers (ToT) programmes all around the country, in association with various hospitals and Pollution Control Boards/ Committees. These programmes create a brigade of trainers who act as ambassadors and take the message of waste management forward.

By the end of such sessions, trainees are exposed to a lot of information, but they do not have enough time to assimilate everything. Once they return to their workplaces, they have expressed the need for a comprehensive resource on training. This manual has been compiled to fulfill their requirement.

The main aim of the manual is to ensure that every healthcare worker and other stakeholders are aware of the hazards associated with improper bio-medical waste management.

The manual has been produced to provide a convenient, up-to-date training resource that will allow interested people and trainers to increase

**The main aim of the manual is to ensure that every healthcare worker and other stakeholders are aware of the hazards associated with improper bio-medical waste management.**

awareness on waste management and related issues at every level in their organisation.

The Training manual has six sections and each section has slides on a particular topic. Most of the points in the slides are self explanatory, but some of them, which may need explanations, have descriptive notes.

This manual would keep evolving to address newer issues as experience in this field grows. Your suggestions and comments on the manual would therefore be highly appreciated.



# How to use this resource

**T**he manual has been divided into logical sections. Beginning with an overview that introduces the audience to the history of bio-medical waste and its management, the manual moves on to the issue of implementing bio-medical waste management in a hospital and the issues around it. This section deals with segregation of waste, its transportation, management policies at hospitals and techniques that a hospital could follow to have a successful bio-medical waste management programme.

The Training of Staff section that follows focuses on specific kinds of bio-medical waste, such as sharps, glutaraldehyde and cytotoxic drugs. Each kind of waste is discussed, and the hazards associated with it are elaborated.

The next section, Aspects of Waste Management deals with managing each kind of bio-medical waste. This includes the processes to be followed and the precautions to be taken for different waste categories.

After this, the manual spells out the Rules and Policies that apply to medical institutions. This section is appropriate while training senior managerial staff at hospitals.

Alternative Technologies for waste treatment are discussed in a separate section. This section introduces the hospital staff to emerging technologies in the area of waste management.

Since incineration of bio-medical waste is a serious issue, we have devoted an entire section to this burning issue.

Each of the above mentioned training modules are provided as PowerPoint presentations in the accompanying CD. The slides of the presentations also have hyperlinks to relevant pictures that visually depict a point. Depending on the resources available, trainers can either print out the slides and pictures or use a computer to make the presentations.

The manual also provides supporting material to key slides of each section. The trainer should study the section for which s/he wants to conduct a training session and familiarise herself/himself with the issues concerned. The level of elaboration of each slide and discussions around the topics will obviously depend on the kind of audience, its needs, knowledge-base and the purpose of the training. The trainer is expected to exercise discretion in making such decisions.

The trainer should be able to select a set of slides appropriate for a particular session. Some seminars, lecture series, discussion forums may need discussion on a particular issue. The specific sections can be in such sessions.

A few miscellaneous slides have also been provided. These slides can be used if a discussion starts to build around these topics in a training session.

# Suggested training mechanisms

## **Our experience with training**

We have dealt with a diverse audience while conducting training sessions on waste management: from medical students to practicing professionals, and ward boys to nursing staff. Each group required a different approach. It is important to consider the background of the audience you are about to train, and prepare the sessions in accordance with their knowledge levels, ability to grasp concepts, language and openness to new ideas.

## **Training nursing students**

Students respond well to a classroom situation. A question answer format is ideal for such an audience, as they enjoy the interactivity and are eager to display the knowledge that they have. Usually, a little guidance is required to channelise them into the right direction. Students are also very open to fresh ideas and are naturally inquisitive about developments in the 'real' world.

An effective technique is to approach the training as a problem-solving session.

## **Training ward boys**

Usually, this group responds well when the issues are connected to their daily routines and problems. It is a good idea to begin the session with listening to their problems, even if they are

not necessarily related to waste management. A sympathetic ear makes them shed their inhibitions, and be more open to the session.

The written word is best abandoned with this group. Innovative methods such as street plays are very effective, as this group responds well to drama and visual forms. One will find that this group will make valuable suggestions that can be adopted while setting up a waste management scheme.

## **Training with doctors**

Doctors require a more academic approach, which has well-researched data and working examples from other institutions.

Information about various international conventions, global movements and negotiations are required to convince them about the importance of waste management.

Often, they feel that the sessions are an imposition on them, therefore, their time should be respected and the sessions should be highly professional.

## **Training with staff nurses**

Training with staff nurses is the most critical as they form the backbone of the waste management system in a hospital. Nurses are generally quite interested and active. However, they might

be in a hurry if they are required to attend the sessions after their shift. The timing of the training should be carefully chosen to avoid such issues. When it cannot be avoided, the sessions must be made interesting through the use of various tools such as quizzes, placards, etc.

One can have nurses enact a particular procedure and dispose off waste generated during the course. Or one can have photographs of good and bad practices and ask people to point out problems in the photograph and suggest corrections. If trainees know that a quiz would follow the training session they are generally more alert during the trainings.

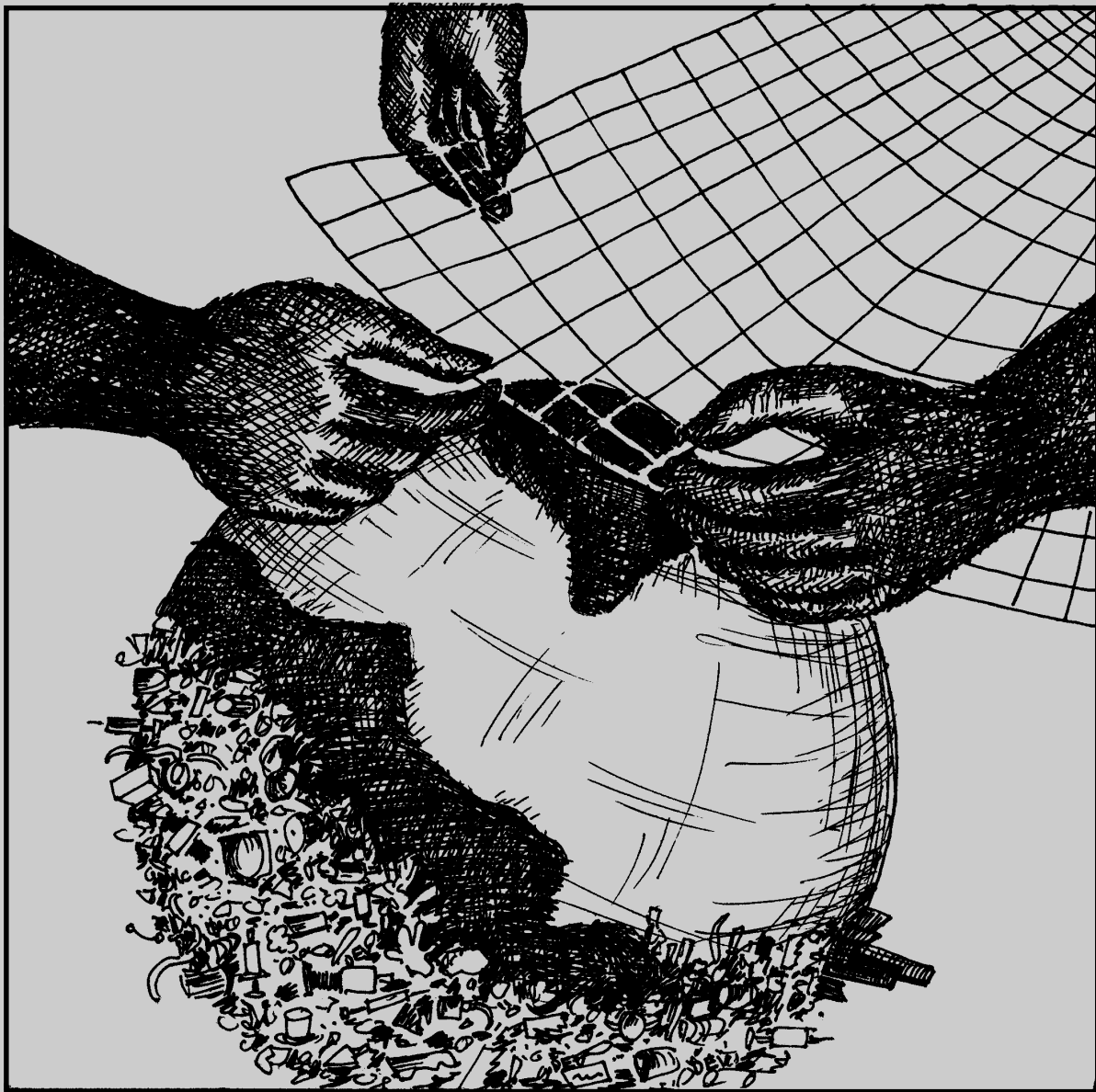
Any training can be made more effective with a good trainer, training tools and techniques. Thus the trainer should have good communication skills and should be able to mould the style of the presentation according to the target audience.

Visual aids help demonstrate good practices effectively. Representatives from another hospital which is following a sound waste management system can be called for sharing their experience.



# *Section A*

## **An overview of bio-medical waste management**



# A1 An overview of bio-medical waste management

**T**he public concern with medical waste dates back to the late 1980s when large quantities of syringes and needles were found on the beaches of east coast Florida, USA. About the same time, the HIV/AIDS epidemic was rearing its head and healthcare professionals were waking up to its enormity. The public outcry following the discovery of the needles, led to the formulation of the US Medical Waste Tracking Act (MWTa), which came into force on November 1, 1988.

A quick-fix solution that was employed was to buy and install small on-site incinerators. Retired incinerators were also resurrected, and in some cases more waste was added to the existing incinerators. Many of these incinerators were unregulated. A number of them had few, if any, pollution control devices. In the early 1990s the United States Environment Protection Agency (USEPA) estimated that there were some 6,000 hospital incinerators operating in USA.

Incineration, too, was opposed by communities living close to them as they were found to be seriously harming the health of people. Study after study exposed the hazards of incineration, and linked them to emissions of cancer-causing dioxin and furan. As a result, incinerators were phased out. By 2003 the number of incinerators in USA had come down to just about 115.

[compilation by Dr. J. Emmanuel]

In India, concern for medical waste was an outcome of judicial and NGO interventions. Ministry of Environment and Forests came out with the first draft rules on bio-medical waste in 1995. It was the first time that medical waste was addressed as a category separate from municipal waste.

The problem with this draft was that it laid too much emphasis on incineration. All hospitals having 80 or more beds were asked to install on-site incinerators. Timely intervention by NGOs (Srishti being one of them), helped change this draft. The final rules had provisions for alternative technologies, standards for all listed technologies and centralised facilities for bio-medical waste treatment.

Concern about the environmental and health risks of medical waste incineration has increased in recent years as a number of studies have shown that incinerators are a major source of extremely toxic dioxin and other pollutants. In industrialised as well as less-industrialised countries, growing movements of health workers, labour and environmental advocates, and concerned citizens have called for the replacement of medical waste incinerators with cleaner, safer and less expensive alternatives.

In fact, NGOs have been lobbying for zero incineration facilities for medical waste treatment.

One problem with bio-medical waste has been that it has a complex composition, and one type of waste can easily contaminate another, making it difficult to manage the waste. Around 80-90 per cent of waste generated in a hospital is general waste, and the remaining 10-20 per cent can be infectious and/or hazardous (for example, cytotoxic, chemical and radioactive waste). This breakup of waste also depends on the type of hospital and the facilities it has.

The different types of bio-medical waste generated at a single medical establishment requires different kinds of treatment technologies. It is highly impractical to expect each hospital to invest in these different technologies. This has led to the concept of centralised waste treatment facilities.

The idea was mooted years ago, and as these facilities were being established, the second amendment to the Bio-medical Waste (Management and Handling) Rules came out with some new clauses for establishment of such facilities. As a number of these units started operating and countrywide experience started pouring in (regarding the problems being faced by the authorities, operators, subscribers, NGO observations, etc.), it was realised that some standards/guidelines were required for such facilities. Thus, in addition to the national guidelines for implementation of the rules, two new guidelines – Guidelines for Centralised Bio-medical Waste Treatment Facilities and Guidelines for Construction and Operation of Incinerators – were drafted by the Central Pollution Control Board.

At the same time, NGOs were demanding the elimination of incineration as a treatment option for bio-medical waste. Srishti compiled a national survey on incineration conducted by four members of HuMAN (Health and Us – Medical Waste Action Network): Chennai based CAG (Citizen consumer and civic Action Group); MMAG (Mumbai Medical

Waste Action Group); Thanal, Trivandrum and Srishti, New Delhi.

This survey was presented to the Ministry of Environment and Forests and the Central Pollution Control Board (CPCB) asking for a ban on incinerators. The CPCB wrote to all its state boards to discourage any new on-site incinerators, and later, during the course of finalisation of the draft on guidelines for centralised facilities, incineration was limited from five to three categories of bio-medical waste.

The new guidelines on incineration are very comprehensive and it would be economically unviable now to install any new on-site incinerators. The guidelines make it clear that on-site incinerators would not be allowed, other than in exceptional conditions where special approval would have to be sought from CPCB.

## **Slide 2: Various networks**

Worldwide, various organisations and networks are working to transform the healthcare industry so that it is not a source of harm to public health.

Safe Injection Global Network (SIGN) is a coalition of several public and private partners, including WHO, UNICEF, UNAIDS, NGOs, governments, and health workers. It was formed in Geneva in October 1999 to focus on injection safety, of which safe disposal is an important component.

Another network called Global Alliance for Incineration Alternatives, or Global Anti-Incineration Alliance (GAIA) is an international network of NGOs working against incineration and is trying to promote safer alternatives to treat bio-medical waste.

Healthcare Without Harm (HCWH) is an international coalition of NGOs, hospitals,

medical professionals, community groups and labour unions working on ecologically sustainable healthcare systems. Medical waste is one of their focus areas.

In India, too, environmental organisations and individuals have come together to form Health and Us - Medical Waste Action Network (HuMAN). This is a network of NGOs, academicians, practitioners, etc, lobbying for safe medical waste practices in the country. Its aim is to take the message of safe management of healthcare waste to the grassroots.

### Slide 3: What is this concern for?

*Infectious waste* is suspected to contain pathogens (bacteria, viruses, parasites or fungi) in sufficient concentrations to cause disease in susceptible hosts.

*Sharps* are items that could cause cuts or puncture wounds. They include hypodermic needles, scalpels and other blades, knives, infusion sets, saws, broken glass, and nails. They are considered highly hazardous whether they are infected or not.

*Cytotoxic* drugs have the ability to stop the growth of certain living cells and are used as chemo-therapeutic agents. They are carcinogens and can also be mutagenic. Any material used to handle these products and contaminated in due course would also need to be disposed off in the same manner.

*Pharmaceutical waste* includes expired, unused, spilt and contaminated pharmaceutical products, drugs, vaccines and sera that are no longer useful.

*Radioactive waste* includes solid, liquid, and gaseous materials contaminated with radionuclides. Radioactive healthcare waste usually contains radionuclides with short half-

lives which lose their activity relatively quickly. Radioactive waste is generally produced in in-vitro analysis of body tissue and fluid, in-vivo organ imaging and tumour localisation, and various investigative and therapeutic practices.

The type of disease caused by radioactive waste is determined by the type and extent of exposure. It can range from headache, dizziness and vomiting, to much more serious problems. Radioactive waste is also genotoxic and handling of active sources may have severe consequences such as the destruction of tissue.<sup>1</sup>

*Chemicals* are generally used in diagnostic and experimental work, and in cleaning, house-keeping and disinfecting procedures. Many chemicals and pharmaceuticals used in hospitals are hazardous. They are termed hazardous if they have any one of the following properties: toxic, corrosive, flammable, reactive, genotoxic. Examples of such waste are formaldehyde, glutaraldehyde and photographic chemicals.

They may cause injuries, including burns. Disinfectants are particularly important members of this group as they are used in large quantities and are generally corrosive.<sup>2</sup>

### Slide 4: Know your waste

According to various estimates and surveys around 80-90 per cent of hospital waste is general waste and 10-20 per cent is infectious/hazardous. Of this, 15-20 per cent is pathological and infectious waste, one per cent is sharps waste, three per cent chemical/pharmaceutical and less than one per cent is special waste such as radioactive, cytotoxic drugs, etc. These percentages may be higher or lower depending on the type of hospital (for example, teaching, research and large general hospitals will have higher quantities of these wastes, while rural and small speciality hospitals may have much lower quantities).<sup>2</sup>

→ 1. Safe management of waste from healthcare activities, A. Pruss et al, WHO, 1999.

→ 2. Safe management of waste from healthcare activities, A. Pruss et al, WHO, 1999.



## Slide 5: Impacts of hospital waste

All individuals exposed to hazardous healthcare waste are potentially at risk. This includes persons within healthcare establishments and those outside these sources who either handle such waste or are exposed to it as a consequence of careless management. The main groups at risk include doctors, nurses, patients, visitors to the hospital, workers in support services allied to hospitals like the laundry, workers in waste disposal facilities, etc.

The hazards associated with scattered, small sources of healthcare waste should not be overlooked; this can include waste generated by home-based healthcare.

## Slide 7: Concerns in infectious waste

Infectious waste may contain pathogens in sufficient concentration to cause disease. Infectious waste would include cultures and stocks of infectious agents from laboratory, pathological waste (tissues, organs, body parts, human foetus, animal carcass from research facilities, blood and body fluids) and sharps waste.

Pathogens in waste can invade the body through various routes, including a puncture, abrasion or a cut in the skin, through the mucous membrane or by inhalation/ingestion. Body fluids can act as transmission vehicles for various pathogens as listed in slide 17.

Infectious waste from hospitals is problematic because laboratories harbour not just resistant strains, but also concentrated cultures of microorganisms. Existence of bacteria resistant to antibiotics and chemical disinfectants contributes to the hazards. It has been demonstrated that plasmids from laboratory strains contained in healthcare waste were transferred to indigenous bacteria via the waste disposal system.<sup>2</sup>

## Slide 10: What are sharps?

Anything that can cause a cut or a puncture wound is classified as 'sharps'. These include needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, broken glass, and nails. Whether or not they are infected, sharps are usually considered highly hazardous healthcare waste because they have the potential to cross the passive and primary immunology barrier of the body – the skin – and thus establish contact with blood. Because of this double risk of injury and disease transmission sharps are considered very hazardous.

The principal concerns are infections that may be transmitted by subcutaneous introduction of the causative agent, for example, viral blood infections. Hypodermic needles constitute an important part of the sharps waste category and are particularly hazardous because they are often contaminated with blood.<sup>3</sup>

## Slide 11: Sero-conversion following exposure

Sero-conversion means the percentage of healthcare workers developing the infection after being exposed to body fluids from a proven infective source. These rates have been documented by carrying out a follow-up of healthcare workers with occupational exposure to blood from a patient positive for a particular blood-borne pathogen. For instance, in the case of exposure to a HIV positive patient, the healthcare worker would be tested for HIV antibodies at the time of exposure (baseline testing) and at periodic intervals for 12 months. (Also refer to slide 10 of the section titled *Training hospital staff*).

## Slide 14: Reuse

Unsafe injection practices transmit blood-borne pathogens such as Hepatitis B, Hepatitis

→ 3. Safe management of waste from healthcare activities, A. Pruss et al, WHO, 1999.

C and HIV. Globally, nearly two per cent of all new HIV infections are caused by unsafe injection practices with a total of 96,000 people infected annually.<sup>4</sup>

Reuse of syringes and needles, without their sterilisation, exposes millions of people to the risk of these infections.

The problem of unsafe injection practices can be overcome only by bringing about a change in the behavior of healthcare workers and patients, by ensuring availability of equipments and supplies and by managing the waste generated appropriately and safely.<sup>4</sup>

*For more information visit the Safe Injection Global Network website: [www.injectionsafety.org](http://www.injectionsafety.org)*

### Slide 18: Exposure hazards

The use of radiation sources in medical and other applications is widespread throughout the world. Occasionally, the public is exposed to radioactive waste (usually originating from radiotherapy treatments) that has been disposed off improperly. Serious accidents have been documented in Goiânia, Brazil in 1988 where four people died from acute radiation syndrome and 28 suffered serious radiation burns. Similar accidents happened in Mexico City in 1962; Algeria in 1978; Morocco in 1983 and Ciudad Juárez, Mexico in 1983.<sup>5</sup>

### Slide 21: Mercury

Mercury is used in medical equipment and in dental amalgams. It is a neuro- and nephro-toxic substance. It affects the nervous system and can impair the way we talk, hear, see, walk, feel and think. Humans are exposed to mercury through contaminated air, water or food, or directly through the skin.

In the case of mercury spills, personnel get

exposed and they do not have the capacity to handle either the spill or the exposure. World over, there is a shift to products which do not use mercury. For details refer to the slides on mercury in the Training section.

### Case Studies

Three children, ranging from 20 months to six years, were exposed to mercury from a thermometer spilt on the carpet. They developed symptoms of sensitivity to light, weight loss, sweating and scaling palms, eczema and itching. The two more severely affected required four months of therapy for a complete recovery.

In another instance, 1.1 gram of mercury collected from a broken thermometer was collected in a pan and placed over a hot stove. Two elderly patients, who were exposed to the resulting mercury vapours, developed severe pulmonary edema, confusion, tremors and coma and died after seven and 17 days of hospitalisation, respectively.

### Slide 22: Glutaraldehyde

Glutaraldehyde is a potent skin irritant and sensitiser. Exposure to it is a recognised cause of occupational asthma. People may be needlessly exposed to glutaraldehyde vapours in a patient's room. Glutaraldehyde, along with many other disinfectants and chemicals, needs to be handled carefully to minimise health hazard.

→ 4. [www.injectionsafety.org](http://www.injectionsafety.org)

→ 5. WHO Information Fact Sheet No. 253, October 2000.

