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# Health-care waste management in India

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*Health-care waste management in India is receiving greater attention due to recent regulations (the Biomedical Wastes (Management & Handling) Rules, 1998). The prevailing situation is analysed covering various issues like quantities and proportion of different constituents of wastes, handling, treatment and disposal methods in various health-care units (HCUs). The waste generation rate ranges between 0·5 and 2·0 kg bed$^{-1}$ day$^{-1}$. It is estimated that annually about 0·33 million tonnes of waste are generated in India. The solid waste from the hospitals consists of bandages, linen and other infectious waste (30–35%), plastics (7–10%), disposable syringes (0·3–0·5%), glass (3–5%) and other general wastes including food (40–45%). In general, the wastes are collected in a mixed form, transported and disposed of along with municipal solid wastes. At many places, authorities are failing to install appropriate systems for a variety of reasons, such as non-availability of appropriate technologies, inadequate financial resources and absence of professional training on waste management. Hazards associated with health-care waste management and shortcomings in the existing system are identified. The rules for management and handling of biomedical wastes are summarised, giving the categories of different wastes, suggested storage containers including colour-coding and treatment options. Existing and proposed systems of health-care waste management are described. A waste-management plan for health-care establishments is also proposed, which includes institutional arrangements, appropriate technologies, operational plans, financial management and the drawing up of appropriate staff training programmes.*

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*Keywords*: biomedical wastes, disinfection, health-care establishment, infectious waste, regulations, waste-management plan, waste disposal, India.

## Introduction

The establishment of health-care is a basic requirement of every civilised society. Food, medicines, chemicals, equipment and instruments are used while treating out-patients and patients admitted into hospital, producing a variety of wastes. The wastes generated from the treatment of patients suffering from infectious diseases may spread infection either through direct contact or indirectly through the environment. Globally, this issue has been seriously considered and appropriate waste management systems are being developed and installed. In India, this problem has been recognised by the concerned agencies and Government regulations have been framed to systematise implementation. Accordingly, authorities at health-care units (HCUs) are trying to install systems to meet legal requirements. A number of difficulties are being faced at many places for implementation of these requirements in practice. In order to help resolve these problems, the present paper analyses the issues and identifies current shortcomings. Further, it suggests an improvement plan to develop appropriate waste-management systems.

## Existing health-care waste management

In India, there is a large network of HCUs, both in the public and private sectors. There are large numbers of small clinics or dispensaries, which provide only out-patient care. The community health centres provide health care facilities in rural areas. The next group ranges from sub-divisional and district hospitals to medical college hospitals, and

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hospitals in the public and private sectors. Also, the recent trend of establishing multi-speciality hospitals in urban centres is growing rapidly. The normal bed strength in all such hospitals ranges from 30 to 1000 beds or more. These hospitals generate waste in substantial quantities, which needs to be managed by the hospitals themselves. However, in rural hospitals the quantity of waste generated is much less. According to health information statistics 20% of total beds are in rural hospitals while 80% are in urban hospitals (Ministry of Health and Family Welfare, India, 1998). Extrapolating from past figures of number of beds and average quantity of waste generation at the rate of 1 kg bed$^{-1}$ day$^{-1}$, it is estimated that about 0·33 million tonnes year$^{-1}$ of hospital waste is being generated overall.

## Hazards of health-care waste management

At present, there is no specific system ensuring separation of infectious and non-infectious waste at source. This results in mixing of infectious wastes with others which are normally disposed of along with municipal waste leading to various types of hazards (Kelkar, 1998). These are illustrated in Figure 1.

## Quantities

In order to prepare a well-planned waste-management system, it is essential to know the quantity of waste generated in the establishment. Hence, the quantities of different categories of waste have to be estimated by discussions, interviews and by physical checks. The quantities generated vary from hospital to hospital and depend on the type of health-care facility and local economic conditions. Normally, the data on waste quantities are not maintained by the hospitals. In one of the studies carried out in Indore City, the waste quantities were physically weighed in different hospitals having specialised units. The average values are presented in Table 1 (Malviya, 1999). In India, many hospitals are over-occupied and hence the waste quantities are estimated assuming 100% bed-occupancy.

**Table 1.** Quantity of solid waste from health-care units (HCUs)

| Category of HCU | Quantity (kg bed$^{-1}$ day$^{-1}$)[a] |
|---|---|
| Paediatric unit | 0·53 |
| Eye unit | 0·66 |
| Orthopaedic unit | 2·15 |
| Gynaecology unit | 1·43 |
| Medicine unit | 1·80 |
| Surgery unit | 1·04 |
| OPD, burns, X-ray and canteen | 2·64 |
| General hospital | 1·95 |
| Multi-speciality hospital | 2·23 |
| Average | 1·60 |

Number of beds per HCU ranges from 50 to 125.
[a]Assuming 100% bed occupancy.