## **Slides 23 to 25: Salient features of the rules and associated rules**

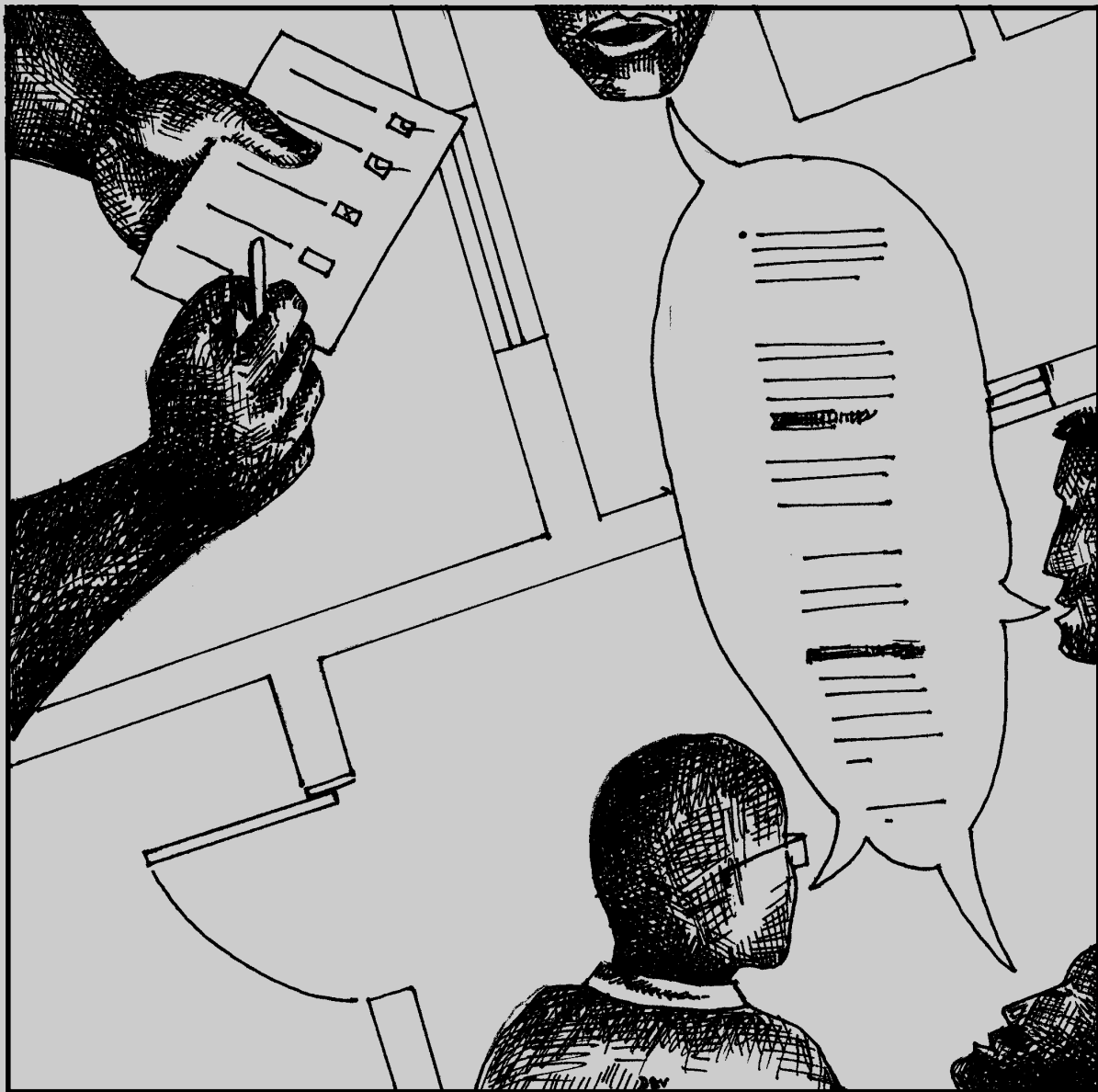
The section on Rules gives a detailed account of the Indian legislation on this issue. However, these slides touch on some salient features of the rules. The last slide highlights the fact that a hospital generates many different types of waste. For effective waste management the hospital would have to follow several legislations and guidelines, including the Municipal Solid Waste (Management and Handling) Rules, Atomic Energy Act and Hazardous Waste Rules.

The other Acts that a hospital would need to adhere to include the Water and the Air Act.



# *Section B*

## **Implementing a waste management system**



# B1 Implementing a waste management system in a hospital

## Slide 1 and 2: Project plan

The person in charge of setting up the waste management system in the hospital would need to be well-versed with the entire functioning of the hospital.

The minutest detail of the hospital's processes would need to be looked into as they may be useful through the course of work. For example, a hospital's layout can be useful while one is working out the transportation route within and outside the hospital. Even while planning the location of bins, linen storage sites, final storage sites, or deciding on the trolley requirements (size and manoeuvrability), one has to take into account the passage design and dimensions.

A survey of the existing practices is important as it:

- ◆ Lays down the basic framework and methodology of work and has bearing on the inputs required;
- ◆ Provides some discussion points during the training sessions;
- ◆ Gives an insight into the awareness level of the staff and their attitudes;
- ◆ Makes one familiar with the hospital set up and helps strategy planning.

## Waste survey

- ◆ Helps in deciding the type, size and placement of bins.
- ◆ Helps in identifying specific needs. The need of waste survey is discussed in greater detail in Slide 8.

A waste survey helps in deciding the right kind of material required for managing waste. Ordering for the right kind of bins, etc., required for waste management is important. These things should be ordered before starting the training of the staff. A hospital may not be always able to decide what kind of equipment it needs. In that case it can initially choose a Model Ward and set up a waste management prototype system there. Different equipment, bins and bags, etc., can be tested in this ward, and then, the most suitable kind can be selected for the entire hospital.

## Slide 2: Project plan, stage II

The second stage would involve training and implementation of the waste management system in the hospital. In this phase, the Model Ward can be duplicated in the entire hospital.

Ongoing training is very important because a hospital's staff turnover rate is generally very high. Moreover, the subject may lose its importance over a period of time. It is important there-

fore to keep reminding the staff about waste management issues till the concepts are ingrained into the system.

Monitoring is very essential in the early stages of the system. Continuous monitoring in the early stages helps establish the system and subsequent monitoring helps in its upkeep. Monitoring would involve inspecting segregation, disinfection and mutilation of waste in the wards, use of protective gear, route and means of transportation, final treatment and disposal of waste, etc. It primarily covers all the aspects of waste management and takes a close look at waste from the cradle to the grave.

Monitoring each and every aspect of waste management in the entire hospital at one time is difficult. Monitoring should thus be done in a layered manner.

Primary monitoring can be done by the nurse incharge of the ward during her morning rounds. Her daily reporting formats should include waste management. The floor incharge can take up issues like transportation of waste and checking the ward nurses. The nursing superintendent can make rounds once in a while and make the floor incharges accountable for waste mismanagement on their floors. The nursing superintendent could report to the medical superintendent and the director, one of whom can be the head of the waste management committee.

This system would ensure that the waste management committee is not burdened with the task of monitoring the entire hospital. They could make their presence felt at some locations each day through surprise visits.

*In the Holy Family Hospital, monitoring by seniors helped in building and strengthening waste management practices.*

#### **Slide 4: Waste management committee**

It is important to set up a waste management committee because one needs to have some nodal people who will look after waste management and be responsible for it. Even the guidelines issued for bio-medical waste management suggest that medical institutions constitute a waste management committee, (preferably headed by the institute's head) to look after waste management in the institution.

The committee should comprise of people from all hierarchal levels and its members should be carefully selected to have a good, energetic and committed team. Amongst them one or two nodal people (depending on the size of the facility) can have waste management as their key responsibility.

The committee's responsibilities would include the training of staff and scheduling training programmes. The committee would also look into the legal requirements of the system – from getting authorisation to maintaining annual records regarding waste management.

#### **Slide 5: Waste management policy**

The waste management policy should address all important aspects of waste management. It should be clearly laid down and be available in writing. This not only brings clarity in the working place but also provides a scope for further improvement.

All hospital personnel should be handed over a summary of the waste policy and their role in the whole chain. This would help in fixing responsibilities. Personnel can also be motivated to suggest improvements in the policy after their practical experience in waste management.

The policy needs to be reviewed periodically and any new standards and regulations from the implementing authorities and suggestions from the staff should be included to make it effective.

### **Slide 6: Occupational safety and health**

In India, occupational safety has always figured low in the priority of employers. This situation needs to be changed, especially in hazardous sectors.

The hazards in a hospital environment include the transmission of infections through needle-stick injuries, blood splashes and body fluid spills, mercury poisoning and other chemical exposures.

A group of experts should identify problem areas and find ways of minimising worker exposure. Work involving hazards should be done by the fewest possible number of personnel, and this work should be rotated so that the level of exposure to each individual is minimised.

### **Slide 7: Why do a waste audit?**

A waste audit is the complete survey of a hospital's waste management practices. One can either do a survey by visiting each department and ward (to weigh and analyse the composition of waste) or one can get all the waste bags labelled and analyse them at a central location. The first method gives an advantage of getting to know the hospital and its personnel better (for an external survey agency) while the second method offers the benefit of speed.

For insights into the consumption pattern of the hospital and ways of reducing the waste stream, one needs to go to the stores, pharmacy and the users (nurses and doctors) and explore the possibility of changing the consumption patterns. Over-packaging, high wastage due to

over-use or excess procurement and ordering in smaller packs are some areas which can be looked into.

### **Slide 8: Setting up a Model Ward in the hospital**

The concept of a Model Ward is helpful in a large set up where the cost of establishing a waste management system is high. One ward or department in the hospital can be chosen and the staff of that ward area can be trained to set up a 'pilot' waste management system.

Different kinds of equipment, bins, bags or any other material can be tested in this model ward and can then be selected for the entire hospital. This not only helps in having a demonstration site within the hospital for trainees, but also helps decide the best possible equipment through feedback from the staff. Thus, it makes good economic sense.

### **Slide 9: Components of hospital waste management**

After the waste survey is completed and the Model Ward is in place, one can start setting up a waste management system in the hospital.

The first step in this process is training. The entire hospital staff needs to be adequately trained. The details about training are covered in a separate section. At this point it is important to discuss experiences and experiments with regard to training methodologies in hospitals.

Training can be done by going to various wards/departments and speaking with nurses at their workstations so that they understand things practically. This method takes a lot of time and also makes the sessions less serious at times because the nurses are generally busy with their patients and leave the sessions intermittently.



The second method is the seminar/lecture approach. All the personnel work in shifts, thus it is necessary to work out a timetable according to the shift and involve the entire staff. This not only ensures that each person in the hospital has been trained but also saves time and brings a focus to the training sessions.

While the staff is being trained, the equipment required for waste management should be made available at their workstations so that they can start practicing what they have learnt.

## Slide 10: Segregation

Segregation refers to the storing of waste in separate containers. It is the most important aspect of Bio-medical Waste (Management and Handling) Rules, 1998. The rules specify different categories of waste, the materials that comprise those categories, the prescribed colour codes for them and the type of treatment technology for each of them.

While there are 10 categories of waste specified in the rules, most of the waste commonly found in wards can be sorted into three categories. Some of the waste is very location specific and is not generated at all points.

Segregation of waste is always done at the point of its generation and as soon as it is generated. Doing it elsewhere, or delaying the process, would result in mixing of waste (that is, contaminating the entire waste stream) and will thus defeat the purpose of segregation.

Segregation not only reduces the chances of spreading infection, but also prevents occupational hazards (since only limited waste needs special handling and a responsible person with all protective gear and resources can handle it for the entire hospital). Segregation also reduces the investment in waste disposal. Since 80 per cent of a hospital's waste is general waste, it

does not require special treatment, provided it is not contaminated with other infectious waste. If everything is mixed, the hospital would have to treat the entire waste and would not only spend upto five times the cost of treating only infectious waste, but it would also lose out on the revenue it would have earned by selling the general waste.

## Slide 11: Disinfection and mutilation

Segregation should be done in accordance with the rules. Hospital staff should be briefed about the rules. Posters can be put up on walls near the bins or any other suitable place to continuously remind the staff about their responsibilities.

Several things affect the degree of segregation:

- ◆ All bins should be preferably easy to use, in terms of their design and placement. There are instances when mixing of waste was directly linked to the poor access of one particular bin. All decisions regarding bins (their number, placement, etc.) should be taken in consultation with the personnel.
- ◆ The number of each bin type should be optimised. As each bin directly translates into a liner (bag), economically it makes sense to use bins intelligently. In case of bag usage, one can eliminate the use of black bags meant for general waste in case only dry waste is reaching the bin. The bins and bags should be of the same size to minimise wastage.
- ◆ The bins should be kept clean and should be covered and foot-pressed. This will eliminate the hesitation to approach a bin due to its appearance.

### Slide 13: Collection

Waste management does not stop at segregation – it only begins with it. Everyone down the line has to contribute to make the system effective and sustainable.

House keeping staff should be trained to collect and transport waste in a responsible manner, so that there is minimal risk of exposure – to themselves and to others. They should be warned against mixing, spilling or mishandling the waste. They should be told about the contingency measures in case of accidents/spills and the method of reporting these. Designating different people for different waste introduces some specialisation into waste management. Specialisation, in this case, refers to the collection of one particular hazardous waste from the entire hospital by one person (this can be done in rotation). This has the advantage of bringing in a system of accountability (one man is answerable for that waste) and safety.

Different waste streams should be collected at different times. This reduces the chances of mixing. It also avoids wastage of bags, for example, general waste needs to be collected frequently, while the other bags do not. The time of collection for each type of waste would also depend on the time of its maximum use. In hospitals, mornings generally begin with dressings and other such activities, and the yellow bags meant for such waste are filled up in the morning shift. Thus, noon is a good time for collection of this waste. A similar ‘timing’ strategy can be adopted for all types of waste according to the hospital set up.

Closed containers not only offer an aesthetic advantage, but are also much safer in cases of accidents (to minimise spillage).

### Slide 14: Storage

Storage time is the time lag between the generation of waste and its treatment. Storage could be of different kinds: storage of waste within the hospital’s wards/departments; storage outside wards but within the hospital premises; if the waste is taken to a treatment site, then storage in a vehicle; and finally storage at the central facility.

According to the Indian rules, waste should not be kept untreated for more than 48 hours. One must remember that this is the maximum time limit. Keeping the Indian climate in mind (the hot and humid conditions in most parts of the country) it is advisable to treat waste as soon as possible.

According to WHO, unless a refrigerated storage room is available, storage times for healthcare waste (i.e. the delay between production and treatment) should not exceed the following:

- ◆ Temperate climate: 72 hours in winter; 48 hours in summer.
- ◆ Warm climate: 48 hours during the cool season; 24 hours during the hot season

Storage within the hospital should be done in labelled, colour-coded bins and bags in secured, balanced, easily washable containers that do not have any sharp edges.

The main storage site of the hospital should be accessible to vehicles so that the collection vans can reach it. This reduces the number of personnel handling the waste. The storage site should have a smooth surface so that it can be washed easily in case of spills. The hospital should ensure that there are written instructions to handle spills, and that the personnel at the storage site are trained for such work.

### **Slide 17: Special cases**

Some places like operation theatres, ICUs and emergency wards have a different style of working. These places therefore need special attention. People from these areas need to be consulted to optimise the system of waste collection so as to suit their requirements while not compromising on waste management.

### **Slide 18: Monitoring**

A waste survey should be done before, and after, implementing a waste management system. The comparative analysis can be presented in a hospital meeting and the entire staff can be shown the economic and environment benefits of waste management. This would encourage them to continue the waste management practice. One can, as an example, document the decrease in accident rates related to waste disposal, or demonstrate the decreased cost in the treatment of waste, revenue earned by selling recyclables, etc.

A waste survey also helps in pin-pointing areas of extra usage and wasted products. The hospital can concentrate on waste segregation in the initial stages and can, later, move on to waste minimisation.

### **Slide 19: Keep score**

It is very important to monitor the waste management system once it is in place. Monitoring would highlight area-specific problems which can be discussed, and sorted out, with concerned personnel.

It is important to conduct routine Waste Audits to be able to spot any increase in infectious waste or fluctuations in waste generation. These changes could be evaluated by the hospital administration.

### **Slide 24: Economics of waste management**

Economic factors play a major role while setting up a waste management system. The attempt should always be to have the best system with minimum investment.

In our hospitals we keep a track of the expenditure on the system and possible ways of reduction of the same on a continuing basis. In our observation, a centralised facility turns out much cheaper than on-site facilities. The quality of plastic bags can be compromised, they need not be virgin plastic and the thickness should also be just enough to keep it intact till waste is hauled to its final destination. Several other things influence costing and should be studied carefully.

### **Slide 26: Lessons learnt**

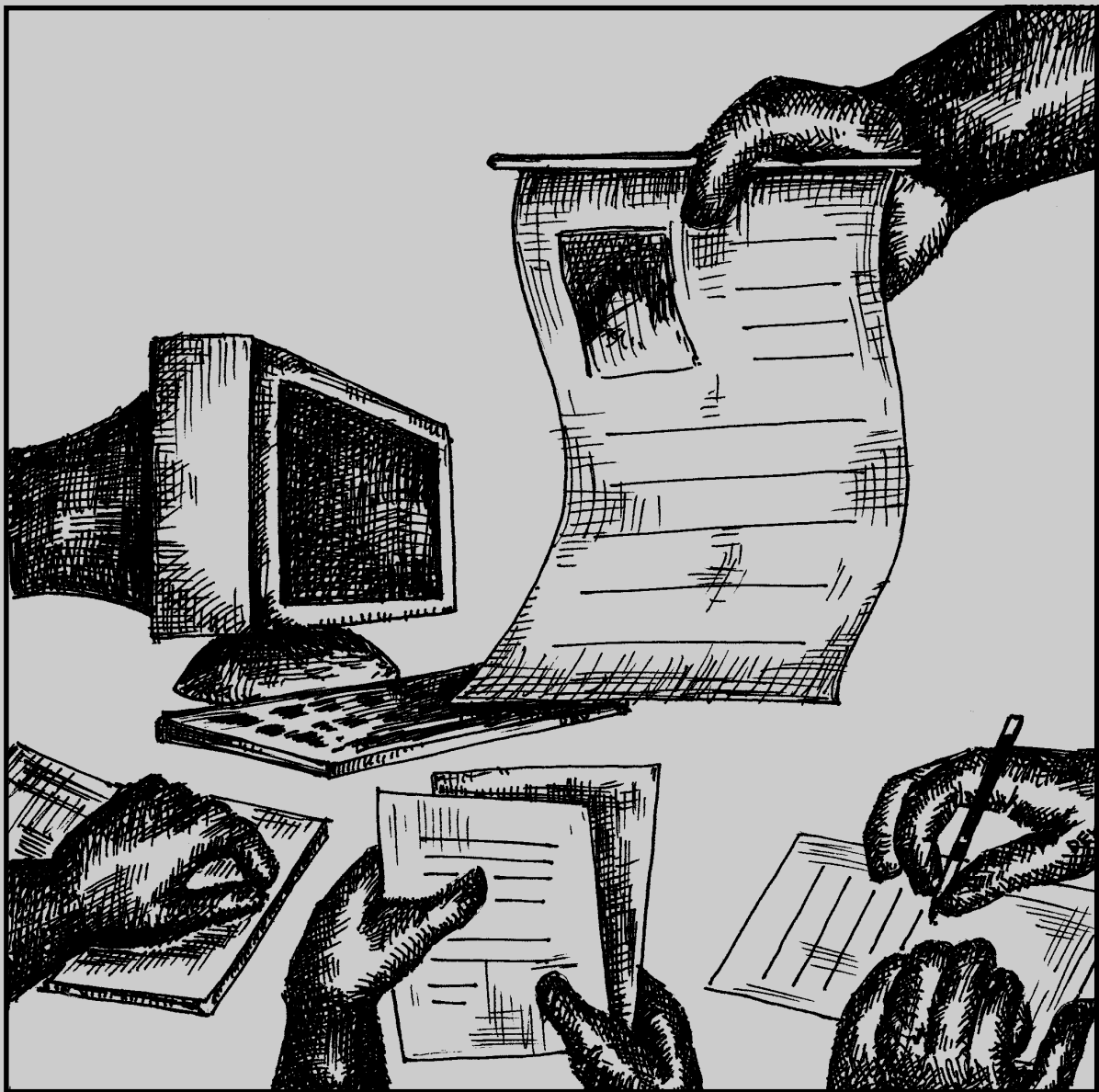
Waste management involves many personnel and requires a good degree of financial management. One can come across ego problems, apathy and indifference during the implementation of such a system. One needs to be patient and remember that waste management is a new concept. Till now, it has not been a priority, and has often been seen as a liability. Things do change after a few weeks and the staff tends to get involved as they see results.

A large time interval between training and the placement of equipment nullifies the impact of training.



# *Section C*

## **Training hospital staff**



# 01 Training hospital staff

**T**raining and creating awareness amongst the hospital staff is the key to having a good waste management system. It not only appraises them of the existing problems and the need of managing waste but also orients them to a practical system.

Training can be done in a particular ward initially where a model system could be established. This ward/ department can be used in further training sessions as a practical model for trainees.

## Slide 1: Who requires training?

A chain is as strong as its weakest link. Thus, not a single person in the hospital should be missed out while training is imparted. Waste management requires the involvement of the entire hospital staff in some form or the other. Administrators, store personnel and other seemingly uninvolved departments also require training to ensure that the waste is carried responsibly from the cradle to the grave.

In order to ensure that all waste is segregated and safely transported, and that the material required for waste management is available to the staff, it is important to involve everyone, including doctors, administrators, nurses, technicians, ward boys and safai karamcharis.

The sessions for different groups should be taken separately, as different ideas need to be

stressed upon for each category.

## Slide 2: Trainers

**Initially, training can be done by**

- ◆ A hospital staff member: a staff member who is well-versed in the subject should take the training sessions. Care should be taken that his/her regular duties are considered while deciding the time of the training sessions.
- ◆ An outside agency: an outside agency with a proven track record can also be asked to train the staff.

Ongoing training can be carried out under the auspices of the Waste Management Committee, Infection Control Committee, or by the medical/nursing/sanitary superintendents for their respective staff.

## Slide 3: Training sessions

Training covers the following aspects: sensitisation, teaching (dissemination), discussion and feedback.

The first session is devoted to sensitising the audience on the need to manage waste in the hospital. In the second session, the audience is made aware of various aspects of hospital waste management – segregation, disinfection, etc. The last session is taken only after the trainees

have implemented the scheme for about one to two weeks in their respective areas. They are asked about the problems that they have faced during the implementation of the programme.

Training sessions should be lively; they may start on a formal note but should be made informal, and one should try to make them interactive at all stages.

Training modules should include equipment and other materials to be used later by the staff for waste management. Slides on various aspects of waste management (including efforts by a hospital already following the system), health effects of mismanagement of waste, etc., help a lot in making the message more powerful.

### **Medium of training**

As far as possible, all training modules should be in the vernacular medium, or the language in which the staff is most comfortable.

### **Demonstrations**

Demonstrations and live acts help in making the training sessions interesting and therefore making trainees understand things faster.

### **Ongoing training**

This is one of the most important components of training. Generally, a hospital's staff turnover rate is quite high. Ongoing training, besides being a continuous reminder for the older staff, ensures that the new staff is aware of the issues. These sessions are thus important in sustaining the scheme.

## **Slide 4**

### **Session 1**

It is imperative to tell trainees why a particular thing needs to be done. Once its importance is realised, people are motivated to make an extra effort to do it. The first session is therefore generally devoted to sensitising trainees about waste management issues by telling them about the problems associated with mismanaged hospital waste.

Initially, one can get inputs from the trainees about waste management practices in their hospital. It is always good to involve trainees by asking them specific questions about what happens to different types of waste, what they think constitutes the major chunk of the waste, and how they think they can help in minimising the waste. Before one begins telling them about waste mismanagement and related problems, probing into the risk perception results in a healthy discussion.

## **Slide 5: Sensitisation – the need for managing waste**

### **Dangers to the patients**

The immune system of our body protects us from external infections. People with weak immune systems are prone to infections. With organ transplants becoming common, hospitals may have patients with suppressed immune systems due to use of steroids (intentional suppression to avoid rejection of a transplant). Moreover, there are many drugs whose side effects include suppression of the immune system. In all these cases it is evident that in a hospital, there is a higher probability to find people with lowered immune response who can easily pick up an infection.