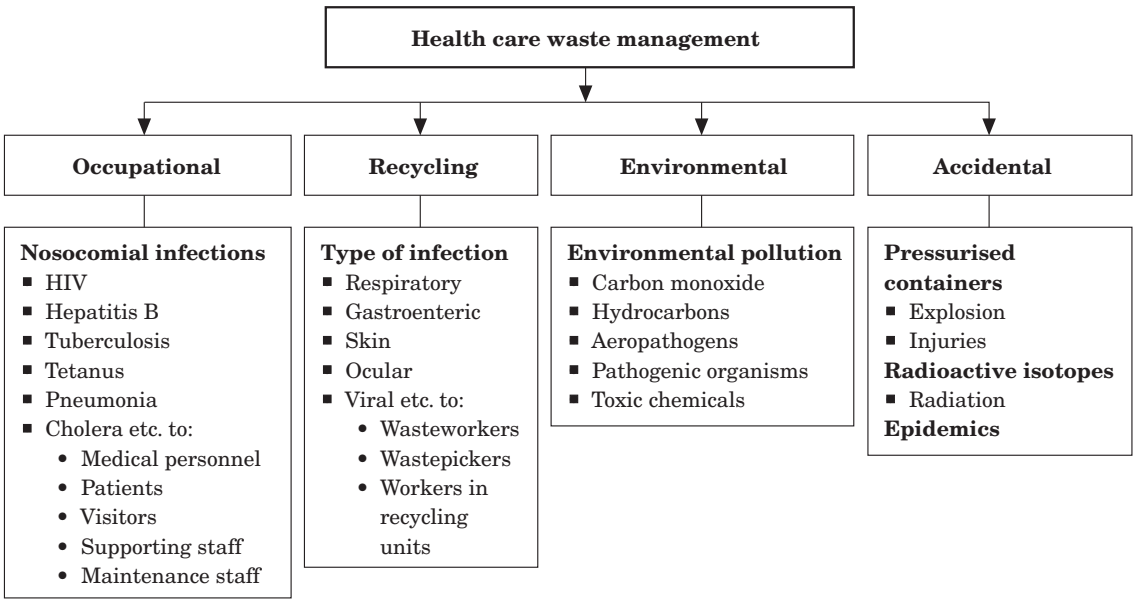


**Figure 1.** Hazards associated with health-care waste management.

## Composition

Health-care wastes are categorised as infectious and non-infectious (Saini and Dadhwal, 1995). Infectious wastes contain pathogens in sufficient concentration or quantity that exposure could result in transmission of infectious diseases. These wastes include cultures and spatulas of infectious agents from laboratory work, and waste from surgery and autopsies on patients with infectious diseases. Also, wastes that have been in contact with animals inoculated with infectious agents or suffering from an infectious disease, including human tissues, organs, body parts, items contaminated with body fluids, cotton dressings and other materials contaminated with blood etc. Non-infectious wastes are generated from packaging, food preparations and visitors' activities. This waste is large compared to infectious waste.

A large fraction is potentially recyclable but may be contaminated with infectious agents. This has to be stored separately and sterilised before sending for recycling. The proportion of solid waste generated in various hospitals in a study carried out in Indore City is given in Table 2. The composition of various constituents varies widely depending on the type of facilities provided by the HCUs. A comprehensive field survey was conducted in Calcutta wherein eight major hospitals were surveyed for solid-waste composition covering three seasons of the year; the average values with standard deviation are presented in Table 3.

## Handling methods

In India, normally the waste is collected in open containers without disinfection. Bandages, cotton and other items used to absorb body fluids are collected in plastic or other non-specified containers. Waste is collected in mixed form. Some hospitals in the country have developed their own system of colour coding (CPHEEO, 1998). Waste sharps are discarded without disinfection and mutilation, which may result in their being re-used thus spreading an infection. The waste collection and transportation workers in the hospital segregate the recyclable material for sale. In a similar way, all disposable plastic items are segregated by the wastepickers, from where the waste is deposited either inside the hospital grounds, or outside in the community bin for further transportation and disposal along with municipal solid waste (Rao, 1995).