### **Dangers to the community through bio-medical waste**

Spread of infection through waste: According to various surveys and reports, of the total waste generated by hospitals only 10-15 per cent is infectious and needs treatment. The rest of it falls under the category of general waste which does not need any treatment. If all the waste is mixed, the entire waste generated by a hospital becomes infected. As the quantity of waste to be treated increases, the hospital fails to treat all its waste and a large chunk of this infectious waste reaches municipal dumps, and increases the possibility of spreading infection.

Municipal waste is rich in organic material and, at times, remains uncollected for days together. This gives pathogens the time to multiply. Municipal dumps are also frequented by animals and birds that can carry various pathogens proliferating in the dump. Thus municipal dumps should be kept free from any infectious or hazardous waste.

### **Problems due to incinerators**

Incineration of waste is linked with the formation and release of acid gases, heavy metals, dioxins and furans.

Acid gases include nitrogen oxide, which forms acid rain and affects the respiratory and cardiovascular system.

Heavy metals are released during incineration of medical waste. Mercury vapourises on incineration and spreads easily in the environment. Lead and cadmium, which are highly toxic heavy metals, are also present in certain plastics. Dioxins and furans are released and get accumulated in the ash when plastic and some other waste containing these metals is burnt. Incineration is thus a hazard not just for the hospital staff, but also for the community.

Dioxins and furans are organochlorines, which form as a result of the combination of organic material with chlorine molecules in plastics (for example, PVC). Organochlorines mimic hormones and thus disrupt the hormonal cascades. They are proven carcinogens and endocrine disrupters, and also weaken the immune system and damage the male and female reproductive organs.

### **Spread of infection through recycling**

A lot of disposable items like syringes and I.V. bottles re-enter the market and reach the hospitals. This increases the risk of spreading infection in the community through the ragpicker who collects it, the person who repacks it, the nurse who opens it and finally the patient who uses it. Thus, it is the duty of the nurse or the person involved in the treatment of the patient to ensure that disposables used in patient care are mutilated immediately to prevent their reuse.

### **Some facts about reuse of sharps**

- ◆ It is estimated that over 30 per cent of the estimated 12 billion injections administered worldwide are done so in an unsafe manner, posing serious health risks to health workers, their patients, and the community;
- ◆ Reusable syringes are not properly sterilised before use;
- ◆ Disposable, one-time-only syringes are used more than once;
- ◆ Used syringes are not disposed off properly;
- ◆ Hepatitis B Virus (HBV) can survive in a syringe, in dry conditions for seven to eight days.



## Slide 6: Dangers to healthcare workers

Hours spent at the workplace: healthcare workers spend a major part of their day in hospitals. Any problem here would affect them the most.

All the points in this slide are discussed in greater detail in the following slides.

## Slide 7: What are sharps?

Our rules define sharps as anything capable of causing cuts or punctures, including used and unused material.

Needle-stick injuries: Skin is our primary protective barrier and sharps have the ability to penetrate it. Thus a needle-stick injury, which is able to establish blood-to-blood contact, has a very high rate of transmitting infections.

The greatest occupational risk for transmitting a blood-borne infection is through parenteral exposure – by a penetrating sharps injury – sustained from an infected person.

*(Note: Detailed slides on needle-stick injuries are provided in the Occupational Safety section).*

## Slide 8: Categories of staff exposed to needle-stick

There are several published papers where researchers have tried to document the incidence of needlestick injury in various categories of hospital staff. As all these studies are in different hospital settings the percentages and the actual figures may vary with each paper.

OSHA estimates that 5.6 million workers in the healthcare industry, and related occupations, are at risk of occupational exposure to bloodborne pathogens, including HIV, hepatitis

B virus (HBV), hepatitis C virus (HCV) and others. According to the CDC, in March 2000, it was estimated that 600,000 - 800,000 needlestick and other percutaneous injuries occur annually among healthcare workers.

Studies also show that nurses sustain the majority of these injuries.

## Slide 9: Incidents leading to needlestick injuries

Many researchers have tried to figure out the situations and use of any particular equipment, which makes people more prone to needle-stick injury. It has been found that that as many as one-third of all sharps injuries are related to the disposal process. Thus, a good sharps management programme within the hospital can greatly improve safety.

## Slide 10: Sero-conversion following exposure

Sero-conversion means the percentage of healthcare workers developing the infection after being exposed to body fluids from a proven infective source. These rates have been documented by carrying out a follow-up of healthcare workers with occupational exposure to blood from a patient positive for a particular blood-borne pathogen. For instance, in the case of exposure to a HIV positive patient, the healthcare worker would be tested for HIV antibodies at the time of exposure (baseline testing) and at periodic intervals for around 12 months.

### Potential risk factors for sero-conversion following percutaneous injury:

- ◆ Interval between needle use and exposure.
- ◆ Depth or severity of exposure: deeper injuries lead to more blood transfer, thus increasing

the probability of infection transmission.

- ◆ Quantity of blood injected: this is directly related to virus particles passed to the person. At least 0.1ml of blood is thought to be required to cause infection in case of HIV, whereas for HBV which is much sturdier than HIV and whose circulating titer is also high, it is estimated that 0.00004 ml of blood may be enough to cause an infection as a result of needle-stick injury.
- ◆ Bore of needle: studies have suggested that more blood is transferred by deeper injuries and by hollow bore phlebotomy needles, especially those of larger gauges than with solid suture needles.
- ◆ Source patient: a patient's clinical status or stage of disease and the drug therapy he/she is receiving would affect the virus titer in blood thus influencing sero-conversion.
- ◆ Clinical status.
- ◆ Titer of circulating virus: the titer of freely circulating virus in the blood greatly influences the sero-conversion rate. For example, the quantity of infectious virus in plasma or serum of HIV infected individuals is estimated to be 10-15 infectious particles (ip)/ml with the highest levels of 10<sup>4</sup>ip/ml in patients with AIDS.

A small amount of freely circulating virus in the blood could explain the low risk of infection following a needle-stick injury compared to that of HBV, which is present in infected individuals at 10<sup>9</sup>ip/ml. In other body fluids like tears, saliva and ear secretions the virus titer is one-tenth or one-hundredth of the titer in blood.

- ◆ Use of antiviral drugs/vaccination: use of antiviral drugs like zidovudine after exposure

to HIV and inoculation of vaccination following a HBV exposure have proved helpful in preventing sero-conversion in most cases. Research evidence seems to suggest that the use of anti-HIV drugs like zidovudine in combination with other anti-HIV drugs if given soon after the injury can reduce the rate of transmission. It is recommended that Post Exposure Prophylaxis (PEP) should commence within 24-36 hours of injury; preferably within a few hours of exposure.

- ◆ Healthcare worker: the immune response, adoption of universal precautions and post prophylaxis affect the susceptibility of the healthcare worker.
- ◆ Use of barriers: use of personal protective equipment, like gloves, may help reduce sero-conversion. Studies have shown that a single pair of surgical gloves appears to decrease the volume of blood injected by solid suture needle by 70 per cent or more in almost every simulation. Two pairs of gloves may reduce it by another 50 per cent, or more.<sup>1</sup>

There are a small number of instances when HIV has been acquired through contact with mucous membranes or non-intact skin (If intact skin is exposed to HIV infected blood, there is no risk of HIV transmission). Research suggests that the risk of HIV infection after mucous membrane exposure (for example, splashes of infected blood in the eye, is much less than one in 1,000). If muco-cutaneous exposure occurs, wash the affected area thoroughly with soap and water. If the eye is affected, irrigate thoroughly.

Given this backdrop, the importance of all types of protective gear is paramount.

In 1995, the Center for Disease Control (CDC), USA, estimated that 800 healthcare workers were infected with the hepatitis B virus. This figure represented a 88.3 per cent decline

→ 1. Bloodborne occupational diseases of healthcare workers, PRIA and ACILS.

from the 6,800 infections estimated in 1992. Immunisation programmes with the hepatitis B vaccine and the use of universal precautions were responsible for the decline.

### Slide 11: Mercury products

Mercury is found in various types of equipment, predominantly thermometers and sphygmomanometers. Other mercury-based instruments likely to be found in the hospital are barometers, oxygen and foetal monitors, esophageal dilators, etc.

Other than instruments, mercury can be found in laboratory chemicals like mercuric chloride, Zenker's solution, mercury oxide, some fixatives like B5, Schaudinn's fixative, and dental amalgams.

Dental amalgams are a mixture of mercury, (approximately 50 per cent metallic mercury by weight) silver, copper and tin which quickly hardens together into a solid form. Mercury in dental amalgam is not in a stable form and it is well documented that mercury vapour is released from dental fillings.

#### Why is there a shift from mercury products?

There is now an international trend to move away from mercury instruments and use non-mercury alternatives which are safer than mercury-based instruments. The factors that restrain people from using them are their relatively high initial costs and doubts over their accuracy. This skepticism has been proved wrong by various studies. Alternative technologies are not only accurate but are also easier to use; in addition they offer cost benefits in the long term.

A study in an elderly population evaluated the differences in the self-recording of blood pressure with automatic and semi-automatic

equipment, using a mercury sphygmomanometer by a physician as a 'gold standard' control. The findings indicated that there was no difference between the mercury and alternative methods of blood pressure measurement. Interestingly, they found significant differences when the semi-automatic system was used. This was thought to be related to errors made by the patient while measuring the blood pressure; several patients could not inflate the cuff.

Mercury sphygmomanometers are limited by factors such as observer bias which confound the ability to discern the true blood pressure value. On the other hand, automated blood pressure machines demonstrate less within-subject variability during repeated measures than mercury sphygmomanometers. Hourly blood pressure profiles recorded through 24 hours by automated and manual methods from hypertensive patients were nearly identical. These data suggest that blood pressure measured by auscultatory automated methods are similar to, and representative of, those obtained manually.

### Slide 13: Effects of mercury

Mercury is the only heavy metal that can exist in all three states of matter: it readily changes from solid to liquid to gaseous form and is a persistent bio-accumulative toxin. It circulates constantly in the environment. Three major forms of chemical mercury circulate in the atmosphere: mercury (0), mercury (II) and methyl mercury. Methyl mercury can accumulate in muscle tissue and bio-magnify via the food chain.

Mercury is a neurotoxicant and affects the brain and the nervous system. Other vital organs like kidneys and lungs are also affected. Mercury poisoning can be difficult to diagnose since the symptoms are common to other afflictions.

### **Dangers associated with mercury spills**

Some micro-organisms have the ability to change elemental mercury to methyl mercury, which is easily absorbed by all life forms. Mercury not only passes the skin and the blood-brain barrier, but also the placental barrier. Pregnant women and children are most vulnerable to the effects of mercury. A foetus exposed to mercury shows nervous system damage. The Minamata disaster in Japan is an example of mercury poisoning.

Human exposure can happen through consumption of mercury-contaminated food (especially fish) and water. Inhalation of mercury vapour and penetration of liquid mercury through the skin from dental amalgams are other routes of exposure.

The half-life of mercury, or the time needed to excrete half of a dose to which one is exposed is 44 to 80 days. Mercury is excreted via faeces, urine and breast milk.

### **Slide 14, 15: Where is glutaraldehyde used ?**

Glutaraldehyde is a broad-spectrum germicide; it is non-corrosive, and non-flammable. Because it can remain stable under certain conditions over several days, it has the potential for re-use. Its high material compatibility and property of acting synergistically with other disinfectants makes it very popular. That is one of the reasons why it has not been phased out despite its health impacts on workers. However, strict regulations have been put on its use.

Glutaraldehyde has a pungent odour and its odour threshold is fairly low (0.04 ppm). It can sensitise the respiratory system. The sensitisation can be long-term or permanent in certain cases, and that can create problems for people in certain professions. It can also cause

contact dermatitis, which is why it is strongly recommended that people who work with it never let it come into contact with their skin. The hands and forearms are most likely to be affected by splashes of glutaraldehyde liquid. Vesicular dermatitis consists of redness and tiny pinpoint blisters that may burst to create areas of weeping.

Studies have shown that people who work in healthcare settings where there is regular exposure to glutaraldehyde are much more likely to develop allergic reactions. Rhinorrhoea, or runny nose, is an early sign of the irritant effects on the airway. In normal use there may be complaints of sore eyes, presumably due to vapour exposure. In the case of splashes, animal experiments have shown that if the eye is not irrigated to remove glutaraldehyde, permanent corneal damage can occur. Contact lens wearers should have their lenses removed by ophthalmic staff.

Asthma: this is the most serious of the possible adverse health effects. Sensitisation can occur many years after the first exposure and once sensitised, reactions can occur when exposed to minute airborne concentrations.

Glutaraldehyde can be damaging to the environment because it is a very potent disinfectant. It can kill bacteria or the ecological microbial flora. For this reason, a system that uses a septic tank can have problems disposing off huge amounts of glutaraldehyde. Its fixative property kills germs, but this can be a bit of a disadvantage too. If some medical devices or environmental surfaces are not pre-cleaned properly then the organic matter can become very rigidly fixed to their surfaces. If glutaraldehyde from medical devices is not washed well before they are used on a patient, any residue that subsequently comes out during its use can be damaging to the tissue.

A number of regulatory agencies in Canada

and USA, as well as in Australia and UK, have reviewed the permissible limits of glutaraldehyde. The general trend is to reduce the allowable limits of glutaraldehyde in air to a lower level. For example, in several jurisdictions the permissible level will go down from the earlier limit of 0.2 ppm to 0.05 ppm.

Alternatives to glutaraldehyde are available and are based on peracetic acid, ortho-phthalaldehyde, hydrogen peroxide, superoxidised water, and gas plasma systems.

### **Slide 16: Cytotoxic drugs**

Adverse health effects from both acute and chronic exposures to cytotoxic drugs have been demonstrated in healthcare personnel.

Over a long term, almost all of these drugs have the potential of damaging cells or adversely affecting cellular growth and reproduction. The drugs bind directly to genetic material in the cell nucleus, or affect cellular protein synthesis.

In-vivo, in-vitro and human studies have implicated anti-neoplastic drugs in chromosomal damage, teratogenesis, and carcinogenesis. Testicular and ovarian dysfunction, including permanent sterility, have been demonstrated in male and female patients, respectively, who have received these drugs singly, or in combination. Studies in Finland have shown an increased incidence of foetal loss among nurses routinely working with anti-neoplastic agents than among those who do not. Other studies have suggested a correlation between exposure to anti-neoplastic agents and foetal malformation in pregnant nurses.

Additionally, organ damage has been associated with exposure to some anti-neoplastic agents. Liver damage has been reported in oncology employees, and appears to be related to the duration and the concentration of the

exposure.

The risks to workers handling anti-neoplastic agents are a result of the inherent toxicity of the drugs themselves, and the actual dose that a worker receives. The dose is dependent on the concentration of the drug, the duration of the exposure, and the route of entry.

The adverse health effects as a result of exposure to a particular drug may depend on whether the drug enters the body through inhalation, through the skin, or ingestion.

### **Slide 18: Dangers to ragpickers**

Lot of young children get involved in the business of waste-sorting to look for recyclables to supplement the income of their families. They frequent municipal waste dumps, which have municipal waste mixed with some component of infectious and hazardous waste. Various studies have documented the exposure of these children to infectious medical waste. A study with 152 rag-picker children handling hospital waste, found the mean age to be 13.2 (+/-2.1) years. Almost one-third of the ragpickers were married. All of them were handling infectious waste with their bare hands. None of them had ever used gloves and all of them moved around in waste heaps in bare feet, without any protective boots or shoes. Almost 80 per cent of them had evidence of skin infections and/or injuries on their hands and feet.

Protective barriers such as protective gear (gloves, boots), immunisation, antiviral, etc, which are known to reduce the possibility of transmission of infection following a needle prick, are unknown to these people. With the potential of sero-conversion following needle-stick injuries and the exposure of the mucous membrane to blood and other body fluids it is not difficult to imagine the health status of these children who are always amidst needles, infec-

tious bandages, blood and urine bags, etc.

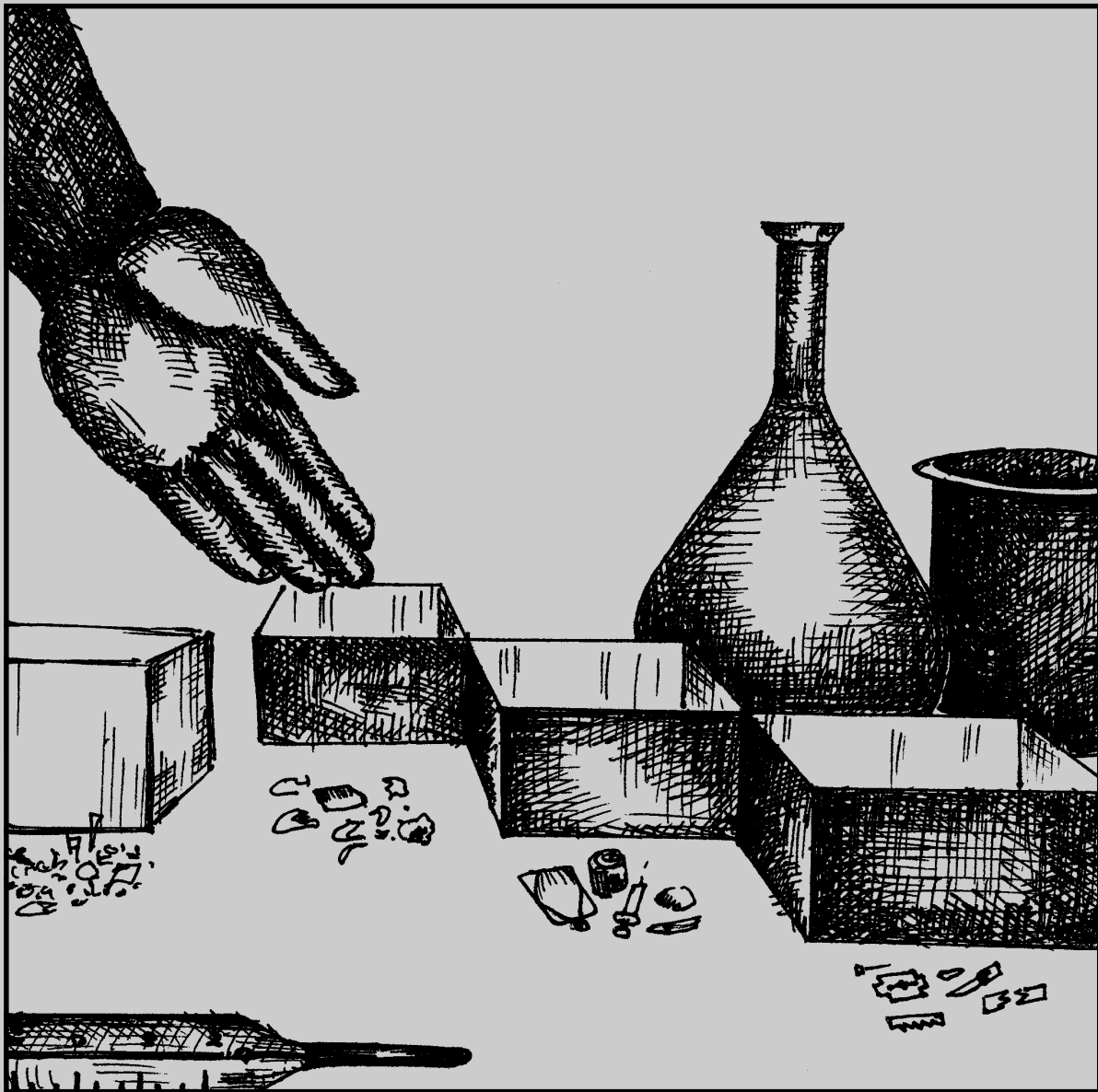
### **The new legislation for medical waste**

The entire hospital team needs to know about the provisions of the Bio-medical Waste (Management & Handling) Rules, 1998. The reasons of how and why these came into existence should be explained so that they appreciate the usefulness of this legislation. It must also be impressed upon them that much effort would be needed from their side to make a waste management programme succeed.

The clauses regarding fines and other legal implications should also be dwelt upon. The trainees must know that the rules have been made under the Environment Protection Act, 1986 and under this Act the onus of non-compliance lies not only on the owner/head of the area/institute, but also on the officer incharge of the particular department where the problem has been spotted. Others present at the time of negligence are also accountable.

# *Section D*

## **Aspects of waste management**



# D1 Aspects of waste management

**T**his session focuses on managing different kinds of bio-medical waste such as chemicals, sharps and cytotoxic material. It presents specific suggestions and methods for dealing with each category of waste.

This section requires a fair degree of practical demonstrations. Any new equipment, bins, etc., that would be introduced in the wards for waste management should be shown and their use explained to all personnel during the training sessions.

## **Slide 3: Categories and colour codes**

The Bio-medical Waste (Management & Handling) Rules, 1998 carry instructions regarding segregation of waste (depending on its type) in differently coloured containers. The rules describe the categories of waste, the colour codes to be used for them and the treatment options for each type of waste.

Schedule I of the rules (as shown in the slide) describes the various categories of waste and their treatment options. The schedule lists ten categories of waste which can be generated in a hospital. All the hospitals may not generate all types of waste. Even big hospitals, which generate all categories of the listed waste, would generate them at specific locations in the hospital, and not in the entire hospital.

## **Slide 4: Waste segregation system**

Three colour codes have been designated for medical waste: yellow, red and blue. An explanation of the colour codes, and the type of waste that falls under each code is given below:

### **Yellow**

This colour has been recommended for waste that can be burnt. It includes human and animal waste.

Initially, the rules included five categories (1, 2, 3, 5, 6) in the list of waste that could be incinerated. Of these, only two categories, namely, animal and human waste, had incineration as the only treatment option (for cities with a population of more than 5,00,000). The other three categories could be treated by alternative technologies. But now, the Draft Guidelines on Common Waste Treatment Facilities limit incineration to Categories 1, 2 and cytotoxic drugs.

### **Red**

Red coloured containers are meant for waste that needs disinfection.

This applies to plastic waste used in patient care (for example, blood and urine bags, I.V. sets, syringes), microbiological and bio-technological waste, blood soaked bandages, swabs, etc. Such waste should go for alternate treatment



technologies which could include autoclave, hydroclave or microwave).

### **Blue**

Blue containers have been recommended for sharps and solid waste.

Sharps waste needs to be segregated from all other waste because of its invasive potential. Thus, blue puncture-resistant containers should be made available for sharps waste. In that case, the solid waste category can be clubbed with the red bag waste and need of any separate blue bags for plastics would be eliminated.

### **White**

General waste from a hospital is not included as a category in the Bio-medical Waste Rules. This waste would come under the purview of Municipal Solid Waste (Management & Handling) Rules, 2000. Nursing stations would mainly have recyclable general waste, including packaging material like paper, plastic and cardboard. Under MSW rules, recyclable municipal waste can be stored in white bags. Thus, one can have white bags for general waste in the wards and nursing stations. Green coloured bins can be used at places where bio-degradable waste is present, for example, in the kitchen and canteen.

### **Slide 4,5: Segregation, making a difference**

A successful waste management initiative hinges on segregation. By segregating the waste conscientiously the amount of waste that needs treatment is reduced drastically. It also leads to reduced costs for transporting and treating waste.

Yellow bags need to be placed in very limited areas, such as operation theaters, delivery

rooms, and laboratories. Red bags need to be provided at locations where they are accessible to the hospital staff only.

### **Slide 6: Chemical disinfection**

In the absence of disinfection technologies such as autoclave, microwave or hydroclave, waste should be chemically disinfected.

According to the rules, 1 per cent hypochlorite or any other equivalent reagent can be used for disinfecting. Chemical treatment must ensure disinfection. For this the Central Sterile Supply Department (CSSD) has to follow the supplier's directions closely.

Concentration of the disinfectant is critical to the process and dilution should be done accurately. Chlorine and alcohols are most rapid disinfectants and may be effective in two minutes if they have immediate access to bacteria. Phenolic disinfectants act more slowly. In the presence of organic material, 30 minutes contact may be necessary for effective action, while eight minutes are good enough on a clean surface.

Many disinfectants gradually deteriorate after dilution with water, thus, freshly prepared solutions should be used.

The Kelsey-Sykes test may be used to determine the effective concentrations of halogen disinfectants. Chemical estimation of available chlorine, expressed as a number of parts per million (ppm) can be used. For clean surfaces, which are totally free from organic material, a solution providing 100-200 ppm available chlorine is sufficient, but in the presence of organic material 1,000 ppm is recommended.

A chlorine disinfectant is the ideal choice when there is a possibility of a virus presence, in particular for disinfection of equipment soiled with blood. A higher concentration with 10,000

ppm available chlorine should be used in these conditions, due to the high level of inactivation by blood.

The concentrations, 100-200 ppm and 1,000 ppm are referred to as weak and strong chlorine solutions, respectively, and can be prepared easily by diluting a concentrated hypochlorite solution or by dissolving available powders. However, an extra strong solution, with 10,000 ppm cannot be prepared from powders as it is difficult to dissolve the high amount of powder needed for this concentration.

### **Slide 8: Cleaning up a body fluid spill**

There are two seemingly paradoxical processes for disinfecting body fluid spills:

- ◆ Clean and disinfect
- ◆ Disinfect and clean

Body fluid that has been spilt on floors must be cleaned and then disinfected. To do this, cover the spill with absorbent cotton or a cloth. Discard this in the red container. Disinfect the surface with 10 per cent bleach for 10-15 minutes or use phenolic disinfectants.

A clear soluble phenolic disinfectant is a good choice for these situations because it is not seriously inactivated by the organic material and is compatible with an anionic detergent and soap.

The two-step process of cleaning first and disinfecting later gives better results as cleaning removes most of the organic material, which is known to inactivate disinfectants significantly. Cleaning first also exposes the micro-organism to disinfectants which may otherwise remain hidden in the soiling material.

This process is recommended for disinfection of surface or equipment where there is no risk of infection to the workers.

Where the staff is required to wash used equipment or glassware potentially contaminated by pathogenic micro-organisms, the rule is to disinfect first and clean later. The glassware can be disinfected, washed and then disinfected again by heat treatment.

### **Slides 9-11: Evolving sharps management**

The hospital can choose one of the following two methods to dispose of the sharps waste.

In the first method, all sharps, including needles, can be stored in large puncture-resistant containers with a small hole to discard sharps. Once the container is full, its contents can be autoclaved and then recycled. The recycler can return the containers, which can be utilised again.

The second method would be to destroy the needles through needle destroyers, cut the syringes and then disinfect these in separate containers. All other sharps can be put directly into the disinfecting solution. The sharps, after disinfection, can be collected and sold to a recycler.

As sharps have been linked with the transmission of blood-borne pathogens, the hospital staff should be adequately trained to eliminate the risk of needle-stick injuries. Staff must be aware of acts or omissions likely to cause an accident.

The reporting of accidents is an integral part of successful management of sharps waste. The bio-medical waste rules mention this clause but are silent on the details. Some countries have made reporting mandatory. In UK, for instance, all employers are legally obliged by the Health

and Safety at Work Act, 1974 to ensure that their employees are trained properly and are proficient in safe working practices.

Employers are also obliged by the Control of Substances Hazardous to Health Regulations, 1994, to review every procedure that involves contact with potentially dangerous substances, including bacteria and viruses in patients' blood and body fluids.

It is advantageous for the injured person to make a prompt record of any work-related accident so that an accurate account of events is available, if details are needed at a later stage.

In UK, the responsibility for reporting the injury to the concerned authorities rests with the employer, as is also the case with Indian rules.

Once reporting of sharps-related accidents becomes a norm, the hospital can identify the situations in which such injuries occur. This would naturally help reduce the accidents. For example, recapping has been banned in some countries since a survey revealed that many injuries happened because of this practice.

Trainee's queries on injuries and precautions should be answered with scientific data as far as possible. For example, during training sessions when Universal Precautions were being emphasised, nurses complained of getting needle-stick injuries even while wearing gloves and thus questioned its advantage. They were told about the study, which found that when a needlestick injury happens in presence of any barrier (such as a glove), the amount of inoculum (blood) reaching the body is reduced by 70 per cent and wearing two pairs reduces the risk further, thus reducing the chances of sero-conversion significantly.

### **The basics of safe practice when using sharps**

- ◆ Where possible, replace the use of sharps with other instruments or procedures;
- ◆ Used needles should never be recapped, bent or broken;
- ◆ Sharps should not be passed from hand to hand;
- ◆ All individuals have a personal responsibility to dispose of used sharps in a safe manner;
- ◆ Used sharps should be discarded into a sharps container as soon as possible;
- ◆ Sharps containers should be close to clinical areas but away from locations which may involve injury to patients, staff or visitors;
- ◆ Sharps containers should be securely closed when three-quarter full;
- ◆ The local policy regarding management of clinical waste must be strictly observed.

### **Suggested action following a needle-stick injury**

- ◆ Encourage bleeding at the site of injury: if percutaneous exposure occurs, bleeding should be encouraged by pressing around the site of the injury (but taking care not to press immediately on the injury site). It is best to do this under running water;
- ◆ Wash the wound with soap and hot water and dry the hands;
- ◆ Apply povidine-iodine to the wound;
- ◆ Cover the wound with an occlusive dressing (preferably water proof);

- ◆ Report the incident immediately to the person concerned/waste management committee;
- ◆ Fill in the accident form;
- ◆ Identify the source of needle contamination if possible.

### Supplementary information

More than 20 infections can be transmitted through needlesticks, involving viruses, bacteria, fungi, and other micro-organisms.

The diseases include: blastomycosis, brucellosis, cryptococcosis, diphtheria, cutaneous gonorrhoea, herpes, mycoplasma caviae, Rocky Mountain spotted fever, sporotrichosis, syphilis, toxoplasmosis, tuberculosis, malaria and mycobacteriosis. Many of these diseases are transmitted in rare events, but it still demonstrates that needle-stick injuries can have serious consequences.

During training sessions people should be convinced about the importance of reporting. Research findings suggest that all grades of hospital staff under-report sharps injuries. One study found that 53 per cent of the injuries were not reported on an accident form. The reasons for this are: a perception that the injury is not worth reporting; that reporting is too time consuming or inconvenient; a lack of awareness of the need to report the injury; and an inability to get to the employee health service.<sup>1</sup> Lack of time and the belief that there is a low risk of infection because of the involvement of a clean needle or a history of vaccination against hepatitis B have also been stated as reasons for staff failing to report a needle-stick injury.

A surveillance on healthcare workers who have been exposed to blood-borne viruses has been carried out since 1984 in UK. By the end of June 2000, the PHLS Communicable Dis-

ease Surveillance Centre had received 827 reports of exposures to material from patients with antibody to HIV, hepatitis C or hepatitis B. Of these, 242 workers were exposed to HIV. Of the total workers infected, 337 were nurses and 262 were doctors. These two groups remain the most frequently exposed.

Sharps waste in rural areas and immunisation settings is a big concern. In such situations the waste generation sources are scattered and the quantum of waste generated per location is little. Various options are being tried to manage this waste stream with minimum manipulation in the existing infrastructure and environment. See appendix (new policy paper)

### Slide 14: Mercury spill management containment kit

A 'Mercury Containment Kit' should be available in all wards to clean up mercury spills. The kit should contain the following items:

- ◆ Nitrile gloves or two pairs of latex gloves (mercury can pass through a single pair of latex gloves), though chemical resistant gloves are ideal for the situation.
- ◆ Face mask
- ◆ Protection for the eyes
- ◆ Scotch tape
- ◆ 10 cc syringe
- ◆ Covered plastic/glass container with water

### Slide 15: Mercury spills – thumb rules

Mercury-based instruments should never be used in a carpeted area as recovering spilt mercury from carpets would be extremely difficult. If

→ 1. Under-reporting of needlestick injuries in a university hospital, Hamory B.H.

a mercury spill occurs, the following precautions should be followed:

- ◆ Never touch mercury with bare hands as mercury is absorbed quickly through the skin.
- ◆ Remove all jewellery when dealing with mercury, as mercury combines with gold, silver and other metals.
- ◆ Clear the area around the spill and contain the spread of mercury.
- ◆ Wear protective gear. Workers need to wear fit-tested respirators with chemical filters, not the ones they wear for biological risks. They need to, preferably, wear chemical resistant gloves, and not latex gloves.
- ◆ Try to gather all the droplets of mercury with the help of two hard cardboard sheets and then use a syringe to suck this big droplet of mercury. Mercury is a non-wetting liquid, which has the affinity to hold to itself (a property called ‘cohesion’); thus all small drops of mercury stick to each other to form a big drop.
- ◆ Pour contents of the syringe into a plastic/glass container with 5-10 ml of water. Since mercury is heavier than water it settles down and this minimises the chances of its vapourisation.
- ◆ Put the used syringe back in the kit, upside down.

Slides 17-19 give additional information about the seriousness of a mercury spill.

### **Slide 20: Glutaraldehyde safety action plan**

Implementing the nine-step programme, detailed in the slide, will eliminate all glutaraldehyde

overexposure during routine work procedures.

- ◆ Identify usage locations: all departments that use glutaraldehyde must be identified. As many usage locations as possible should be eliminated. Usage should be centralised, where possible.
- ◆ Monitor exposure levels: measurement of glutaraldehyde exposure levels must be conducted in all usage locations using monitoring badges or hand-held direct reading meters.
- ◆ Training: an in-depth education and training programme should be conducted for all employees who work with hazardous chemicals.
- ◆ Use personal protective equipment: all employees who work with glutaraldehyde must be provided appropriate protective equipment. This equipment includes proper eye/face protection, chemical protective gloves, and protective clothing. Only splash goggles with side shield protection and fitting snugly all around the eyes are acceptable when working with glutaraldehyde. These goggles should have combination eyeshield/face masks, which are commonly used for splash protection because the liquid could splash on the forehead and drip into the eyes. In addition to splash goggles, OSHA guidelines require face protection when working with glutaraldehyde. Employees should wear face shields that wrap around the face and extend down past the chin for adequate face protection.
- ◆ Administrative controls: Limit employee access to glutaraldehyde usage locations and eliminate as many usage locations as possible by centralising usage in a few locations. Central supply is a logical choice for such

consolidation. Suitable eyewash units must be available for immediate emergency use in all glutaraldehyde usage locations.

- ◆ **Work practice controls:** Studies have shown that glutaraldehyde vapours increase whenever the solution is agitated. Vapour levels increase when glutaraldehyde is poured into or dumped out of a soaking bin, when instruments are placed into and removed from the solution, and when instruments are rinsed. Employees should be trained to minimise agitation of the solution as much as possible during these work procedures. If exposure monitoring shows that these procedures result in excessive exposure levels, the work process should be enclosed in a glutaraldehyde fume hood system.
- ◆ **Engineering controls:** Rooms in which glutaraldehyde is used should have a minimum of 10 air exchange rates per hour. General room ventilation, however, will not effectively control glutaraldehyde exposure levels. As recommended, glutaraldehyde exposure limits decrease, installing glutaraldehyde local exhaust fume hoods becomes more important. Placing the glutaraldehyde-soaking bin in a fume hood will eliminate virtually all glutaraldehyde exposure problems. To ensure proper performance, the fume hood should have a minimum face velocity of at least 80 feet per minute.
- ◆ **Neutralise solutions before disposal:** Most healthcare facilities dispose of spent glutaraldehyde solutions by simply pouring them down a drain connected to a sanitary sewer. This practice may adversely affect the operation of the local sewage treatment facility. Pouring several gallons of glutaraldehyde solution may also cause significant worker exposure to glutaraldehyde vapours. These problems can be avoided by neutralising the spent Cidex. A neutralising agent will, over

time, chemically inactivate the glutaraldehyde. Neutralisers such as dibasic ammonium phosphate solution, sodium bisulphate and liquid ammonium hydroxide can also be used.

- ◆ **Develop a spill clean-up plan:** A 'response team' should be created to develop and execute procedures for glutaraldehyde spills. All spills, no matter how small, should be cleaned up immediately.

### **Emergency measures for contacts and spills**

- ◆ **Accidental skin contacts must be dealt with immediately:** wash under running water and dry thoroughly.
- ◆ **Eye contact:** report to the Acute Care Centre for eyes to be flushed with 1 litre of normal saline. Eyes can then be checked by the local medical officer.
- ◆ **Minor spills** are those small enough to be wiped with disposable cloths. These cloths must then be discarded in a *sealed* plastic bag, as general waste.
- ◆ **Large spills for areas without floor drainage:** Glutaraldehyde spill kits should be available. Wear full protective clothing and respirator. Use rolled towels around the edges of the spilled liquid to contain the spread. Neutralise the spill with appropriate neutralisers.
- ◆ **Wipe with towels or mop up.** Rinse towels or mops thoroughly under running water. Place the towels in a plastic bag and convey them to the laundry with a clear warning of their contents. Remove protective clothing. Decontaminate protective clothing and respirator.

## **Slides 21-24: Cytotoxic waste**

<http://www.afscme.org/health/faq-cyto.htm>

## **Slide 25: Contaminated laundry**

This slide enlists the standards given for contaminated laundry in the OSHA Blood-borne pathogen standards.

In most Indian hospitals, soiled linen generated in places like labour rooms, OTs or ICUs are disinfected at source by dipping in a 10 per cent bleaching solution, before giving it to the laundry department. This minimises the risk of infection during transportation and sorting. If the laundry is sent outside the hospital for cleaning, the hospital has to take extra precautions.

## **Slide 26: Follow up meeting with trainees**

### **Discussing problems, answering queries**

During the initial stages of implementation of a waste management policy, the staff is likely to have many questions. Teething problems should be resolved swiftly so that the staff does not lose confidence in the waste management process.

As problems emerge, one can make a list of them and discuss their solutions with staff members who might not have experienced those problems yet. Monitoring sheets are an excellent tool for uncovering problem areas of the waste management process. Senior people from the waste management committee, or any officer who has been instrumental in monitoring the waste management system, should maintain monitoring sheets that list various problems noticed in the system.

### **Awareness**

Posters, circulars and hospital magazines can be used to disseminate timely information on medical waste and its treatment. Posters can serve as a continuous reminder of existing waste management schemes. They would also help sensitise new staff and visitors to the hospital.

Staff meetings are also a good forum to raise awareness and discuss issues pertaining to waste management.

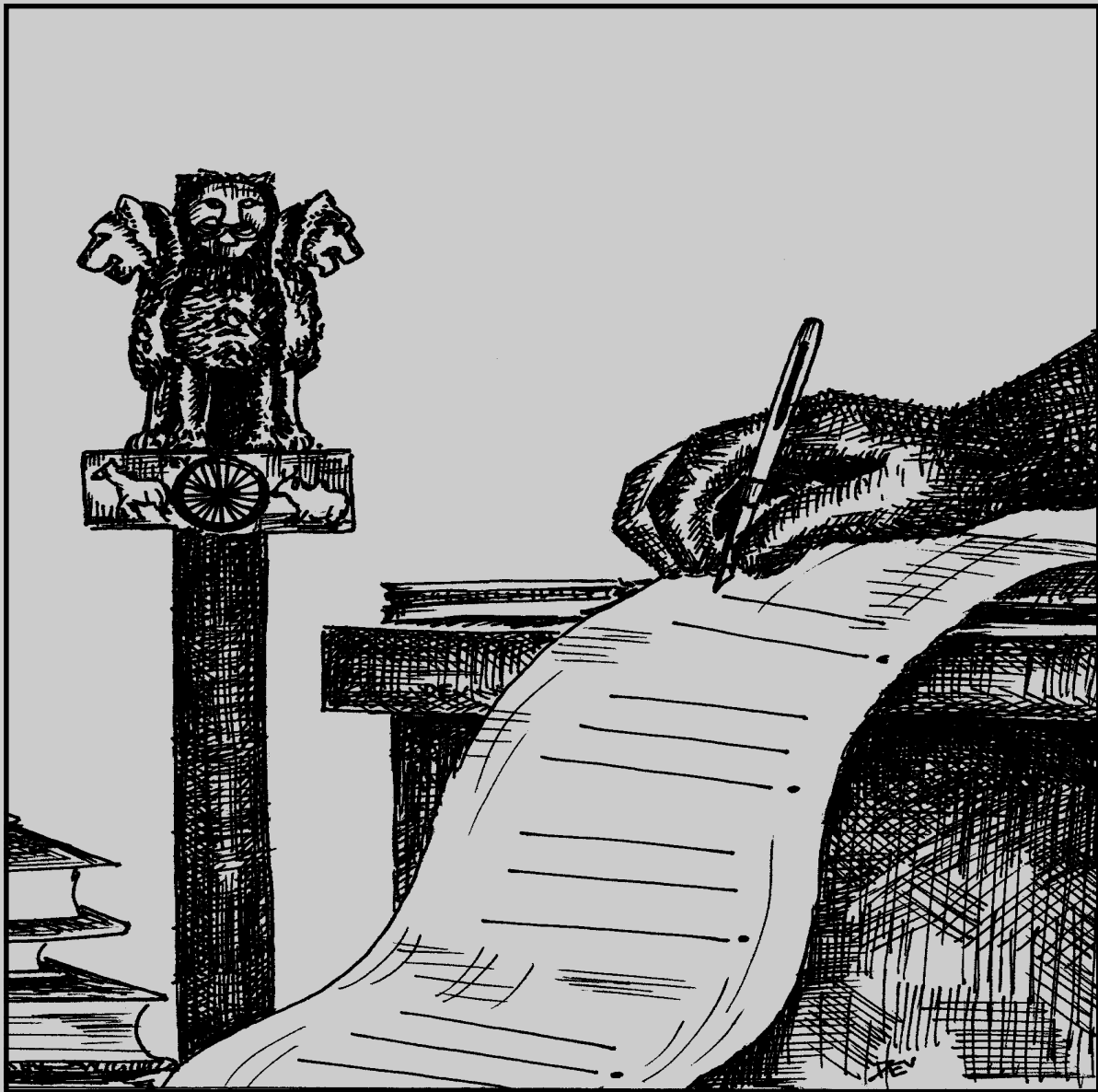
Various incentives and disincentives can be introduced to encourage people to follow the correct waste management techniques.





# *Section E*

## **Rules and policies**



## **Bio-medical Waste (Management & Handling) Rules 1998**

Medical waste was earlier considered a part of municipal waste. It was only when the problems with mixing the two were realised that separate policies were framed for their treatment. In India, there was no legislation on medical waste till the Ministry of Environment and Forests came up with the first draft rules in 1995.

The rules recommended on-site incinerators for all hospitals with 30 or more beds. In the public interest case of Dr B.L. Wadhwa vs. Union of India, the Supreme Court of India, in March 1996, ordered that this rule be implemented in the city of Delhi. Srishti intervened with a Public Interest Litigation (PIL) of its own in which it petitioned for a review of this dangerous order. The court was also requested to include alternative technologies and their standards into the rules, both of which were agreed to.

The second draft rules were notified in 1997 and objections were invited from the public within 60 days from its date of publication on October 16, 1997. The final rules were notified on July 20, 1998 and were called Bio-medical Waste (Management & Handling) Rules, 1998.

Since then, three amendments have been

made to the rules. The first amendment was notified on March 6, 2000 and is referred to as the Bio-medical Waste (Management & Handling) (Amendment) Rules, 2000. The amendment extended the deadline for implementation of the rules, considering that when the first deadline for eight cities with a population of more than three million was over, these cities had not been able to achieve anything significant.

The second amendment to the rules was notified on June 2, 2000 and was called Bio-medical Waste (Management & Handling) (Amendment) Rules, 2000. Some of the major changes made through this amendment included defining the role of the municipal body, nominating Pollution Control Boards/Committees as prescribed authorities, addition of forms for seeking authorisation to operate a facility and for filing an appeal against orders passed by the prescribed authority.

The third amendment was notified in September 2003. It made DGAFMS (Director General Armed Forces Medical Services) the prescribed authority for medical waste management in all medical establishments under the Ministry of Defence.

## Slide 4: Provisions and clauses

Schedule I categorises bio-medical waste into 10 categories and enumerates treatment and disposal options for each of them. Healthcare institutes are free to select the option best suited to them.

Where autoclave and microwave have been suggested as treatment options, advanced autoclaves (for example, a hydroclave) can also be used. Hydroclave was approved by the CPCB 'Peer and Core Group' after the final rules were notified.

The second amendment added the words 'Disposal options +', implying that the mentioned options are based on available technologies, and anyone interested in using other state-of-the-art technology would have to approach the CPCB for their approval.

Schedule V provides the standards for treatment and disposal of bio-medical waste, including standards for technologies, liquid waste and deep burial.

The colour codes have been carefully chosen to distinguish waste as per its treatment option. They should be followed religiously. Segregation in colour-coded, labelled containers has been suggested for ease and uniformity. The initial drafts recommended red bags for holding incinerable waste, but the final rules changed that to yellow as red bags contain cadmium dyes (cadmium is a toxic heavy metal and pollutes air, soil and water, if incinerated).

Use of black coloured bags for categories 5, 9 and 10 is another area of discussion. In the municipal and medical waste rules, black has been specified for substances to be landfilled (municipal rules specify that anything that cannot be bio-degraded or recycled should be stored in black bags, and in another clause it mentions

that such waste should go to a landfill). As general waste in any hospital is not subject to the provisions of the Bio-medical Waste Rules, Municipal Waste Rules, 2000 should be applied to such waste.

Colours mentioned for general waste are: green for bio-degradable, white for recyclable and black for any other kind of waste. Most of the waste generated in wards is either recyclable or bio-degradable, thus white or green bags can be used for general waste.

## Slide 5: Provisions and clauses

Containers of bio-medical waste should have appropriate labels (such as bio-hazard, cytotoxic, etc). If the bags are transported for off-site treatment and disposal, they should have additional information on them such as the sender's and receiver's contact details, and the type of waste.