**Table 2.** Proportion of solid waste from HCUs

| Type of waste | Range (%) | Average (%) |
|---|---|---|
| General | 50·46–88·31 | 71·37 |
| Infectious | 10·00–36·23 | 18·83 |
| Pathological | 4·06–19·71 | 8·11 |
| Chemical | 0·22–2·77 | 0·91 |
| Sharps | 0·41–1·42 | 0·78 |

**Table 3.** Composition of hospital waste in Calcutta

| Ingredients | Average (% by wet weight) | SD |
|---|---|---|
| Bandage, cotton cloths, etc. | 36·10 | 8·27 |
| Plastic, PVC and rubber | 6·86 | 1·97 |
| Paper | 7·65 | 3·27 |
| Disposable syringe | 0·43 | 0·31 |
| Food waste | 39·85 | 8·14 |
| Glass | 4·56 | 2·41 |
| Inert[a] | 4·55 | 1·79 |

Source: NEERI (1995).
[a]Includes stones, earthenware, bricks and ash.

## Treatment and disposal

In large hospitals, infectious waste has usually been disinfected and disposed of along with general waste. Waste generated in out-patient Departments (OPD) is similarly treated. Wastes from operation theatres, wards and pathological laboratories are disposed of without any disinfection/sterilisation. Amputated body parts, anatomical wastes, and other highly infectious wastes are incinerated wherever incinerators are available; the remainder is burnt in some corner of the hospital grounds, mostly in open pits.

In small towns, health-care waste is often buried in pits on the available onsite space, or sent to municipal waste-disposal sites.

Smaller private nursing homes and clinics do not take any precautions and often dispose of their waste in the community bins intended for storage of municipal solid waste.

Therefore, it is a common practice to dispose of health-care waste along with municipal waste. Open burning is also normally observed for its disposal. The existing pathways for management of health-care waste are shown in Figure 2.

## Wastepicking

Large numbers of wastepickers collect recyclable items like plasticware, needles and glass materials

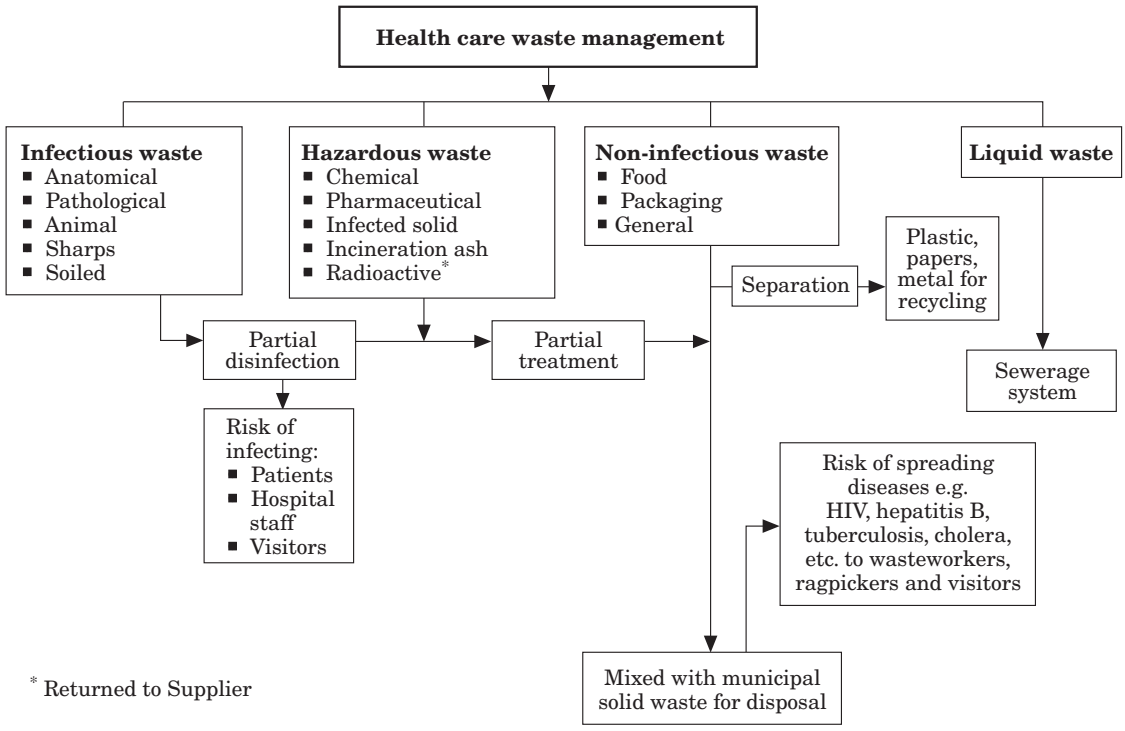


**Figure 2.** Existing pathways for management of health-care wastes.

from the waste to sell. Many times cleaning workers in HCUs have been observed to pick up recyclables like plastics, glass and metals from waste and sell them. This practice is dangerous, as it is associated with high risk of infection and serious disease.

## Shortcomings in the existing system

Rapid urbanisation in the country has resulted in medical facilities in urban centres improving faster than those in the rural areas. Waste management systems in the urban areas are already overburdened. Hence, an additional load due to mixing of infectious waste from HCUs aggravates the problem. Separate systems for disposal of HCU waste are available in only a few establishments. The shortcomings in the existing system are:

- mixed collection of wastes increases the quantity of infectious waste;
- absence of colour-coded storage containers for different categories of waste;
- non-availability of treatment and processing devices compatible with waste generation;
- lack of common treatment and processing facilities;
- unplanned waste-management systems;
- inadequate provision of budget allocation;
- lack of awareness of better waste management;
- lack of waste management training for HCU staff.

In view of these shortcomings, efforts have been made in the past by several agencies for improvement in this area. The Bureau of Indian Standards (1989) has prepared the guidelines for hospital waste management. A working manual (Pruthvish *et al*., 1998) has been prepared by another group of experts. In this manual, practical aspects of safe management of hospital waste, including handling, disinfection, housekeeping and disposal are dealt with in detail.

Shrishti, a non-governmental organisation, has prepared a guide for developing a system for hospital waste management. It has been written to encourage participation by both management and staff, and ensure resourcing. A two-stage planning process is outlined, addressing issues like organisation, evaluation of existing practices, collection, processing, equipment, training and reporting. Simple techniques for waste classification, mainly as infectious and non-infectious, their segregated collection, handling and treatment are described in detail. Waste collection in in-patient departments, operating theatres, etc. are dealt with in greater detail. The guide includes the training methodology

for various levels of staff. Finally, case-studies are presented for better understanding for the techniques in the guide (Kela *et al*., 2000).

SKAT (Swiss Centre for Development Cooperation in Technology and Management), has compiled case-studies from various developing countries like Ghana, India, Nepal, Palestinian Territories, Senegal and Tanzania; these are presented in question and answer form. In keeping with the answers to each question, conclusions are drawn appropriate to the situation of the agencies in the field. Lessons learned from earlier studies are summarised. The authors stress that management of health-care waste is not simply a matter of data compilation and technology; it requires training, commitment, management, leadership and effective legislation (Code and Christen, 1999).

A comprehensive document has been prepared by the World Health Organization, with definitions, characterisation, health impacts, legislation, policies and planning of waste management for health-care waste described in detail (Pruss *et al*., 1999). Related costs and safety practices for both personnel and waste workers, hygiene and infection control are also discussed. A similar comprehensive report has been prepared in India (Mehta, 1998).

## Biomedical wastes (management and handling) rules

In 1998, the Ministry of Environment & Forests issued a notification on the Biomedical Wastes (Management and Handling) Rules for regulating the management of biomedical wastes (The Gazette of India, 1998). The Ministry, while establishing the legal framework, introduced the term *biomedical waste* for all types of waste generating from HCUs and veterinary establishments. Biomedical wastes are classified into ten categories, listed in Table 4.

The Rules also make the generator of the waste liable for segregation, packing, storage, transportation and disposal of the wastes so that they will not harm public health. Table 5 indicates the colour coding and type of containers for different categories of biomedical wastes and their corresponding treatment and disposal options. The categories are grouped together to facilitate waste handling by unskilled staff. The containers used for storage of biomedical waste should be labelled with the appropriate biohazard or cytotoxic symbol.

Authorisation by prescribed authorities such as the State Pollution Control Boards, is mandatory for HCUs (termed occupiers) providing services to more than 1000 patients per month. This is granted for a trial period of 1 year.

The rules describe the duties of occupiers in the treatment and disposal of biomedical wastes. Incineration, deep burial, autoclaving, microwaving, disinfection, mutilation and disposal in municipal landfill are among the disposal options identified. As the system of waste management in India is in its initial stages, the technologies prescribed in the rules are generic and are expected to be developed for specific conditions.