Bags should be sealed when they are three-fourth full and kept for collection and transportation to the designated site by the designated person. Transportation within the hospital should be carried out in trolleys, which should be designed in such a way that there is no spillage during transportation. Transport routes should preferably avoid patient areas and different time slots should be allocated for the transport of different wastes to reduce the chances of their mixing. Dedicated wheeled trolleys with labels and without any sharp edges should be available for this purpose. Regular cleaning and disinfection should be carried out along the transportation route.

## Slide 7: Authorisation

Only institutes catering to more than 1,000 patients per month need to seek authorisation.

But it should be realised that this provision does not absolve others (those with less than 1,000 patients) of the duty of managing their bio-medical waste. Under the Bio-medical Waste Rules, it is the duty of every occupier to ensure that the waste generated in their premises does not harm the environment or people. Moreover, it has been held that maintenance of health, and the preservation of sanitation and environment falls within the purview of Article 21 of the Constitution of India which ensures the right to a healthy life.<sup>2</sup>

→ 2. LK Koolwal v. State of Rajasthan, AIR 1988.

Thus, all waste generators come under the purview of the rules though some may not need to seek authorisation.

Centralised facility: anyone interested in setting up facilities for the collection, reception, treatment, storage, transportation and disposal of bio-medical waste shall also need to seek authorisation from the Prescribed Authority. Few terms and conditions have been listed in the rules and there is provision of any additional conditions that may be stipulated by the Prescribed Authority. Some significant points are listed below:

- ◆ The person authorised shall not rent, lend, sell, transfer or otherwise transport the bio-medical waste without obtaining prior permission of the Prescribed Authority.
- ◆ It would be the duty of the authorised person to take prior permission of the Prescribed Authority to close down the facility.

One instance of a specific condition being listed down by the Prescribed Authority to ensure smooth functioning of the system is seen

in Andhra Pradesh. Here, in case of more than one facility being available, the facilities have to commit to act as a stand-by for each other in case of any problems.

**Authorisation Fee:** There is a provision of a fees along with the form, while seeking or renewing authorisation. The fee structure is different for each state and Union Territory and separate structures are applicable to hospitals, laboratories/clinics and centralised facilities.

The Prescribed Authority may issue provisional authorisation for a period of one year. This trial period gives a chance to the applicant to prove the capacity to handle bio-medical waste according to legal requirements. The subsequent renewal can be of three years, but the authorities can cancel this authorisation anytime if they are dissatisfied with the procedures followed by the authorised person.

## Slide 8: Records

The concerned institution should maintain every detail pertaining to waste generation and its disposal. This is to be compiled and submitted to the Prescribed Authority at the end of the year. The records are also helpful during the internal audit of the waste procedures.

The type and quantity of waste generated, mode of transportation, people involved, level of segregation in each unit of the hospital, mode of treatment and the parameters of functioning of the treatment technologies or other relevant details of the procedure could be covered by the monitoring authority.

Accident reporting formats should be made available at each hospital, either at a central place or at each work station. The rules mention that each accident involving waste should be reported, but what constitutes an accident has not been elaborated.

In the context of medical waste, an accident can include the following:

- ◆ Spillage of bio-medical waste during transportation within or outside the hospital.
- ◆ Spillage of blood or any other body fluid.
- ◆ Spillage/accidental exposure to any hazardous chemical or drug.
- ◆ Needle- stick injury to any personnel.

### Slide 9: Implementation schedule

*This slide is only for trainees' information, as all deadlines for implementation have expired.*

The rules had made a provision for staggered/phase-wise implementation in the country based on the population size of a city and number of beds in a hospital.

The idea was to give hospitals enough time to build their waste management capacities. The first phase covered cities with a population of more than three million. All healthcare facilities in these cities had to comply with the rules by December 31, 1999. None of the eight cities identified (Delhi, Mumbai, Kolkata, Hyderabad, Chennai, Ahmedabad, Thane and Bangalore) were able to achieve anything substantial even after the deadline was over.

An amendment was therefore made to the law, and the deadline was extended to June, 2000. The deadline for the entire country expired in 2002.

### Slide 10: Categories

Schedule I of the rules categorises bio-medical waste into 10 categories. Various treatment technologies have been suggested for each category and a particular option can be chosen

depending on its availability and suitability.

Different areas within a hospital would be generating different types of waste. The number and type of bins can be decided, based on the type of waste generated at each location.

Some conditions that have been prescribed for various categories are:

- ◆ Deep burial is an option given for categories 1 and 2, but this can be done in rural areas and in towns with a population of less than 5,00,000.
- ◆ Anything going for incineration should not be pre-treated with any chemical. Chlorinated plastic should not be incinerated.
- ◆ Mutilation of categories 4 and 7 is a must to prevent unauthorised reuse. Mutilation/shredding has been mentioned, implying that one has to necessarily ensure mutilation, even if complete shredding cannot take place at a particular location.
- ◆ The new Guidelines for Common Bio-medical Waste Treatment Facilities limit incineration to categories 1 and 2 and cytotoxic drugs.

### Slide 11: Colour coding

The Second Schedule of the rules mention colour codes for various waste categories depending on the treatment option used. This slide is a combination of Schedule 1 and 2 of the rules. Wherever the rules mention autoclaving and microwaving the trainers should tell the trainees about the addition of hydroclave in this list.

**Slide 12: Take note**

- ◆ The law prescribes a maximum time limit of 48 hours for storing waste. One must, however, make provisions for treating the waste on the same day. If, for some reason, untreated waste has to be stored beyond 48 hours, the Prescribed Authority needs to be informed about it. In Indian conditions with a hot and humid climate one has to be careful about storing the waste for so long.
  - ◆ Chlorinated plastics are not to be incinerated. No chemical pre-treatment of waste is allowed before incineration. Chlorine content in the waste has been linked with the production of toxic gases like dioxins and furans, thus our rules prohibit the incineration of any chlorinated plastics. Since, in India, there is no provision of labelling of plastics it would be advisable to abstain from incinerating any plastic material. Most hospitals use chlorine-based disinfectants, thus it is essential that none of the waste destined for an incinerator is chemically pre-treated. This practice would help eliminate any chances of introduction of chlorine into the incinerator.
  - ◆ Bags for incineration should not be made of chlorinated plastic. This provision is to avoid introduction of chlorine into the waste stream. Non-chlorinated bags should be used for incineration. These bags are readily available in the market and can be made up of polyethylene, polypropylene or any other non-chlorinated plastic.
  - ◆ The label shall be non-washable and visible prominently. It should have details such as the date, category, class and description of waste. If transported off-site, the contact details of the sender and receiver should also be mentioned on the label. The labels help in tracking the waste to its origin in case of any problems or if clarifications are required.
- They also help guide people handling the bags and act as warning signals for unauthorised people who may come in contact with the bags due to negligence or an accident. In case of off-site treatment the vehicle and driver should have visible notes/labels with all instructions. This is necessary, as in the event of an emergency information like precautions, immediate steps to be taken, contact number and names of people to be informed are available.
- ◆ Deep burial is an option for towns with population of 5,00,000 or less, and in rural areas. This provision has been kept to ward off the possibility of contamination of ground water. Moreover, towns with a population of more than 5,00,000 may have problems like shortage of land making it difficult to identify such a site.
  - ◆ For use of treatment options not specified in the rules, one shall approach CPCB to get the standards laid down. In the 1998 final Rules, three technologies had been mentioned for the treatment of medical waste. Later, another technology was given approval by the CPCB's 'Peer and Core' Group. The second amendment gave the provision of inclusion of any other technology for medical waste treatment, subject to its approval by CPCB.

**Slide 13: Role of municipal body**

Schedule 2 of the Municipal Waste Rules, 2000, mentions that bio-medical waste shall not be mixed with municipal waste.

The Bio-medical Waste Rules specify that general waste and treated medical waste from the hospitals has to be treated as municipal waste and continue to be picked up by the municipal authorities.

Municipal authorities have also been made responsible for providing land for common treatment and disposal sites for medical waste in the area under their jurisdiction.

### Slide 14: Incinerator standards

The combustion efficiency is computed as:

$$\text{C.E.} = \% \text{CO}_2 / (\% \text{CO}_2 + \% \text{CO}) \times 100$$

### Slide 22, 23: Environment Protection Act

Section 5: subject to the provision of this Act, the Central Government may issue directions in writing to any person. This includes the power to direct:

- a) The closure, prohibition or regulation of any industry, operation or process; or
- b) Stoppage or regulation of the supply of electricity or water or any other service.

Section 6: This section empowers the Central Government to make rules in respect of all or any environmental issues.

Section 8: no person shall handle, or cause to be handled, any hazardous substance except in accordance with such procedure and after complying with such safeguards as may be prescribed. Under the Act, a hazardous substance is defined as any substance or preparation which, by reason of its properties or handling, is liable to cause harm to human beings, other living creatures, plants, micro-organisms, property or the environment.

*With reference to medical waste, mercury, glutaraldehyde, blood or body fluids will all fall under the hazardous waste category. Thus, all hospitals should have procedural safeguards to handle them.*

Section 10 (Power of entry or inspection): any person empowered by the Central Government (*Pollution Control Board under Bio-medical Rules*) shall have the right to enter, at all reasonable times with such assistance as he considers necessary, any place for inspection to ensure whether or not the rules are being complied with, inspecting records and equipment used to handle bio-medical waste, etc.

A hospital would be bound to render all assistance to the visiting member without delaying or obstructing him; an institution that fails to do this shall be guilty of an offence under this Act.

Section 11 (Power to take samples and procedures to be followed therewith): the Inspecting Officer would have the liberty to take samples (in the presence of the occupier) of any kind for analysis, after completely informing the occupier about the process, and issuing a notice then and there of his intention to get a sample analysed.

The samples have to be sealed and signed by both parties. In case the occupier wilfully absents himself during this process or refuses to sign, then the officer has the power to take the sample and sign it himself. The samples should then be sent for analysis to a government-approved laboratory without any delays.

Section 15 (Penalty for contravention of the provisions of the Act and the Rules, Orders and Directions): whoever fails to comply with or contravenes any provision of this Act, or the rules or orders or directions issued thereunder, shall, in respect of each such failure or contravention, be punishable with imprisonment for a term which may extend to five years or with a fine which may extend to Rs 1,00,000, or with both. In case the failure or contravention continues, there would be an additional fine which may extend to Rs 5,000 for every day during

which such failure or contravention continues after the conviction for the first such failure or contravention.

If the failure or contravention continues beyond a period of one year after the date of conviction, the offender shall be punishable with imprisonment for a term, which may extend to seven years.

Section 16 (Offences by Companies): where an offence has been committed by a company, every person who, at the time the offence was committed, was directly in charge of, and was responsible to, the company for the conduct of the business of the company, as well as the company, shall be deemed to be guilty of the offence and shall be liable to be proceeded against.

If the person proves that the offence was committed without his knowledge or that he exercised due diligence to prevent the commission of such offence then the person shall not be liable to be punished.

In case the offence is attributable to any other people in the company other than or in addition to the occupier, then that person would also be liable for punishment.

Section 17 (Offences by Government Departments): in case the government departments are involved, the head of the department (HOD) would be guilty. But, like the above clause, if the HOD proves that the offence was committed without his knowledge or he exercised due diligence to prevent it, he will not be guilty.

## **Slide 24: Other rules**

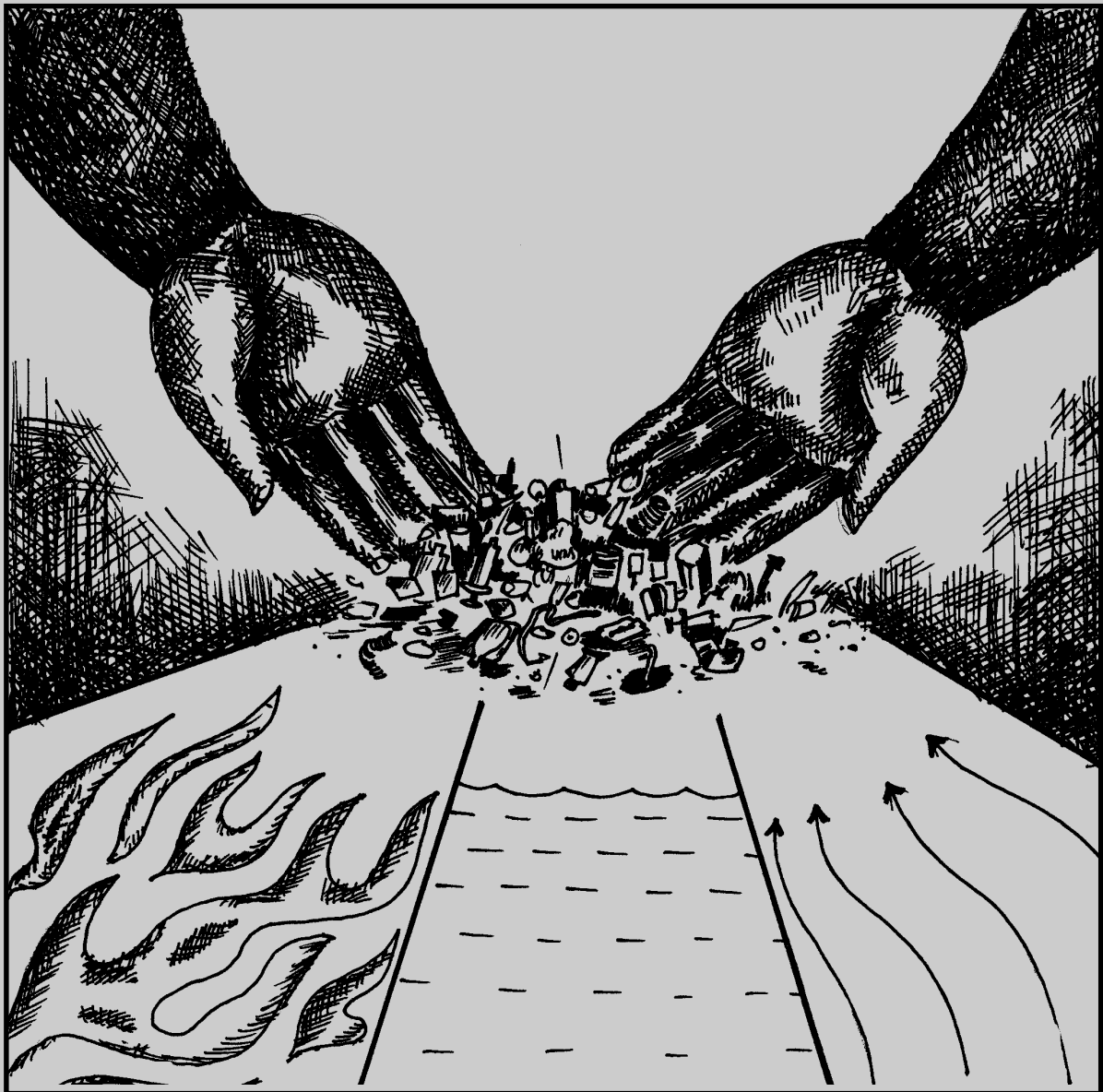
A hospital is basically a complex system and would generate various kinds of waste, including bio-medical, general, radioactive and hazardous waste. As there are already some guidelines/ rules available for each of these aspects, these have not been covered under Bio-medical Waste Rules. Hospitals are supposed to implement all relevant guidelines, applicable to them.

To assist implementers and enforcers of the Bio-medical Waste Rules, the government has come out with various guidelines, including the National Guidelines for Bio-medical Waste, Guidelines for Design and Construction of Incinerators and Guidelines for Common Bio-medical Waste Treatment Facilities.



# *Section F*

## **Alternative technologies**



## **Slide 1, 2 and 3: Bio-medical waste and technology**

Around 15-20 per cent of hospital waste is comprised of bio-medical waste (depending on the type of facility). Thus, the most important task is to segregate the hospital waste from the general municipal waste (nearly 80 per cent of hospital waste). After the segregation, the bio-medical waste needs to be sub-categorised as infectious or hazardous waste.

Different kinds of waste need different types of technology for their treatment. Therefore, waste needs to be segregated according to the treatment technology suitable for a particular waste type. At the same time, the healthcare facility needs to think of ways by which the use of hazardous substances is minimised to prevent the expense on treatment and disposal, and also the environmental and health costs involved.

Subsequently, a waste audit needs to be conducted to determine whether or not an on-site facility would be feasible, what capacity would be the best, and other related questions.

Any technology used for the treatment of bio-medical waste should effectively disinfect it, and then mutilate it to make it non-reusable. The first draft rules provided for incineration of bio-medical waste, but the final rules mention other options for treating waste. They also cater for any new new technology that might come up.

Incineration as a technology has been discussed in detail in a separate chapter, and this chapter focuses on environmentally safer alternative technologies.

## **Slide 4: Treatment technologies**

Hospital waste that needs special attention can be classified into infectious and hazardous waste.

Infectious waste includes body parts, anatomical tissue, bandages, infectious plastic, microbiology and biotechnological waste or any other thing contaminated with blood or body fluids (refer Schedule I of the BMW Rules).

Hazardous waste includes radioactive waste (covered under the Atomic Energy Act), pharmaceutical waste (including cytotoxic drugs) and various disinfectants.

Over the years, incinerators have been identified as problematic. Incineration is a process that changes the waste not just physically but also chemically. The end products, which can be more toxic than the original waste, need to be disposed off. Thus incineration can be called a polluting treatment technology, and is not a disposal method.

After years of study, incineration has been linked to various health hazards. Alternatives to this technology have therefore been developed

for treating infectious waste. Various technologies available or still under research can be grouped as:

- ◆ Thermal processes: low heat, medium heat, high heat.
- ◆ Chemical processes.
- ◆ Irradiative processes.
- ◆ Biological processes.

Thermal processes utilise heat to disinfect. Depending on the temperature they operate at, these technologies have been grouped into low, medium and high heat technologies.

Low heat technologies operate between 93-177°C (200- 350 °F). This temperature is insufficient to cause any chemical change or support combustion or pyrolysis. The two types of low heat technology are: wet heat (steam), as found in autoclaves and microwaves, and dry heat (hot air) disinfection.

Medium heat processes work between 350-700 °F and involve chemical breakdown of organic material. Some newer technologies like reverse polymerisation, using high-intensity microwave energy and thermal de-polymerisation using heat and high pressure are examples of medium heat processes.

High heat technology involves a temperature range of 540-8,300 °C (1,000-15,000 °F) or even higher. Electrical resistance, induction, natural gas and/or plasma energy provides such intense heat.

These processes involve both chemical and physical changes of organic, as well as inorganic material, causing the total destruction of waste. A significant change – 90-95 per cent reduction in the mass and volume of waste also occurs as

compared to 60-70 per cent in low heat methods using shredders. Examples of high heat technology are pyrolysis-oxidation, plasma pyrolysis, induction-based pyrolysis and laser-based pyrolysis.

Chemical processes use chemicals that act as disinfectants. Sodium hypochlorite, dissolved chlorine dioxide, peracetic acid, hydrogen peroxide, dry inorganic chemicals and ozone are examples of such chemicals. Generally speaking, the higher the surface area, the higher the disinfection, thus the waste needs to be either shred, ground or mixed. Most chemical processes are water-intensive and require neutralising agents.

Irradiative processes involve electron beams, Cobalt-60, or UV irradiation. These technologies do not alter the waste physically - they need grinders to do that.

Some biological processes, which use enzymes to destroy organic matter, have also been developed. Composting and vermiculture are also examples of biological processes that are being tried out by various healthcare organisations and individuals worldwide.

Mechanical devices like shredders and grinders are accessories to treatment technologies. These devices assist in volume reduction of waste. Generally, these should be applied after disinfection to prevent problems due to aerosolisation of pathogens.

## Slide 5: Biological indicators

Technologies that are used to treat infectious waste are judged by the efficiency with which they inactivate micro-organisms.

Microbial inactivation is more appropriately expressed as a probability function, measured as reduction by factors of 10 in survival probability of a microbial population. Suspensions of resist-

ant endospores (a suspension of  $2 \times 10^{10}$  initial inoculum in a plastic container) are typically used as biological indicators.

These indicators are placed inside the treatment chamber, with waste, during the treatment cycle. Then the test strip and the control strips (without treatment) are placed and the colony forming units (cfu) are counted to determine the efficacy of the technology.

Four levels of disinfection are generally recognised; level four means sterilisation, that is, complete destruction of microbial life (99.9999% or greater reduction of vegetative bacteria, fungi, all viruses, mycobacteria and bacillus thermophilus spores).

According to (STAATT) State and Territorial Association on Alternative Treatment Technologies, USA, alternative technologies should meet at least level three requirements. Our rules have the same requirements. The various levels are:

- ◆ Level one: inactivation of vegetative bacteria, fungi, and lipophilic viruses at a  $6 \log_{10}$  reduction or greater.
- ◆ Level two: inactivation of vegetative bacteria, fungi, lipophilic/hydrophilic viruses, parasites and mycobacteria at a  $6 \log_{10}$  reduction or greater.
- ◆ Level three: inactivation of vegetative bacteria, fungi, lipophilic/hydrophilic viruses, parasites and mycobacteria at a  $6 \log_{10}$  reduction or greater and inactivation of bacillus stearothermophilus and bacillus subtilis spores at a  $4 \log_{10}$  reduction or greater.
- ◆ Level four: inactivation of vegetative bacteria, fungi, lipophilic/hydrophilic viruses, parasites, mycobacteria and bacillus stearothermophilus at a  $6 \log_{10}$  reduction or

greater. This level is also called sterilisation.

### Slide 6: Autoclave

Autoclave is a low heat thermal process and it uses steam for disinfection of waste. The boiling point of water (reaches saturation) is dependent on its pressure; if the pressure is increased water boils at a higher temperature. Steam-based sterilisation technologies make use of this principle.

An autoclave has an inner chamber where waste is loaded and surrounded with a jacket. Steam is applied to the inner chamber and the outside jacket. Heating the outside jacket reduces condensation in the inner chamber walls and allows the use of steam at lower temperatures.

The rules allow for use of different temperature, pressure and time combinations for a treatment cycle.

### Slide 7: Types of autoclave

Steam is the disinfecting agent in autoclaves, thus it is very important that the entire waste comes in contact with the steam. Air, being an insulator, needs to be removed to ensure penetration of heat into the waste.

Autoclaves are of two types depending on the method they use for removal of air pockets. Two common ways of doing this are:

- ◆ Gravity/downward displacement: these autoclaves take advantage of the fact that steam is lighter than air; steam is introduced under pressure into the chamber forcing the air downward into an outlet port or drain line in the lower part of the chamber.
- ◆ Pre/high vacuum: vacuum pumps are used to generate vacuum. This is therefore a more

effective system to evacuate air pockets from the inner chamber, resulting in shortened sterilisation times. After the removal of air, steam is injected into the chamber.

## Slide 9: Stages in autoclave operation

- ◆ Pre-heating: introduction of steam in the outer jacket.
- ◆ Loading of waste with an indicator.
- ◆ Air evacuation: air is removed using either the gravity displacement or the vacuum method.
- ◆ Steam treatment: steam is introduced into the chamber till the required temperature is reached. Additional steam is automatically fed into the chamber to maintain the temperature for a fixed time period.
- ◆ Steam discharge: steam is vented from the chamber, usually through a condenser, to reduce the pressure and temperature. In some cases a post-vacuum cycle is used to remove residual steam.
- ◆ Unloading: unloading is usually done after giving the treated waste some time to cool.
- ◆ Mechanical treatment: shredder/compactors/grinders are attached to reduce the bulk of treated waste and to render it unusable.

## Slide 10: Types of waste allowed/disallowed

Category 3 (microbiology and biotechnology waste): waste from laboratory cultures, stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell culture used in research, infectious agents used in research and industrial labs, waste from production of

biologicals, toxins, dishes and devices used for transfer of cultures.

Category 4 (waste sharps): needles, syringes, scalpels, blades, glass etc., that may cause puncture and cuts. This includes both used and unused sharps.

Category 6 (soiled waste): items contaminated with blood and body fluids, including cotton dressings, soiled plaster casts, linen, beddings, etc.

Category 7 (soiled waste): waste generated from disposable items other than the waste sharps, such as tubings, catheters, intravenous sets, etc.

Hazardous waste and chemicals should not be autoclaved as they might cause toxic emissions. Heat-resistant containers, beddings and other bulky containers cannot be successfully autoclaved because of their bulky size, which inhibits proper contact with steam.

## Slide 13: Points to remember

- ◆ Segregation of waste is important to avoid emission problems.
- ◆ Proper ventilation should be ensured to reduce or eliminate odours and minimise exposure of workers to odours.
- ◆ Air evacuation is necessary to eliminate the possibility of air pockets which would decrease the efficacy of the system. Air evacuation is more effective in autoclaves with a pre-vacuum or multiple vacuum cycles. With higher vacuum levels and more cycles, the heat penetration is deeper and uniform. (All evacuated air, which may contain pathogens, must be disinfected prior to being released into the environment. This is often done by mixing steam with the air or using a high

efficiency particulate air (HEPA) filter which must be disinfected prior to disposal).

- ◆ Place bags in multi-load trays to increase surface area for disinfection.
- ◆ Facilities should do test runs to standardise the waste load, its type, composition, size and the cycle time and temperature using indicator strips. In case of bulky waste loads, or any other special type of waste, different options of cycle parameters can be used to ensure an acceptable level of disinfection. Indicator strips should be placed at the points of minimal contact; they can be placed at different places in a cycle to check for faulty points.
- ◆ Workers should be trained in all aspects of waste handling – from waste categorisation, handling, and accident reporting to personal protection.

### Slide 17: Microwaves – action mechanism

Microwaves can also be classified under steam-based low-heat technology, as disinfection happens through the action of moist heat and steam generated by microwave energy.

A magnetron is used to convert high voltage electrical energy to microwave energy, which is then transmitted into a metal channel called a wave guide that directs the energy into the treatment chamber.

The microwave cycles rapidly between positive and negative at very high frequency (around 2.45 billion times per second). This causes water and other molecules in the waste to vibrate swiftly as they try to align themselves to the rapidly changing electromagnetic field. The intense vibration creates friction, which in turn generates heat, turning water into steam.

The heat denatures proteins of the microbial cells, but in addition to this, denaturation may happen due to alignment of protein molecules in the field (even the protein molecules try aligning in the field and thus lose their complex structures and get denatured). Studies have shown that heat denaturation is a basic disinfectant and that without water the lethal effects of microwaves on dry microbial cells are reduced.

### Slide 21: Advantages and disadvantages

The advantages of the microwave system is that there are minimal emissions, provided no hazardous waste is fed.

Volatile and semi-volatile organic compounds, chemotherapeutic wastes, mercury and other hazardous chemical wastes and radiological waste should not be microwaved.

There are some disadvantages of using this system, including its high capital. As far as odour problems are concerned, they are minimised due to HEPA filters, but it is still a problem in the vicinity of the machine.

There is probability of microwave energy leakage and thus workers should be trained on a regular basis to inspect, monitor and contain any leakages.

### Slide 23: Other thermal technologies

*This slide is primarily for people who want to know more about technologies. These technologies are not used in India so far.*

#### Low heat (dry) technology

High velocity heated air: this system, being used in some countries, uses heated air at high speed. After the waste is loaded, it is shredded

and then transferred to a treatment chamber. Hot air is directed in a way that causes the waste particles to rotate turbulently around a vertical axis in a torroidal mixing action. This causes high rates of heat exchange and within four to six minutes, dry unrecognisable waste is ejected.

The type of waste to be treated and emission problems with this system are similar to those of autoclaves.

Medium heat technologies include reverse polymerisation or thermal de-polymerisation. This technology involves application of high-energy microwaves to medical waste in a nitrogen atmosphere to break down the organic material. Unlike other microwave systems that heat waste near the boiling temperature of water, this system operates at temperatures high enough to cause chemical change. The low-heat microwave units use between 2-6 magnetrons with outputs of around 1.2 KW each, whereas this system uses 14 magnetrons with a variable output of 3 KW each. As intense microwave energy is absorbed by the waste, the internal energy of the organic material increases to a point where chemical decomposition takes place on the molecular level. Since the microwaves heat inside out, the inside temperature is high but the chamber temperatures remain between 150-350°C. Nitrogen provides an oxygen free atmosphere and thus no combustion takes place. Scrubbers or bio-filters can be used to capture off-gases, which may contain hydrocarbons and hydrogen chloride. Shredders are used to mutilate the disinfected waste.

**Pyrolysis Oxidation:** the waste enters a pyrolysis chamber where it is heated to 200-1,100°F. This causes organic solids and liquids to vapourise, leaving behind an inert ash and inorganic material such as glass and metal fragments. In the second step, the vapours are drawn by an induced draft fan to a combustion

chamber operating at 1,800-2,000°F. Use of sufficient oxygen and proper pollution control equipment ensures a relatively clean exhaust stream.

### **Plasma based pyrolysis**

Plasma is a physical state of matter consisting of ionised particles. Ionised gas can conduct electric current but due to its high resistance, the electric energy is converted to heat producing temperatures from 3,000-21,000 °F. Most systems use a plasma arc torch to generate the plasma energy.

These are technologies being proposed as alternatives for incineration but they too might not be safe. Medium and high heat technologies involve chemical reactions and produce significant levels of pollutants including dioxins and furans.

## **Slide 24: Chemical methods**

### **Chemical based Technologies**

There are various chemical treatment technologies already in use, while some are under development. All chemical processes exploit the disinfecting properties of chemicals. Though chemical disinfection is a simple methodology it is often accompanied with problems of chemical hazards, occupational safety, toxic liquid effluents, problems of concentration, deactivation (certain chemicals are inactivated by particular material/s), contact area, etc.

Sodium hypochlorite may also form dioxins and other toxic by-products in waste water. Glutaraldehyde is toxic and poses occupational safety issues. Peracetic acid also poses occupational safety issues (it breaks down to form vinegar). Sodium hydroxide, which is used to digest pathological waste can also destroy cytotoxic waste.

**Slide 25: Evolving technologies**

Irradiation technologies use ionising radiations like X rays/gamma rays or electron beams. Ionising radiations damage the DNA, causing cell death; they also produce free radicals, which damage macromolecules (proteins, enzymes, etc).

Ionising radiation, especially radio nuclides that produce gamma rays, poses occupational hazards.

Biological methods for waste treatment are currently being researched. These utilise enzymes; waste is subjected to an enzyme solution (mixture) and waste water and solid waste are separately disposed.

Worldwide, people are also trying out composting and vermiculture methods to deal with biodegradable infectious waste, such as bandages, tissues and body parts, etc.

**Slide 26-27: Choosing an alternate technology**

Setting up a technology for waste management is an important decision which needs to be taken after the hospital has done audits and surveys to determine the type and quantum of waste generated by it. A hospital would have to decide on the technology which would be best suited for most of its waste and the capacity would have to be estimated by taking into account the present needs and the future growth estimates.

As more and more hospitals move towards centralised treatment facilities, it is important that city-wise quantifications of waste are also done. Before a centralised facility comes up, all healthcare facilities expected to use it should be asked to submit the type and amount of waste generated by them. This would help in determining the capacity and the type of technology needed. Most centralised facilities in India are now using a technology mix of 90 per cent non-burn and 10 per cent burn technology (there are continuing efforts on finding non-burn solutions for even this 10 per cent waste component).

Some technologies have a minimum feed-rate in order to be cost-effective and a maximum design feed rate. The range of waste generation during the expected life of the equipment should fall within this range.

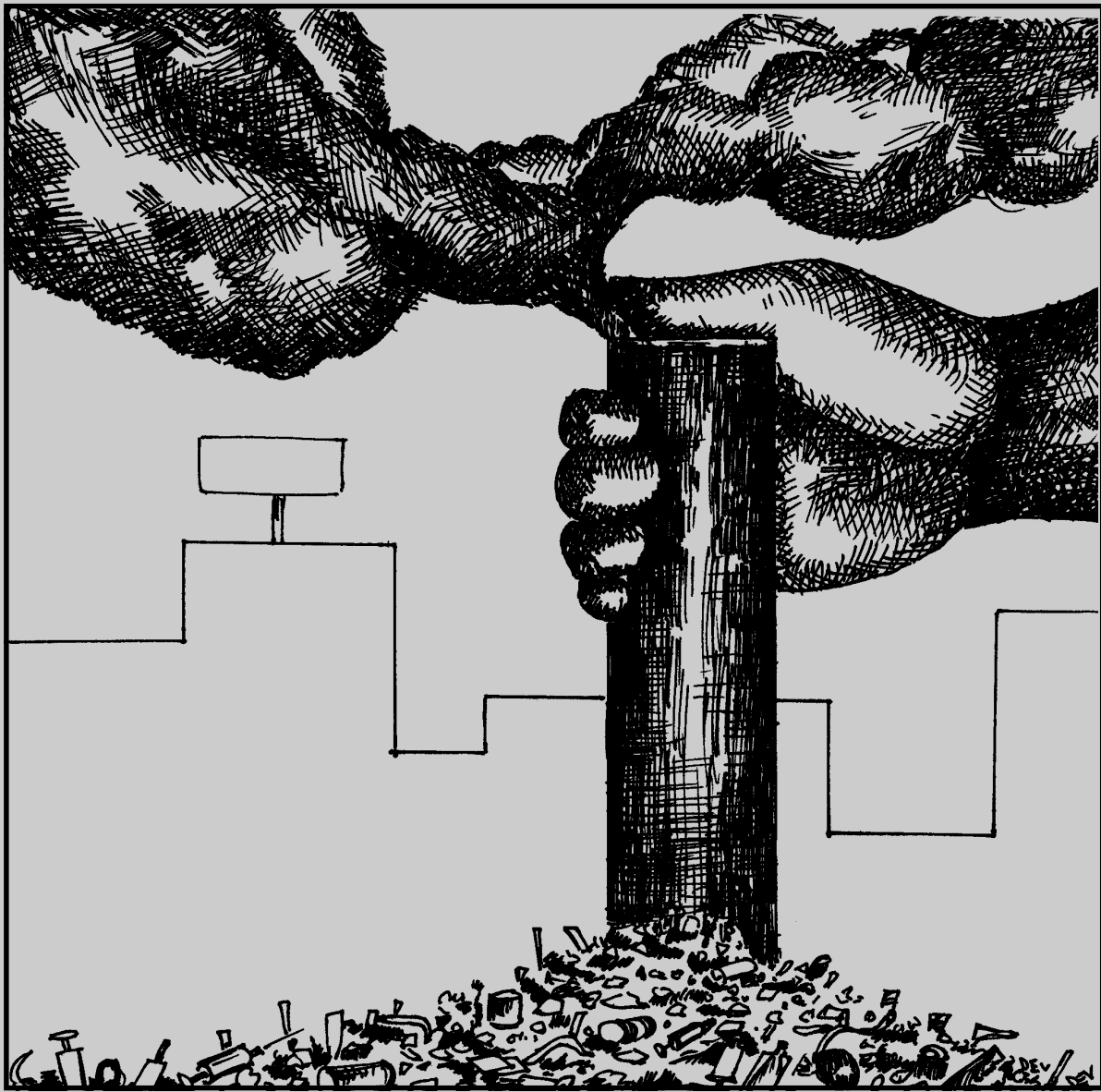
**Slide 28: Centralised facilities**

Draft Guidelines on Common Bio-medical Waste Treatment Facilities have come through and some salient features have been discussed in this slide.



# *Section G*

## **Incineration and its hazards**



# G1 Incineration and its hazards

## Slide 1: Decline in medical waste incinerators in US

When USA first woke to the hazard of medical waste, the first solution that was proposed was to burn the waste. Later, burning turned out to be a bigger problem than the waste itself, due to its release of dioxins and furans.

In India, the incinerator boom started in 1996, with the court order to implement the first draft rules for Bio-medical Waste. Fortunately, this trend was reversed in favour of other alternatives due to the timely intervention of Srishti. NGO pressure continued and resulted in the inclusion of alternatives to incineration in the rules. Now, incineration has been limited to three categories in place of five categories listed in the final rules. The new incinerator guidelines do not allow for on-site incinerators (except in some special cases).

Globally, there is mounting pressure on the incinerator industry to shut down.

### Current trend: move towards cleaner technologies

In the US, the incinerator boom of the 1980s was fuelled by business interests and a perceived landfill crisis. But the boom spawned a massive grassroots resistance movement that defeated more than 300 municipal waste incinerator proposals. The activists fought for stricter

emission standards and removal of subsidies, which virtually shut down the industry by the end of the 1990s. In Japan, public pressure has resulted in over 500 incinerators being shut in recent years. In Europe, resistance has taken the form of implementing alternatives. As a result, there is little market for new incinerators in Europe.

In Mozambique, the country's first indigenous environmental organisation succeeded in stopping a proposed cement-kiln incinerator for pesticides in a residential neighbourhood. Elsewhere, activists have had to resort to protests and direct action to stop incineration. Increasingly, however, this public opposition is being manifested in the law.

Jurisdictions in 15 countries have passed partial bans on incineration, and in Philippines, incineration has been totally banned. International law is also starting to bear upon the incineration industry.<sup>1</sup>

## Slide 2: Incineration problems

Incineration is a burn technology and high temperatures are used to kill the pathogens and, in the process, destroy the materials on which they reside. During incineration and post combustion cooling, waste components dissociate and recombine, forming hundreds and thousands of new molecules, which are referred to as products of incomplete combustion (PIC).

→ 1. Waste incineration: a dying technology; Neil Tangri, 2003.

Metals are not destroyed, but are dispersed into the environment. Theoretically, an incinerator would change hydrocarbons to carbon-dioxide and water, but this does not happen in practice.

“The complete combustion of all hydrocarbons to produce only water and carbon-dioxide is theoretical and could occur only under ideal conditions...real-world combustion systems however, virtually always produce PICs, some of which have been determined to be highly toxic.”<sup>2</sup>

The deviations from theoretical running are called ‘combustion upsets’. These upsets are classified as macro- and micro-level upsets.

Macro-level upsets include equipment failure, human error and rapid changes in the waste fed to the machine.

Micro-scale upsets include transient departures from ideal conditions and are usually a consequence of a rapid perturbation in the incineration operation resulting from a rapid transient in feed rate or composition, failure to adequately optimise a liquid fuel, excursions in operating temperatures, instances where the combustible mixture fraction is outside the range of good operating practice, or inadequate mixing between the combustibles and the oxidant.

### Slide 3: Types of incinerators

**Three types of incinerators used for hospital waste treatment are:**

- ◆ Multiple hearth incinerators: these consist of two or more combustion chambers. The primary chamber is for solid-phase combustion, whereas the secondary chamber is for gas-phase combustion. These incinerators are often referred to as excess-air incinerators, because both the chambers have excess air levels.

- ◆ The rotary kiln: this is a cylindrical refractory-lined shell that is mounted at a slight incline from the horizontal plane to facilitate the mixing of waste materials with circulating air. It usually has a secondary combustion chamber after the kiln; the kiln thus acts as the primary chamber.
- ◆ Controlled air incinerator: this type of incinerator burns waste in two or more chambers under conditions of both low and excess stoichiometric oxygen requirements. In the primary chamber, waste is dried, heated, and burned at 40-80 per cent of the stoichiometric oxygen requirement. Combustible gas produced by this process is mixed with excess air and burned in the secondary chamber at 100-150 per cent of the stoichiometric requirement.<sup>3</sup>

→ 2. Playing with fire: hazardous waste incineration; Pat Costner, Thornton J; Greenpeace report 1993; USEPA, 1990.

→ 3. Manual on hospital waste management, CPCB, May 2001.

### Slide 4: Incinerator standards

The combustion process should be done in two stages: primary and secondary.

#### Primary Combustion

A primary combustion chamber in an incinerator, ideally, performs the following functions:

- ◆ Evaporates the moisture content of waste in a short time, followed by rising temperature of the organic waste to decompose and devolatilise. The volatile matter ignites, giving a flame atmosphere to complete devolatilisation of organic matter.
- ◆ Temperature should not be more than 850°C, whereby residual char becomes less reactive, and thus, makes complete combustion of carbon more difficult.

## Secondary Combustion

The secondary combustion chamber is mainly meant for total combustion of volatile matter, gases and products of incomplete combustion generated in the primary chamber. This is done by presence of excess air, maintenance of temperature above 1,000°C and also mixing of the gases usually affected by change of direction in the flow path.

Residence time: volatile organics will require a residence time of one second at 1,000°C for 99.99 per cent combustion, for which sufficient volume must be provided for gas phase transformation.

The Indian incineration standards are not very stringent; some international standards require at least two seconds of residence time and at least 1,100°C in the secondary chamber.

## Slide 6: Particulate matter

Particulate matter is released in every combustion process. The heavy particles remain at the combustion grate and are called bottom ash, whereas the lighter particles, which move upwards with the flue gases, are called fly ash.

Larger particles (as large as 100 millimeters) can be cleared by the nose and throat. The smaller particles, on the other hand, are not only difficult to capture in pollution control equipment but also have the ability to travel deep into the lungs and lodge there. The greater surface area of smaller particles increases the amount of toxicants attached to them, including heavy metals, toxic organic compounds such as polynuclear aromatic hydrocarbons, dioxins, etc.

Fly ash poses serious health hazards. The particles can impair lung function, cause coughing, bronchitis and other respiratory problems. Some of the toxins attached to the finer parti-

cles, which can be heavy metals and other organics are proven carcinogens and thus increase the hazard.<sup>4</sup>

Though it is possible to reduce the release of particulate matter by ensuring better combustion and installing various pollution control devices, they can not be entirely eliminated.

## Slide 8: Heavy metals

Heavy metals present in the waste stream are not destroyed but are dispersed during incineration. Some of the heavy metals found in medical waste incinerator emissions and their health impacts have been mentioned in this slide.

## Slide 9: Products of incomplete combustion

Products of incomplete combustion (PICs) are formed normally and especially during combustion upsets. They are generally formed by combustion of the original waste; some PICs may come from waste and others may be products of fuel combustion. They are more toxic and difficult to destroy than the original compound.

## Slide 10, 11: Dioxin - where does it come from?

Dioxins have no commercial value; they are an unintentional by-product of waste combustion and some manufacturing processes.

Dioxins are a group of 75 chemicals, which co-occur with another group of toxins called furans (a group of 135 chemicals). Dioxins are poly-chlorinated dibenzo-para-dioxin (PCDDs) and furans are poly-chlorinated-dibenzo-furans (PCDFs). Seven congeners of the dioxin family and 10 of the furan family are very toxic. Amongst these, 2,3, 7, 8, tetra-chlorinated dibenzo-para-dioxin (2,3,7,8, TCDD) is the

→ 4. *Incineration: decisions for the 1990s*; Tellus institute, JSI Centre for Environmental Health Studies, 1994.

most toxic and, consequently, the most researched.

Dioxins are toxic even in doses too low to measure; in fact, there may not be any safe limit of exposure to them. Dioxin toxicity is expressed in terms of toxicity of 2,3,7,8 TCDD. In 1994 USEPA's acceptable daily exposure was 0.006 picograms/kg/day, which was revised to 0.01 pg/kg/day, but studies show that humans are exposed to 300-600 times this level. Breast feeding babies, being the highest in the food chain, get exposed to 50 times this amount. (Dioxin accumulates in the fatty tissue of the body. In breast-feeding mothers these fatty tissues are broken down for milk production; nursing infants are thus at the highest risk).

The chlorine bonds of these molecules are very strong and are resistant to any physical or chemical breakdown. This makes the toxins persistent and they bio-accumulate through the food chain.

Due to its tendency of accumulation in fatty tissues dioxin travels up the food chain. Exposure to humans can happen through consumption of dairy products, fish, meat, etc. These sources are in turn exposed to dioxin settled in soil, water and plant surfaces. Dioxins get deposited in the adipose (fat) tissue of the body. Thus a fish may have ten to thousand times higher dioxin concentrations than the surrounding water.

### **Slide 12: Medical waste incineration and dioxins**

Dioxins are produced when organic material is burned in the presence of chlorine. Other than medical waste incineration, other things have also been implicated in dioxin formation, like some industrial processes, hazardous and municipal waste incineration, metal smelting, vehicles running on leaded gasoline, processes of the

paper and pulp industry, etc.

Medical waste incinerators, however, remain one of the largest dioxin producers; this is due to the high amount of poly-vinyl-chloride (PVC) used in the medical sector. PVC is a very rich source of chlorine. Metals present in the waste act as a catalyst to dioxin formation.

Initially, the incineration industry denied charges of dioxin formation on the grounds that as long as high temperatures are maintained in the incinerator, dioxins would get destroyed. Later, some groups showed that dioxin could be reformed after the flue gases left the combustion chamber. It is now well-established that if flue gases are passed through pollution control equipment working in the temperature range of 200-400°C, more than a hundred fold increase in dioxin and furan formation can take place. Moreover, if the pollution control equipment captures the pollutants in flue gases, it becomes rich in these toxins.

Minimising this formation would require immediate quenching of flue gases, once they leave the combustion chamber. As a continuous monitoring of dioxins cannot happen, it is very difficult to ascertain whether or not the incinerator is running safely; it is thus always risky to run it.<sup>5</sup>

### **Slide 13, 14: Human health effects of dioxin**

Dioxins have been linked to some very serious health effects, including cancer. The 1994 USEPA draft assessment estimated that the levels of dioxin-like compounds found in the general population may cause a lifetime cancer risk between one in 10,000 to one in 1,000. This is 100 to 1,000 times higher than the risk level of one in million that is considered acceptable in certain regulations.

→ 5. *Municipal waste incineration: a poor solution for the twenty first century*; Dr Connert P, 4th Annual International Management Conference Waste to Energy 1998, Healing the Harm, Healthcare without Harm.

Dioxins damage the immune system leading to increased susceptibility to infectious disease. Dioxins are also endocrine disrupting, which means that they mimic our body's hormones and thus activate or suppress receptors and their associated cascades at the wrong times. As the endocrine system works at very low hormone concentrations and works via an amplification cascade, dioxin is capable of acting at low levels and causing serious effects.

### Dioxin levels in India

India is yet to realise the gravity of dioxin contamination and its related health effects. The government has not conducted any study to find out the levels of dioxin exposure in the population. Two recent studies have found very high amounts of dioxins in samples of Indian breast milk (human), meat and dairy products. Until now considered a Western problem, this scary trend should make our environmental managers and industry sit up.