**Table 4.** Categories of biomedical waste

| No. | Category | Type of waste |
|---|---|---|
| 1 | Human anatomical waste | Human tissues, organs, body parts |
| 2 | Animal wastes | Animal tissues, organs, body parts, carcasses, fluid, blood; experimental animals used in research, waste generated by veterinary hospitals |
| 3 | Microbiology and biotechnology wastes | Waste from laboratory cultures, stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell cultures used in research, infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used to transfer of cultures |
| 4 | Waste sharps | Needles, syringes, scalpels, blades, glass, etc., capable of causing punctures and cuts. This includes both used and unused sharps |
| 5 | Discarded medicines and cytotoxic drugs | Waste comprising outdated, contaminated and discarded drugs and medicines |
| 6 | Soiled wastes | Items contaminated with blood fluids including cotton, dressings, soiled plaster casts, linens, bedding |
| 7 | Solid wastes | Disposable items other than the waste sharps, such as tubing, catheters, IV sets etc. |
| 8 | Liquid wastes | Waste generated from laboratories, washing, cleaning, house-keeping and disinfection activities |
| 9 | Incineration ash | Ash from incineration of any medical wastes |
| 10 | Chemical wastes | Chemicals used in production of biologicals, disinfection, insecticides, etc. |

Source: *The Gazette of India* (1998).

**Table 5.** Colour coding and type of container for disposal of biomedical waste

| Waste category | Type of container | Colour code | Treatment options with standards |
|---|---|---|---|
| • Human anatomical waste<br>• Animal wastes<br>• Microbiology and biotechnology waste<br>• Soiled wastes | Plastic bag | Yellow | *Incineration*<br>Temperature of primary chamber: 850±50°C<br>Secondary chamber: 1050±50°C<br>Stack height: 30 m<br>*Deep burial*<br>Pit: 2 m deep<br>Lime cover: 50 cm |
| • Microbiology and biotechnology wastes<br>• Soiled wastes (body fluids, cotton, dressings, soiled plaster casts, linens, items contaminated with blood) | Disinfected container/ plastic bag | Red | *Autoclaving*<br>121°C at 15 psi for 60 min.<br>135°C at 31 psi for 45 min.<br>149°C at 52 psi for 30 min.<br>*Microwaving*<br>*Bacillus subtilis* as an indicator in the form of spores using vials or spore strips with at least $1 \times 10^4$ spores per ml |
| • Waste sharps<br>• Solid waste (wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets, etc.) | Plastic bag/ puncture proof container | Blue/white translucent | *Autoclaving*<br>121°C at 15 psi for 60 min.<br>135°C at 31psi for 45 min.<br>149°C at 52 psi for 30 min.<br>*Microwaving*<br>*Bacillus subtilis* as an indicator in the form of spores using vials or spore strips with at least $1 \times 10^4$ spores per ml |
| • Discarded medicines and cytotoxic drugs<br>• Incineration ash<br>• Chemical wastes (solid) | Plastic bag | Black | Disposal in secured landfill |

Source: *The Gazette of India* (1998).
Colour coding of waste categories with multiple treatment options as given above shall be selected depending on treatment option chosen. Waste collection bags for waste types needing incineration shall not be made of chlorinated plastics, namely, Polyvinyl Chloride (PVC); other chlorinated waste should not be incinerated. Liquid waste and Chemical waste in liquid form do not require containers and bags. Microbiology and biotechnology waste, if disinfected locally need not be put in the containers/bags. Deep burial should be adopted only in towns with population less than five lakhs and in rural areas.

The agency responsible for implementation of the regulations is the prescribed authority to be constituted by each State Government/Union Territory. Recycling and reuse of sharps and disposable devices have been prohibited. They have to be disinfected/sterilised and mutilated before disposal.

An advisory committee has to be constituted which will include experts from medical and health, animal husbandry and veterinary sciences, environmental management, municipal administration, and any related department HCUs are included. Representatives from the State Pollution Control Board/Pollution Control Committee shall also be included in the advisory committee. The committee as and when required should advise the Government of the State/Union Territory about matters related to the implementation of the Rules.

Every occupier is required to submit an annual report to the prescribed authority in a prescribed format. The report will present information about the categories and quantities of biomedical wastes handled during the preceding year. The authority is required to send this information to the Central Pollution Control Board by March 31st every year.

## *Implementation of the regulations*

The Rules should be implemented by the different HCUs. Waste treatment facilities like incinerators, autoclaves, microwaves etc. have to be adopted in a phased manner by the end of 2002. Facilities for storage, collection, treatment and disposal have

to be provided. However, efforts to provide the appropriate technologies have so far been limited.

The Rules have not been publicised as widely as required. Hence, smaller HCUs may not be fully aware of them. A number of issues have not been dealt with in detail, such as standards of collection and storage devices, equipment, etc. However, due to lack of availability of the appropriate equipment, it is difficult for them to manage their waste as per the provisions. The prescribed pathways in the regulations are shown in Figure 3.

### *Need for additional provisions in the regulations*

A critical review of the Rules indicates that there is a need to address the following issues for effective implementation: (1) the responsibility of a local agency, such as the municipal authority, for transport and disposal of the wastes after disinfection; (2) provisions for occupational health and safety for waste handlers; (3) provisions against waste picking and scavenging of medical waste; (4) awareness programmes for the generators of biomedical wastes including authorities of veterinary institutions, etc.; (5) provision of common processing and disposal facilities for small generators of biomedical wastes; (6) provision of special charges to be collected by private HCUs and budget allocation in Government hospitals for waste management.

## Waste management plan for HCUs

Members of a Waste Management Team (WMT) should be appointed to carry out a review of existing waste management in their area of responsibility. Existing practices should then be evaluated in the light of provisions made in the Rules and an appropriate system developed.

### *Institutional arrangements*

Management of health-care waste depends on the input from the administration and active participation by trained staff in segregation, storage, collection, transportation, treatment and disposal. The personnel responsible for these activities are mainly ward attendants and other supporting staff. Hence, it is desirable to form a committee consisting of the head of the establishment, all the departmental heads, hospital superintendent, nursing superintendent and hospital engineer. A waste management officer could be appointed by the committee who would be advised by an environmental

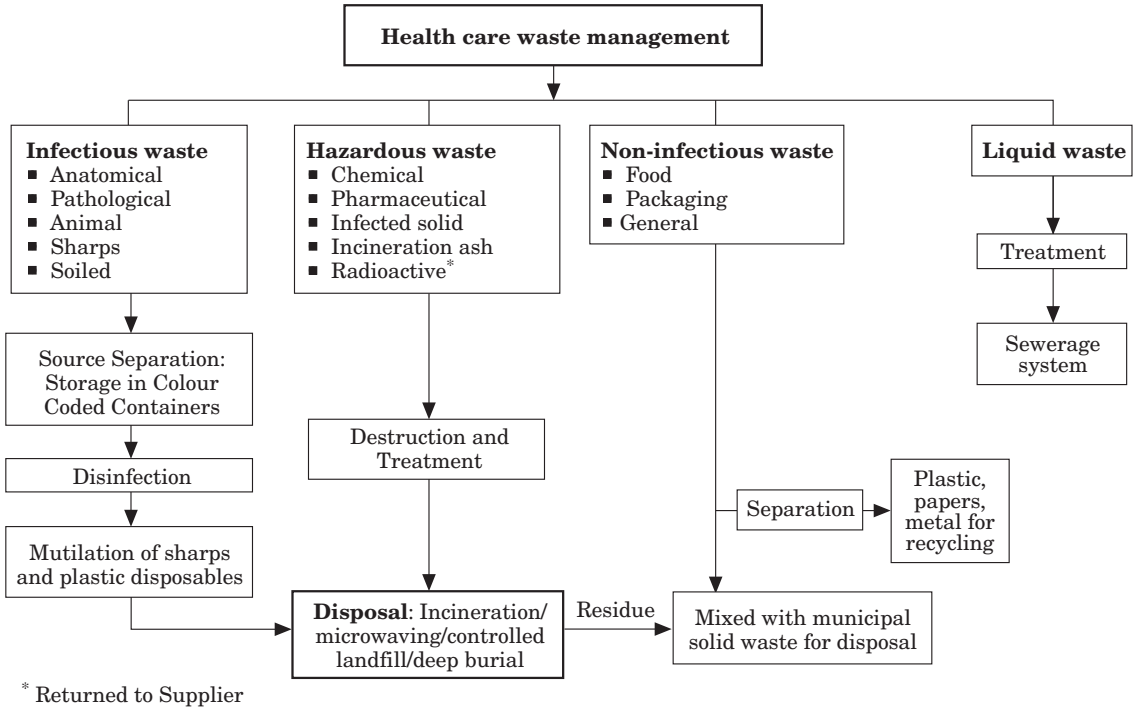


**Figure 3.** Prescribed pathways for management of health-care wastes.

control advisor and an infection control advisor. The committee could be constituted according to facilities and personnel available in the HCU. A typical organisational structure for a large hospital with a medical education facility is shown in Figure 4.