In the first study, dioxins were detected in human breast milk samples collected from Perungudi, Chennai, in August 2000. The town has dumping sites of municipal wastes in the suburbs. Dioxin levels of people living here were found to be higher when compared with those in the general public of developed countries, such as Japan, USA and Canada. This indicates that significant pollution sources of dioxin-related compounds are present in dumping sites in India, probably due to secondary formation caused by burning of municipal wastes.<sup>6</sup>

In the second study, concentrations of dioxins were measured in the tissues of humans, fish, chicken, lamb, goat, predatory birds and dolphins of the river Ganga. The tissue samples were collected from different locations in India. Dioxins were found in most of the samples analysed, with the liver of the spotted owl

containing the highest concentration of 3,300-pg/g fat weight, while in human fat tissues dioxin concentrations ranged from 170 to 1,300 pg/g fat weight. As compared to even conservative WHO limits of 1-4 pico grams per kg of body weight, the study translated to alarmingly high contamination levels. This is the first study of its kind that has detected dioxins in human tissues, fish, meat and wildlife samples collected from India.

Why are these studies so significant? Firstly, they are the first ones to be carried out in India, and among a few in developing countries. Secondly, India has been refusing to acknowledge that dioxin is a problem.

While the developed world has managed to reduce dioxin emissions through expensive measures and strict regulation, we do not even have the facilities to test for their presence. Moreover, waste incineration, the highest source of dioxin release, is not only being propagated, but also subsidised in India through the programmes of the Ministry of Non-Conventional Energy Sources.

### Slide 15: Ash

As mentioned earlier, two kinds of ash are produced in an incinerator: bottom ash (around 90 per cent of the ash), which consists of large particles and falls through the grate system in the furnace, and fly ash, a fine material that is collected in the boilers, the heat exchangers and the pollution control equipment.

Bio-medical rules ask for regulation of incineration ash as per the Hazardous Waste Rules. Ash has been listed under Waste Category 12 of the Hazardous Waste (Management and Handling) Rules 1989. Thus, incinerator ash is hazardous irrespective of any quantity and needs to be sent to a secured landfill for disposal. Its packing, labelling, and transport have to be in

→ 6. Dioxin paper presented at dioxin, 2001, International Symposium on Halogenated Environmental Organic pollutants and POPs; Kyoung ju; Korea, September 2001.

**Slide 19: Typical maintenance schedule for hospital waste incinerators**

Frequency	Incinerator component	Procedure
<b>Daily</b>	Oxygen monitor	Check operation of the monitor.
	Thermocouples	Check operation of thermocouples.
	Under-fire air ports	Inspect and clean as required.
	Limit switches	Inspect for freedom of operation and potential obstructing debris
	Door seals	Inspect for wear, closeness of fit, and air leakages.
	Ash pit/internal drop out sump	Clean after each shift on batch units that do not have continuous ash conveyor cleaning system.
<b>Weekly</b>	Blower intakes	Inspect for accumulations of lint, debris; clean as required.
	Burner flame rods (gas-fired units)	Inspect and clean as required.
	Swing latches and hinges	Lubricate.
<b>Bi-weekly</b>	Fuel trains and burners	Inspect and clean as required. Investigate sources of fuel leakages
	Control panels	Inspect and clean as required. Keep panel security closed and free of dirt to prevent electrical malfunction.
<b>Monthly</b>	External surface of incinerator and stack	Inspect external 'hot' surfaces. White spots or discolouration may indicate loss of refractory.
	Refractory	Inspect and repair minor wear areas with plastic refractory material.
	Internal ram faces	Inspect for wear. These stainless steel faces wear out and may require replacement in one to five years depending on services.
	Upper/secondary	Inspect and vacuum any particulate matter combustion chamber that has accumulated on the chamber floor.
	Burner pilots	Inspect and adjust as required.
<b>Semi-annually</b>	Hot external surfaces	Inspect and paint with high temperature paint as required.
	Ambient external surfaces	Inspect and paint with equipment enamel as required.

accordance with the Hazardous Waste Rules.

Ash needs to be checked prior to landfilling for 40 toxins (which are likely to leak) using the TCLP test. USEPA has given the regulatory levels for maximum concentrations of contaminants in wastes for the TCLP test (Toxic Characteristics Leaching Procedure) and these have been adopted by India also. In the TCLP test, constituents are extracted from the waste and tested. If they equal or exceed the specified limits they need to be treated before landfilling.

All this adds up to the incinerator's running cost. But such things are not being practiced anywhere in the country.

## **Slide 16: Air pollution control devices**

### **Air pollution control devices**

Pollution control equipment captures particulate matter and acid gases. Such equipment is capable of removing approximately 90-95 per cent of the pollutants present in emissions; the removal, however, is never complete. There is always some residual matter, either in the form of solids, or as fly gas, or in the form of waste water. Thus, these control devices simply shift the pollutants from air to either the waste water (through the wet scrubber) or solid waste (through filters, dry scrubbers, or electrostatic precipitators). They do not control pollution, but only change its form. For other pollutants such as mercury, removal efficiencies of these devices can be less than 10 per cent.

Primary emission control devices can be of the following types:

- ◆ Electrostatic precipitators, to control particulate emissions.
- ◆ Fabric filter baghouses, to control fine

particulate.

- ◆ Scrubbers, to control gaseous emissions.

### **Wet Scrubbers**

Venturi, spray tower, and packed-bed scrubbers are the most common types of wet scrubber systems used on bio-medical waste incinerators. Venturi-scrubbers are used primarily for the control of particulate matter whereas packed-bed-scrubbers are used primarily for the control of acid gases. Both systems achieve some degree of control for particulate matter and acid gases.

### **Fabric filters**

Fabric filters (or baghouses) can be used on a limited number of hospital incinerators for the control of particulate matter emissions. They have some advantages over wet scrubbers: they are highly efficient at removing fine particles if they are properly operated and maintained. However, poor operation and maintenance can result in bag blinding, bag corrosion, or bag erosion.

A fabric filter is a collection of bags constructed of nylon, wool or other fabrics. When the exhaust stream from the incinerator is drawn through the fabric, the particles are retained on the fabric material, while the cleaned gas passes through the material. The collected particles are then removed from the filter by a cleaning mechanism and stored until they are disposed.

### **Dry scrubbers**

Dry scrubbers use absorption for the removal of sulphur dioxide, hydrogen chloride, hydrogen fluoride, and other acid gases. Some absorption of vapour state organic compounds and metallic compounds also occurs in some dry scrubber applications. Dry scrubbers use an alkaline sorbent to react with, and neutralise the acid



gases. The reaction product is a dry solid, which can be collected by a particulate control device.

## Slide 17: Pollution control equipment

Pollution control equipment is exorbitantly priced. According to a report, a 2,000 tonne per day incineration facility near Amsterdam, Netherlands, cost a massive \$600 million with half the investment going towards air pollution control.

Besides, rather than being a solution, it has its own set of problems. Improved conditions used to control emissions of one pollutant can lead to the rise in emissions of another pollutant. For instance, an increase in furnace temperature and better combustion to control dioxin formation leads to increased formation of nitric acid and increased emissions of heavy metals and reduced mercury control. Attempts to capture energy via water boilers and the use of electrostatic filters for particulate control increases post-combustion dioxin formation. The use of lime and baghouse scrubbing combinations has led to a more toxic fly ash.

Thus pollution control equipment give a false sense of security.

## Slide 18: Operational problems

### Operational and occupational problems

Operational problems include excessive stack emissions in the form of white or black smoke, smoke leakage from the charging door or other openings, excessive auxiliary fuel usage and incomplete burn-out of the waste. Proper operation of the incinerator, together with an effective preventive maintenance programme, can minimise, but not eliminate, these problems.

Occupational safety is another significant problem associated with incineration. An important issue is exposure of incinerator workers to ash particles which is generally contaminated with heavy metals, dioxin and other toxic compounds. Workers are exposed to high levels of ash when they clean the primary chamber (especially with incinerators that have no wet sumps for ash collection) and when they transfer the ash to containers.

### Excessive stack emissions

The proper operation of controlled air incinerators results in relatively low emission rates. Excessive emission rates are usually attributed to one of the following causes:

- ◆ High set-point for the secondary burner temperature is not high enough.
- ◆ Excessive negative draft in the primary chamber.
- ◆ Excessive infiltration of air (from the charging door).
- ◆ Excessive under-fire air in the primary chamber.
- ◆ Very high primary chamber temperature.
- ◆ Overcharging.
- ◆ Problem wastes.
- ◆ Inadequate secondary combustion air.

### Black smoke

The appearance of black smoke is caused by incomplete combustion and indicates the presence of unburned carbonaceous material. This, in turn, is due to insufficient amount of combustion air for the quantity of volatiles/soot present.

It is usually the result of overcharging the incineration unit, or charging of a highly volatile material, or operating the primary chamber at an excessively high temperature. The following steps may assist in eliminating black smoke:

- ◆ Check/increase secondary chamber combustion air.
- ◆ Check/decrease under-fire air; an air decrease should result in reducing the primary chamber operating temperature.
- ◆ Check/increase secondary chamber temperature.

### **White smoke**

The appearance of a steady stream of white smoke from the stack indicates the presence of small aerosols in the effluent gas.

This could either be due to excess air in the incinerator which causes entrainment of micron-sized particles, or due to the secondary chamber operating at an excessively low temperature causing premature cooling of the combustion gases.

If adjustment of the combustion parameters fails to stop the white smoke, the material to be charged should be examined. The white smoke is the result of finely divided non-combustible mineral material present in the waste charge, which is being carried out of the stack.

### **Leakage of smoke from primary chamber**

The leakage of smoke through charging doors or other openings indicates that a positive pressure differential exists in the primary chamber. Positive pressure can be caused by excessive combustion air, by excessive charging of a highly volatile material, by a high primary chamber

operating temperature or by too much hot air being discharged to a wet sump at one time.

### **Excessive auxiliary fuel usage**

For controlled-air units, improper under-fire air distribution, excessive air infiltration, or improper setting of the under-fire and secondary combustion air levels can result in excessive fuel usage.

Another cause of excessive auxiliary fuel usage is that the incinerator is not consistently charged. It is best to charge waste in batches, which are 10-15 per cent of rated capacity.

### **Incomplete burn-out, poor ash quality**

The causes of incomplete burn-out include primary burner malfunction, insufficient primary chamber combustion air or poor under-fire air distribution, overcharging the incinerator with waste, and charging too much wet waste.

**Primary burner malfunction:** this causes incomplete burn-out because the primary chamber temperature will not be maintained as the flame is insufficient to ignite the waste. Primary burner malfunction may arise due to burner power loss, burner pluggage, failure of the flame safeguard, or leaking fuel trains.

**Insufficient under-fire air (controlled-air units):** in a controlled-air incinerator, insufficient under-fire can cause the combustion process to stop completely. Primary causes of the lack of combustion air are:

- ◆ An improper under-fire air setting.
- ◆ Clinker buildup around the under-fire air ports.
- ◆ Air ports clogged with ash or slag from previous charges.

Clinker buildup around primary chamber air ports is usually the result of too much air, resulting in local hot spots that cause the ash to soften, agglomerate, and then harden as clinker during the cool-down cycle. Maintaining proper air levels and air distribution through all under-fire air ports is important. Correct operation and maintenance can prevent these problems.

**Waste Charging:** charging of waste into the incinerator should be performed as described in the manufacturer's literature. Two conditions that can cause incomplete burn-out and should be avoided are overcharging the incinerator and charging too much wet waste as part of a charge.

Other reasons for incomplete burn-out are:

- ◆ Poor temperature control (low primary and/or secondary chamber temperatures).
- ◆ Short retention time in the secondary chamber.
- ◆ Too much air (results in high particulate emissions and low temperatures).
- ◆ Upset or transient conditions (when pollutant emissions are at their worst).

### Slide 20: Economic cost

Incineration is an extremely expensive waste treatment method, especially for developing countries like India. A technically sound incinerator can be very expensive, but that is not the only cost attached to it. Air Pollution Control (APC) equipment may add on to the cost. Costing done at some plants has shown that the APC cost may be as much as half of the total incinerator cost. Depending on what APC is used (for example, a combination of high efficiency dry scrubber and baghouse filter), the APC may be as much as the cost of the basic incinerator itself, not just half the cost.

It is also important to have trained manpower to run the machines effectively. In Germany on-site incinerators have been banned because hospitals do not have the technical manpower to man the incinerators. Hospitals are required to send their waste to municipal waste incinerators, which have APCs and are run by trained manpower.

Other operation and maintenance costs of incineration include: cost of periodic replacement of refractories, costs associated with pollution control devices (proper disposal of hazardous filter cakes, cost of water and caustic, cost of electricity), continuous emission monitoring devices, auxiliary fuel, as well as general repair and maintenance costs.

The costs involved with the disposal of ash in secured landfills and the testing of incinerator ash hike the cost of running an incinerator facility. In India, these costs have never been considered. Once hospital managers start taking these hidden costs into account they will never opt for incineration as a treatment option.

Less than 50 laboratories in the world have been certified by the World Health Organisation to conduct analysis of dioxins in human tissue. The cost of establishing a laboratory for dioxin analysis is estimated at US \$1.5-2 million. The cost of dioxin assessment alone ranges from US \$1,000 to US \$ 3,000 per sample (these are laboratory costs and do not include the costs of stack sampling which can be as high as \$40,000 to \$60,000 per set-up).

### Slide 21: Incinerator bans

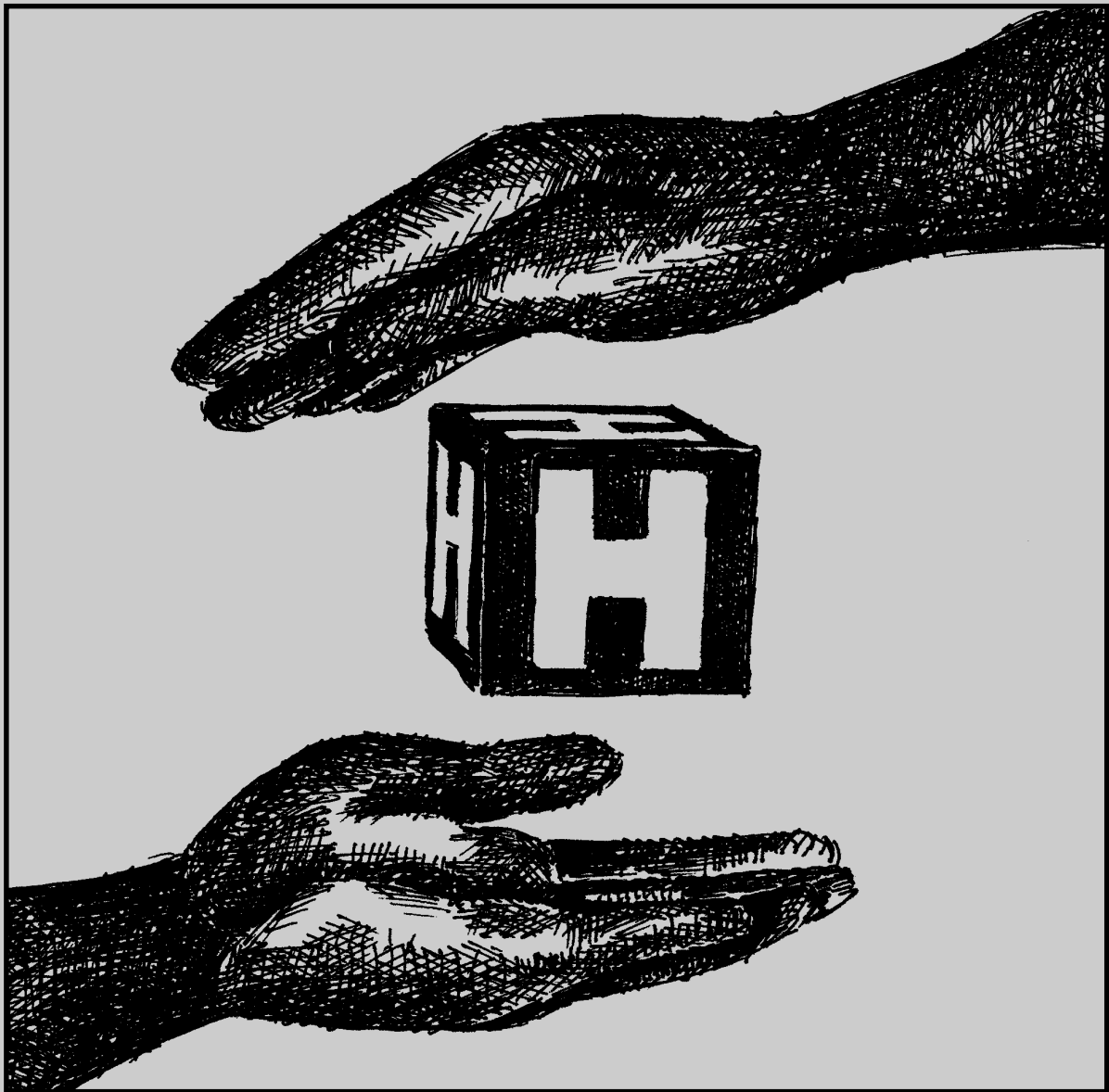
Three principles of international law – precaution, prevention and limiting trans-boundary effects – conflict with incineration. Precaution is cited in the OSPAR, LRTAP, Bamako and Stockholm Conventions. The London, OSPAR and Bamako conventions also place

bans on incineration at sea and in domestic water. The Stockholm Convention, while not banning incineration, places severe restrictions on its use. Four of the 12 chemicals subject to provisions of the Convention are by-products of incineration. The Convention talks about minimising and eventually eliminating the release of their production.

*Note: Draft guidelines for design and construction of Bio-medical Waste Incinerators, 2003, state that incinerators shall be allowed only at common bio-medical waste treatment facilities. For installation on-site special approval should be sought. Draft Guidelines on Common Bio-medical Waste Treatment Facilities limit incineration to categories 1 and 2.*

# *Section H*

## **Annexures**



## Annexure1: Medical waste management in rural waste

→ 1. Personal communication with a hospital in Ghaziabad.

**A** small rural healthcare setup of around 20 beds generates approximately 2 kg of infectious waste in a day.<sup>1</sup> The waste generated, typically includes the following:

- ◆ Infectious waste: placentas, blood soaked cotton and bandages, body fluids.
- ◆ Infectious plastic waste: disposable syringes, IV sets and tubes.
- ◆ Sharps: metal sharps mainly needles and scalpels, glass sharps including broken glasses.
- ◆ Waste generated from immunisation practices: new widespread immunisation programmes are generating millions of single-use syringes globally. These programmes need to incorporate effective systems for safe handling, treatment, and disposal of these syringes.
- ◆ General waste: packaging material, paper and food waste.

### Legislation for rural areas

The Bio-Medical Waste (Management & Handling) Rules, 1998 make it mandatory for all healthcare establishments in rural areas to:

- ◆ Segregate waste at source.

- ◆ Secure collection and transportation.
- ◆ Incorporate deep burial of pathological tissues and animal waste (where the population is less than 5,00,000).
- ◆ Adopt chemical/steam disinfection methods for other bio-medical waste streams.

### Treatment options for infectious waste

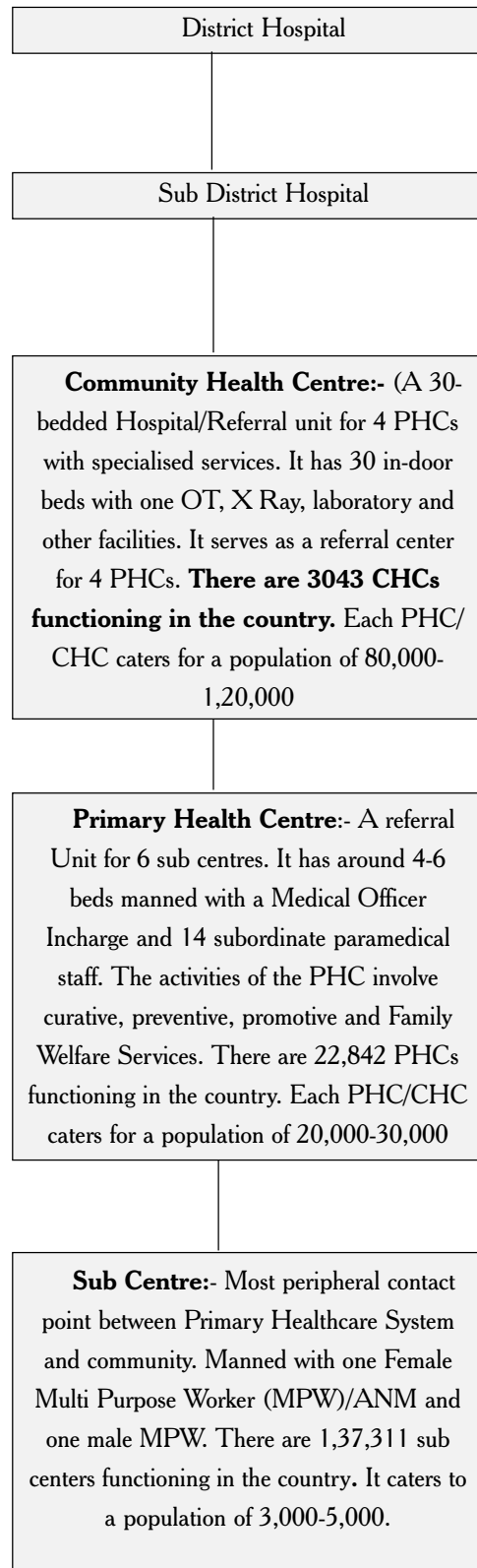
Generally, infectious waste in rural areas is disposed of through open burning or dumping. However this practice should be totally discouraged as it poses a serious threat to the environment and community.

Small clinics or rural areas that generate small volumes of waste may use on-site waste burial pits, as per standards laid down in the Bio-Medical Waste (Management & Handling) Rules, 1998 in areas with population less than 5,00,000.

A pit or trench should be dug about 2 meters deep. It should be half filled with waste, then covered with lime within 50 cm of the surface, before filling the rest of the pit with soil.

On each occasion, when waste is added to the pit, a layer of 10 cm soil shall be added to cover the waste. The deep burial site should be relatively impermeable and no shallow well should be close to the site.

## The rural healthcare system in India



### For infectious plastic waste

Autoclaves are a standard equipment in hospitals and have been used for many years by institutes to sterilise reusable medical instruments and glassware. They range in size from small portable units to huge units.

One advantage of the autoclave is that the equipment is simple enough to be manufactured locally with a light industrial manufacturing sector. It may also be possible to use other energy sources such as gas-fired, kerosene, electricity and locally available steam. The autoclaves should be tested under representative conditions to ensure microbial inactivation.

### For sharps

It is estimated that each year about 12 billion preventive and curative injections are administered worldwide, which amounts to almost 14 million injections per day.<sup>2</sup> Of these, 95 per cent are therapeutic in nature. For every vaccination given, 20 therapeutic injections are administered. Currently, 90 per cent of the syringes used are reusable in nature but the scare of spread of highly infectious diseases like hepatitis B and AIDS have seen the replacement of reusable syringes with single use or auto-disable syringes.<sup>3</sup>

The major challenges associated with the use of disposable syringes are the volume of waste that is generated and its management. The volume of sharps waste will grow exponentially, with estimates of 700 million auto-disable syringes being procured by 2005 for global immunisation programmes (as estimated by WHO). With around 85 per cent of the immunisations being provided in rural India (as estimated by PATH) the quantity of waste generated in rural areas is likely to grow rapidly.

→ 2. Unsafe injections in the developing world and transmission of blood borne pathogens: a review, Simonsen L, Kane A, Lloyd J; Bulletin of WHO 1999, 77(10): 789-800.

→ 3. [Injectionsafety.org/htmlwhoboard.html](http://injectionsafety.org/htmlwhoboard.html)

**Current immunisation practices**

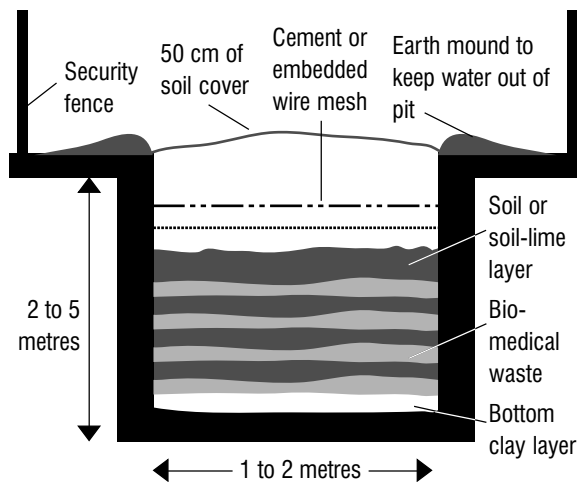
The government will introduce Auto Disable syringes for all immunisation programmes by 2005. This will generate 210 million syringes, of which, around 80 per cent would be in rural centres. The best method for disposing them would entail disinfection and mutilation near the source, and looking for recycling options. The following section deals with some simple ways of handling the sharps generated.

**Sharps pit**

Blades and needles waste after disinfection should be disposed in a circular pit or rectangular pit as shown in figure below. Such rectangular or circular pit can be dug and lined with brick, masonry or concrete rings. The pit should be covered with a heavy concrete slab, which is penetrated by a galvanised steel pipe projecting about 1.5 m above the slab, with an internal diameter of up to 20 mm. When the pit is full it can be sealed completely, after another has been prepared.<sup>4</sup>

→ 4. As per the Report of the committee constituted by The Ministry of Environment and Forests to formulate guidelines for implementation of Bio-Medical Waste (Management and Handling) 1998.

Figure 1. Infectious waste burial pit



**Encapsulation**

Encapsulation is another way of safely disposing sharps. Sharps can be collected in puncture- and leak-proof containers, such as high-density polythene boxes, metallic drums, or barrels. When the container is three-quarter full, a material such as cement mortar, or clay can be poured until the container is completely filled. After the medium has dried, the containers are sealed and disposed in landfills.

**Needle destroyers/cutters**

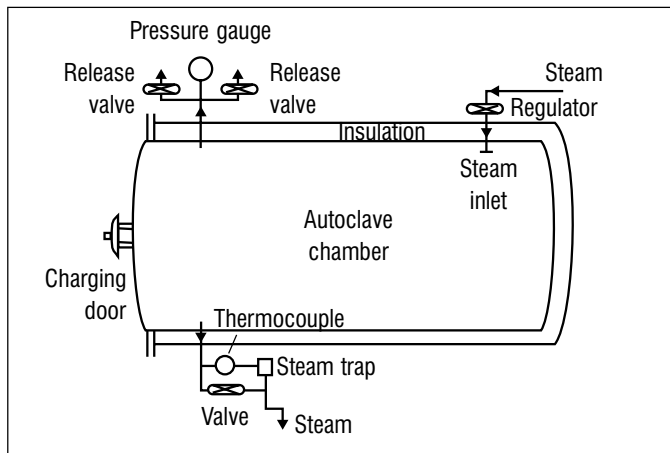
Needle destroyer is an electrical gadget that mutilates the needle. The destroyer has an exposed filament. When the needle is inserted, the circuit inside gets completed and a high temperature electric arc is generated which burns the needle. The destroyer also has a cutter to cut the nozzle of the syringe so that it can no longer be used. Needle destroyers range from battery run portable devices to plug-in desktop units. Most are automated for one-hand quick operation to prevent needle-stick injuries.

**Centralised treatment technology**

Rural communities can be served with a regional or district-level central facility utilising cleaner alternatives. A system of sharps collection, transport and centralised treatment can serve both urban and rural needs. In case of an immunisation campaign, the transport system could be arranged in conjunction with the delivery of vaccine supplies and safety boxes. The safety boxes or sharps containers can be brought back to a centralised facility or a PHC that uses an autoclave. In areas where technologies are not available, the centralised facility could use a combination of treatment with a disinfectant and cement encasing or encapsulation.



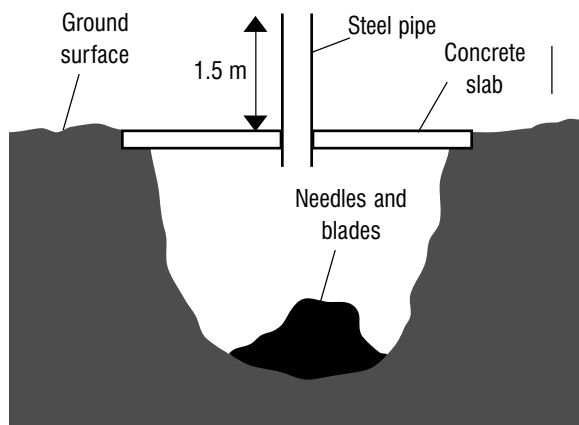
Figure 2: Autoclave



**Cost comparisons**

- ◆ Sharps pit: Rs 10,000-Rs 20, 000 (concrete walls and rust proof lining)
- ◆ Encapsulation: Rs 150-400 (depending on the size of the cement drums)
- ◆ Portable autoclaves (size 350mm diameter x 325 mm height): Rs 2,500-5,800 (depending in aluminum or steel body)
- ◆ Needle destroyer: Rs1,500-4,000
- ◆ Mechanical needle cutters: Rs 200-500

Figure 3. Pit for disposing of sharps



## Annexure 2: Sharps injuries

Table 1 (below) provides data on the type of exposure by profession. There were a total of 626 reported exposures as of January 1996. Nurses sustained the largest number of exposures (441, or 70 per cent) and needlestick injuries were the most common exposure type (378, or 60 per cent).

**Table 1: National surveillance of occupational exposure to HIV –exposure types by occupational group (as of January 1, 1996)**

	Nurse	Therapist/ technician	Student/ resident	Laboratory technician	Physician	Other	Total
Needle-stick	281	15	20	26	20	16	378 (60%)
Surgical instrument wound	18	0	3	6	3	5	35(6%)
Mucous membrane	44	6	1	9	4	4	68(11%)
Skin contact:							
Intact	5	1	0	2	2	2	12(2%)
Non-intact*	59	5	1	4	4	4	76(14%)
Unknown	34	3	0	0	0	0	37(7%)
<b>Total</b>	<b>441(70%)</b>	<b>30(5%)</b>	<b>25(4%)</b>	<b>57(9%)</b>	<b>33 (5%)</b>	<b>40 (7%)</b>	<b>626 (100%)</b>

\* skin with cuts, rashes, abrasions, lacerations, etc.

Table 2 shows the exposures that probably could have been prevented by adherence to the Universal Precautions (223/626 or 36 per cent). The skin contact exposures could have been prevented by covering open areas of the skin before beginning the procedure. Proper handling and disposal of used needles could have prevented 101 exposures.

**Table 2: National surveillance of occupational exposure to HIV –Preventable exposures to blood/body fluids (as of 1 January, 1996)**

Description of exposure	Number of workers	(%)
Recapping a used needle	57	25%
Improper disposal of a used needle	44	20%
Skin contact	122	55%
<b>Total</b>	<b>223</b>	<b>100%</b>

## Annexure 3: Glutaraldehyde safety products

Product Name and Manufacturer	Comments
<p><b>Controlled Work Stations</b></p> <p>GUSÔ Glutaraldehyde User Stations            Medical Products Corporation  <a href="http://www.kemmed.com/">Http://www.kemmed.com/</a>; 800-553-0330</p> <p>Chemdaq Corporation  <a href="Http://www.chemdaq.com/glutaral.htm">Http://www.chemdaq.com/glutaral.htm</a>            800-245-3310</p>	<p>Ductless enclosure units for glutaraldehyde trays/bins. Seven different models/sizes.            Routine maintenance required</p>
<p><b>Aldehyde Neutralisers</b></p> <p>GLUT-RxÔ Glutaraldehyde Solution Neutralizer, Kem Medical Products Corporation; <a href="http://www.kemmed.com/">http://www.kemmed.com/</a> 800-553-0330; 516-454-6565</p> <p>ALDE-XÔAMS 1010, Aldehyde Management System            ISOLYSERÔ  <a href="http://www.sigma-aldrich.com">http://www.sigma-aldrich.com</a>            800-325-3010; 314-771-5765</p> <p>GLUT-SAFE Neutralizer and Absorbent Mats, Health Choice Enterprises  <a href="http://www.healthchoiceproducts.com">http://www.healthchoiceproducts.com</a>            800-957-4758</p>	<p>Aldehyde neutralisation may be required by some publicly operated treatment works (POTWs) before dumping spent glutaraldehyde solutions down the drain.            Neutralises waste glutaraldehyde solutions in thirty minutes or less.</p> <p>Neutralises waste glutaraldehyde solutions.</p> <p>Available in crystal form (for solid waste disposal) and liquid (for drain disposal)            Liquid form requires 4 hours</p> <p>Neutralises waste glutaraldehyde solutions.</p>
<p><b>Safety Equipment</b></p> <p>GLUT-RxÔ Safety Nozzles and Absorbent Mats, Kem Medical Products Corporation  <a href="http://www.kemmed.com/">http://www.kemmed.com/</a>            800-553-0330</p>	<p>Avoids spills, sloshes and glugging effects of pouring.</p>
<p><b>Meters</b></p> <p>Kem GLUTARALDEMETERÔ            Kem Medical Products Corporation  <a href="http://www.kemmed.com/">http://www.kemmed.com/</a>            800-553-0330; 516-454-6565</p>	<p>Measure actual glutaraldehyde levels            Records instantaneous exposure assessment down to .05 ppm.</p>
<p><b>Spill Response</b></p> <p>Glutaraldehyde Spill Response Kit            Health Choice Enterprises  <a href="http://www.HealthChoiceProducts.com">http://www.HealthChoiceProducts.com</a>            800-957-4758</p>	<p>Neutralising solution to isolate and absorb spills and reduce vapour exposure to make clean-up safer.</p>

## Annexure 4: What is HuMAN?

HuMAN is a national network of individuals and groups with a common goal of working for the evolution, development and implementation of safe practices in healthcare waste management.

### HuMAN's mission statement

The Health & Us Medical Action Network (HuMAN) seeks to make the delivery of healthcare in India safe – for the patient as well as for the environment, healthcare workers and the community at large. This it aims to do through adopting safe practices, products, procedures and technologies without compromising patient care.

### HuMAN's objectives

- ▲ To work towards the evolution and adoption of safe and standard practices in healthcare waste management including handling, treatment and disposal.
- ▲ To help eliminate the use of burning any waste, including incineration in all possible instances to safer treatment methods.
- ▲ To reduce, with the aim of the elimination of the use of toxic chemicals (for example, mercury), non-essential plastics and poten-

tially toxic materials (for example, PVC) in healthcare.

- ▲ To work for the occupational safety of healthcare workers.
- ▲ To protect community health and the environment.

### HuMAN Secretariat address

HuMAN, H-2 Jangpura Extension,  
New Delhi 110 014.  
Tel: 011-243320711, 24328006;  
Fax: 011-24321747

## **Annexure 5: American Nurses Association – working for a safer work place**

**T**he American Nurses Association (ANA) has been fighting the silent epidemic of needle-stick injuries since 1980s, through its Safe Needles Save Lives campaign. The association works at the grassroot and policy level. At the grassroot level, nurses are trained and educated about the risks of needlestick injuries, how to avoid such injuries and the action to be taken after any such incident. All this work is done through the state nursing associations.

ANA has also worked with members of Congress to draft the Healthcare Worker Needlestick Prevention Act, which was introduced in the US Senate and House in May 1999. Due to ANA's efforts, the Occupational Safety and Health Administration (OSHA) has added needlestick prevention to its agenda. The American Nurses Association's (ANA) 'Safe Needles Save Lives' campaign scored an important victory for ANA and its constituent members (the state nurses associations) when OSHA on November 5, 1999 published a long-awaited directive which will have a life-saving impact on nurses by effectively mandating the use of safer needlestick devices nationwide.

The Healthcare Worker Needlestick and Sharps Injury Prevention Act was finally passed due to associations' continuous efforts.

## Annexure 6: Related Web Sites

- ◆ USEPA: <http://www.epa.gov/ebtpages/wastmedicalwaste.html>
- ◆ California Department of Health Services: [www.dhs.cahwnet.gov/ps/ddwem/environmental/emb/medwasteindex.htm](http://www.dhs.cahwnet.gov/ps/ddwem/environmental/emb/medwasteindex.htm)
- ◆ Ecology centre: [www.ecocenter.org/healthwaste.shtml](http://www.ecocenter.org/healthwaste.shtml)
- ◆ Sustainable hospitals: [http://www.sustainablehospitals.org/HTMLSrc/IP\\_factsheet\\_contents.html](http://www.sustainablehospitals.org/HTMLSrc/IP_factsheet_contents.html)
- ◆ Healthcare Without Harm: [www.noharm.org](http://www.noharm.org)
- ◆ GAIA: <http://www.no-burn.org>
- ◆ Virginia Department of Environmental Quality: <http://www.deq.state.va.us/waste/medical.html>
- ◆ University of Berkeley: <http://www.ehs.berkeley.edu/default.html>
- ◆ WHO: [www.who.int/health\\_topics/medical\\_waste/en/](http://www.who.int/health_topics/medical_waste/en/)
- ◆ SIGN: [http://www.who.int/injection\\_safety/sign/en/](http://www.who.int/injection_safety/sign/en/)
- ◆ OSHA Blood-borne Pathogens: <http://www.osha.gov/SLTC/bloodbornepathogens/index.html>
- ◆ CDC (NIOSH): <http://www.cdc.gov/niosh/healthpg.html>
- ◆ American Nursing Association: <http://ana.org/needlestick/nshome.htm>
- ◆ Toxics Link: [www.toxicslink.org](http://www.toxicslink.org)
- ◆ Ban the Burn: <http://www.essentialaction.org/waste/index.html>
- ◆ Work on Waste: <http://www.workonwaste.org>

- ◆ Environmental Research Foundation: [http://www.rachel.org/home\\_eng.htm](http://www.rachel.org/home_eng.htm)
- ◆ Hospitals for a Healthy Environment: <http://www.h2e-online.org/>
- ◆ Bio-Medical Waste (Management and Handling) Amendment Rules 2000: <http://kspcb.kar.nic.in/BMW/Laws.htm>
- ◆ Nightingale Institute: <http://www.nihe.org>
- ◆ University of Virginia: <http://www.virginia.edu>



## Annexure 7: Publications

### Publications: Incineration

- ◆ *Non-Incineration Medical Waste Treatment Technologies*, a Resource for hospital administrators, facility managers, healthcare professionals, environmental advocates, and community members, August 2001
- ◆ *Medical Waste Treatment Technologies: Evaluating Non-incineration Alternatives* (pdf), a tool for healthcare staff and concerned community members, May 2000
- ◆ *How to Shut Down an Incinerator, a Toolkit for Activists*
- ◆ *What's Wrong with Incineration?* (pdf), Going Green Factsheet 3-2
- ◆ *Bankrolling Polluting Technology: The World Bank Group and Incineration*, Global Alliance for Incinerator Alternatives, September 2002
- ◆ *California Medical Association Resolution on Dioxin and Medical Waste Incineration*, CA Medical Association, March 12, 2000
- ◆ *When Healthcare Harms; The Dangers of Incinerating Medical Waste*, American Journal of Nursing, April, 2001 (Volume 101, Issue 4), Ann Melamed, RN, and Susan Wilburn, RN
- ◆ *Waste Incineration: A Dying Technology*, GAIA, 2002

### Publications: Waste minimisation

- ◆ *Waste Minimisation, Segregation and Recycling in Hospitals* (pdf), Going Green Factsheet 4-1
- ◆ *10 Ways to Reduce Regulated Medical Wastes* (pdf), Going Green Factsheet 4-2
- ◆ *Guidelines for Optimising Waste Segregation* (pdf), Going Green Factsheet 4-3
- ◆ *Disposables and their Alternatives* (pdf), Going Green Factsheet 4-4

- ◆ *Reach for Unbleached Paper* (pdf), Going Green Factsheet 4-5
- ◆ *Recycling Fact Sheet* (pdf), Going Green Factsheet 4-6
- ◆ *Waste Minimisation Resources* (pdf), Going Green Factsheet 4-7
- ◆ *Reprocessing Single-use Medical Devices White Paper* (pdf), proceedings from Setting Healthcare's Environmental Agenda, October 16, 2000
- ◆ *Waste Management White Paper* (pdf), proceedings from Setting Healthcare's Environmental Agenda, October 16, 2000
- ◆ *Waste Reduction Guide*, Hospitals for a Health Environment (H2E): <http://www.h2e-online.org/tools/guide.htm> Designed to help healthcare sector waste managers develop an action plan tailored to their facilities.
- ◆ *Hospital Waste Prevention Tips*, NYC WasteLe\$\$ Program, A department-by-department list of tips to reduce waste developed by the NYC WasteLe\$\$ Program: <http://www.nycwasteless.com/gov-bus/Tips/hosptips.htm>
- ◆ *H2E Self Assessment Guide* (pdf), Hospitals for a Healthy Environment (H2E) <http://www.h2e-online.org/pubs/selfasmt.pdf>
- ◆ *Waste Reduction Case Studies*, Hospitals for a Healthy Environment (H2E) <http://www.h2e-online.org/tools/waste-case.htm>
- ◆ Presentation on infectious waste by West Virginia Department of Health: [www.wvdhhr.org/wimw/presentations.asp](http://www.wvdhhr.org/wimw/presentations.asp)

### Publications: WHO

- ◆ Safe management of wastes from healthcare waste activities: [http://www.who.int/water\\_sanitation\\_health/medicalwaste/wastemanag/en/](http://www.who.int/water_sanitation_health/medicalwaste/wastemanag/en/)
- ◆ Teachers Guide: Management of wastes from healthcare waste activities: [http://www.who.int/water\\_sanitation\\_health/medicalwaste/wsh9806/en/](http://www.who.int/water_sanitation_health/medicalwaste/wsh9806/en/)
- ◆ Health-care waste management rapid assessment tool (Excel format): [http://www.who.int/docstore/water\\_sanitation\\_health/Documents/Healthcare\\_waste/H2Etool\(3r\).xls](http://www.who.int/docstore/water_sanitation_health/Documents/Healthcare_waste/H2Etool(3r).xls)
- ◆ Wastes from health-care activities. Fact sheet 253, October 2000: <http://www.who.int/inf-fs/en/fact253.html>
- ◆ Decision-making guide for managing health-care waste from primary healthcare centres: [http://www.who.int/water\\_sanitation\\_health/medicalwaste/hcw/en/](http://www.who.int/water_sanitation_health/medicalwaste/hcw/en/)

- ◆ Review of health impacts from microbiological hazards in health-care wastes: [http://www.who.int/water\\_sanitation\\_health/medicalwaste/hcw2/en/](http://www.who.int/water_sanitation_health/medicalwaste/hcw2/en/)
- ◆ Review of health impacts from microbiological hazards in health-care wastes: [http://www.who.int/docstore/water\\_sanitation\\_health/Environmental\\_sanit/Healthcarewaste/healthimpacts.htm](http://www.who.int/docstore/water_sanitation_health/Environmental_sanit/Healthcarewaste/healthimpacts.htm)
- ◆ Aide mémoire for a national strategy for health-care waste management: [http://www.who.int/docstore/water\\_sanitation\\_health/Documents/Healthcare\\_waste/AideMem.pdf](http://www.who.int/docstore/water_sanitation_health/Documents/Healthcare_waste/AideMem.pdf)
- ◆ Teaching material to illustrate the Teacher's guide on the management of wastes from healthcare activities: [http://www.who.int/docstore/water\\_sanitation\\_health/medwaste/index.htm](http://www.who.int/docstore/water_sanitation_health/medwaste/index.htm)
- ◆ Guidelines for safe disposal of unwanted pharmaceuticals in and after emergencies: [http://www.who.int/docstore/water\\_sanitation\\_health/Documents/Healthcare\\_waste/Unwantedpharm/unwantpharm.doc](http://www.who.int/docstore/water_sanitation_health/Documents/Healthcare_waste/Unwantedpharm/unwantpharm.doc)
- ◆ Management of health-care wastes policy analysis: [http://www.who.int/water\\_sanitation\\_health/medicalwaste/en/Polanalysis.pdf](http://www.who.int/water_sanitation_health/medicalwaste/en/Polanalysis.pdf)
- ◆ Database on practical options for health-care waste management: <http://www.healthcarewaste.org/>

### **Publications: Srishti/Toxics Link**

- ◆ Lurking Menace: Mercury in the healthcare sector, June 2004
- ◆ Poster on managing mercury: Don't take mercury lightly, June 2004
- ◆ Flyers on medical waste: Your dental practice could be killing you and your family, June 2004
- ◆ Disposing immunisation waste in India: Policy Paper, August 2004
- ◆ Hospital waste: Time to Act – Srishti's factsheets on 14 priority areas, June 2002
- ◆ Managing hospital waste: A guide for healthcare facilities, September 2000
- ◆ Emerging experiences in medical waste management in India, 2000
- ◆ Poster on bio-medical waste management
- ◆ Medical waste issues, practices and policies, 1999
- ◆ Status of alternative medical waste disposal technologies in the US: A Srishti compilation to aid decision making by health care facilities, February 1996

**Publications : Health Care Without Harm**

- ◆ Disposal of mass immunisation waste without Incineration
- ◆ Non-incineration medical waste treatment technologies in the Europe
- ◆ Environmental health in the healthcare setting
- ◆ Update on pyrolysis
- ◆ Non-incineration medical waste treatment technologies
- ◆ World Bank's dangerous medicine: promoting incineration in third world countries
- ◆ Dentist the Menace? by Michael Bender
- ◆ Protecting by degrees: what hospitals can do to reduce mercury pollution
- ◆ Eliminating mercury discharge in hospital laboratories: a step towards zero discharge
- ◆ Preventing harm from phthalates, avoiding PVC in hospitals
- ◆ Green birthdays

# Notes

# Notes



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