## *Appropriate technologies*

Waste-management technology should be compatible with the waste characteristics, affordable and conform with operation and maintenance conditions and legal provisions. In India, as the systems are in the initial stage of evolution, there is vast scope for the development of appropriate technologies for storage, transfer, collection, transportation, processing and disposal of health-care wastes. These include: (1) source-specific storage containers; (2) closed handcarts; (3) mutilation devices for disposables, such as needles, syringes and plastic items; (4) disinfection/sterilisation devices of appropriate sizes; (5) disposal equipment such as incinerators and microwave furnaces, including dry and wet thermal technologies.

A range of storage containers, disinfecting devices and processing equipment could be made available to help the HCUs select devices suitable for their use. A centrally located common waste-treatment system could be set up for small establishments which have insufficient space. However, such a system requires safe and regular transportation of waste, which incurs additional cost.

At present, as the system is not fully developed in the country, even the large hospitals are apprehensive about installing their own facility and looking for a common treatment facility. However, due to enforcement of regulations awareness of the need for action is gaining momentum.

## *Operational plans*

Operational plans should include the following elements: (1) location and capacity of the storage containers; (2) frequency of collection for various types of wastes; (3) schedule of activities.

Infectious wastes should be stored in the designated colour-coded containers which are rigid for safe handling and can be disinfected/sterilised by the available facility in the hospital.

Transportation of waste within the hospital should be carried out in closed handcarts to a disinfection or treatment facility. After disinfection/sterilisation the waste is transported to a common treatment facility, such as an incinerator or controlled landfill. General wastes from food, packaging, etc. from the HCU should be kept separately and disposed of along with municipal solid waste. Liquid waste after necessary treatment is disposed of in the sewerage system.

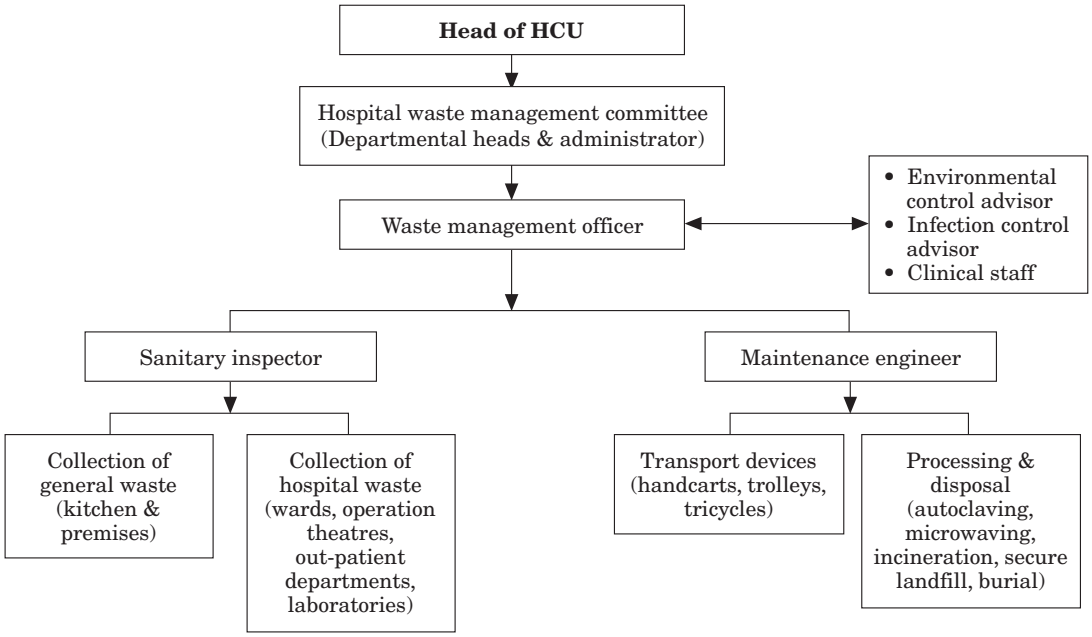


**Figure 4.** Typical organisational structure for health-care waste management.

### Financial management

With dedicated systems being installed in most of the HCUs, financial provision is necessary for capital and recurring expenditure. A long-term plan for resource recovery should also be included. Normally, a separate allocation of funds for waste management is not made. However, provision of funds for sufficient manpower, disinfectants, devices and equipment needs to be made. It is estimated that Rs. 3000–4000 (US$ 70–93) per tonne of hospital waste is required. Private HCUs could itemise this when charging patients. However, Government hospitals should make appropriate provision of funds for waste management and meet the expenditure from the budget.

### Awareness and participation

Awareness of appropriate handling and disposal of health-care wastes among health personnel is a priority; it is essential that everybody should know the potential health hazards. Regular programmes will help prevent exposure of health-care wastes and related hazards. Poster exhibition, proper labelling, and explanation by staff are effective methods. Seminars and workshops, and participation in training courses are also essential. In India, WHO has sponsored regional workshops (WHO, 1999) to focus awareness on this area. These workshops mainly dealt with: (1) waste minimisation, recycling and segregation; (2) handling, storage and transportation; and (3) treatment and disposal options.

### Waste minimisation

Waste minimisation can be achieved by the following strategies: (1) as far as possible purchase reusable items made of glass and metals which can be disinfected and reused (Raghupathi, 1998). (2) Sterilise reusable items, strengthen sterilisation procedures, quality assurance, proper monitoring and validation of cleaning, disinfection for patient care, and reduce the number of pre-sterilised single-use items. (3) Adopt procedures and policies for management of waste generated. (4) Establish effective policy for plastic recycling in collaboration with an authorised plastic manufacturer. (5) Use steam sterilisation methods in preference to chemical disinfection to avoid the generation of hazardous chemical waste.

## Conclusion

Health-care waste management is not only a technical problem, but is also strongly influenced by economic conditions. On its own, enactment of legislation will not make it more efficient. Sustainable solutions can be effected by involving local bodies engaged in waste management and making sure they follow the principles of effective management. Health-care waste should be subjected to disinfection and mutilation prior to reuse, recycling or disposal. Precautions have to be taken so that disposable items like needles, syringes, IV sets and other plastic items are not reused. Efforts have to be made for minimisation of waste: an appropriate plan has to be evolved as per the prevailing conditions. Finally, adequate financial provision needs to be made.

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## References

Bureau of Indian Standards (1989). *Solid Waste-Hospitals: Guidelines for Management*. New Delhi: Bureau of Indian Standards.

Code, A. and Christen, J. (1999). *How are we managing our healthcare wastes?* St. Gallen, Switzerland: SKAT.

CPHEEO (1998). Hospital medical waste management practices in Mumbai. *Industrial Safety Chronicle*, Oct–Dec, 77.

Kela, M., Nazareth, S., Goel, A. and Agarwal, R. (2000). *Managing Hospital Waste: A Guide for Health-Care Facilities*, 3rd edn. New Delhi: Shrishti.

Kelkar, R. (1998). A practical approach to hospital waste management in India. *Industrial Safety Chronicle*, Oct–Dec, 67–70.

Malviya, K. (1999). *Existing Solid Waste Management from Hospitals*. MSc Dissertation. Devi Alivya University, Indore.

Mehta, G. (1998). *Hospital Waste Management*, National Guidelines (Draft) prepared for GOI/WHO project IND EHH 001, Lady Hardinge Medical College and Associated Hospitals, New Delhi.

Ministry of Health and Family Welfare, Government of India (1998). *Health Information of India 1995 and 1996*. pp. 131–136. New Delhi: Central Bureau of Health Intelligence Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India.

NEERI (1995). *Comprehensive Characterisation of Municipal Solid Waste at Calcutta*, Nagpur: National Environmental Engineering Research Institute.

Pruss, A., Giroult, E. and Rushbrook, P. (eds) (1999). *Safe Management of Wastes from Health-care Activities*, Geneva: WHO.

Pruthvish, S., Gopinath, D., Jayachandra Rao, M., Girish, N., Bineesha, P. and Shivaram, C. (1998). *Information Learning Units for Health-Care Waste*. Health-Care Waste Management Cell, Department of Community Medicine, M.S. Ramaiah Medical College, Bangalore, India.

Raghupathy, L. (1998). Medical waste management: an approach. *Industrial Safety Chronicle*, Oct–Dec, 61–65.

Rao, H. V. N. (1995). Disposal of hospital wastes in Bangalore and their impact on environment. In *The Third International Conference on Appropriate Waste Management Technologies for Developing Countries*, pp. 839–842. Nagpur, February 25–26.

The Gazette of India (1998). *Biomedical Wastes (Management and Handling) Rules, 1998*., Extraordinary Part II Section 3-Sub Section (ii), pp. 10–20. India: Ministry of Environment and Forests, Government of India. Notification dated 20th July.

Saini, R. S. and Dadhwal, P. J. S. (1995). Clinical waste management: a case study. *Journal of Indian Association for Environmental Management* **22**, 172–174.

WHO (1999). *Regional Workshop on Hospital Waste Management and Hospital Infection Control*. WHO Project: INDEHH001. Government Medical College and Hospital, Nagpur, India, Nov. 18–20.