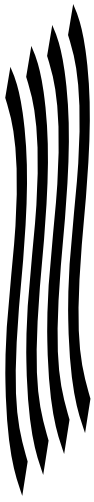
Health Care Waste Management in India

Lessons from Experience

BEKIR ONURSAL

THE WORLD BANK

Environment and Social Development Department
South Asia Region



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Foreword

The World Bank has supported in the health sector in India for many years. As part of that involvement, the Bank has made increasing efforts to highlight issues related to management of health care wastes. These efforts reflect both a growing international awareness and a response to particular events in India.

Improper management of health care wastes is a public concern because of risks of infection, injury, and other health hazards. Poor health care waste management is also a reflection of broader management deficiencies in health care facilities. Public awareness about the dangers of careless disposal, and the introduction of regulatory measures for managing these wastes, are both relatively new in India.

This report presents an overview of the responses and concerns in India associated with health care waste management at the central, state, and local levels. The report is based on the Bank's experience in working with clients and draws heavily on an internal review of Bank operations. We hope that the experience reported here will stimulate debate among, and support for, those engaged in these issues.

Richard Ackermann
Director, Environment and Social Development
South Asia Region
The World Bank

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Abbreviations and Acronyms

BMW	Biomedical waste
CPCB	Central Pollution Control Board
CWTF	Common waste treatment facility
HCW	Health care waste
NGO	Nongovermental organization
SPCB	State Pollution Control Board
WHO	World Health Organization

Executive Summary

Health care wastes (HCWs) are all wastes generated by health care and health research facilities and associated laboratories. They include both (a) "communal waste," such as paper and bottles that can be dealt with through the local solid waste management system; and (b) potentially dangerous "biomedical wastes" (BMWs), such as sharps (needles, scalpels, knives, blades, broken glass) and wastes with infectious, hazardous, radioactive, and genotoxic properties that endanger human health and the environment. Managing HCWs safely is essential, but not easy.

This report describes India's steep learning curve in the management of HCWs in the last decade and draws a number of lessons from India's experience. Since 1995, India has made great progress in managing HCWs, notwithstanding delays caused by weaknesses in the country's legal and institutional framework for HCW management. The national government has promulgated Biomedical Waste Rules, prepared national guidelines, and implemented a national training program. States have devised their own HCW management strategies and guidelines and provided assistance to government hospitals in implementing HCW management initiatives. Nongovernmental organizations (NGOs) have played a major role in bringing the HCW management agenda to the attention of government officials, creating public awareness of HCW issues and training health care facility personnel. The culture at many health care facilities has changed to recognize the importance of adopting good HCW management practices, and the private sector has become increasingly involved in providing HCW management services both on and off the premises of health care facilities. India can now build on this initial HCW management experience to improve legislative and practical approaches. Coupling the current HCW management knowledge base with more effective use of information technology could help health care facilities in India internalize good HCW management practices as an essential component of their operation.

A National Legal Framework for Managing Health Care Wastes

In 1995, despite rising concerns about toxic emissions from the incineration of municipal and HCWs, India's Ministry of Environment and Forests drafted HCW management legislation that identified incineration as the technology of choice for health care facilities. Soon thereafter, the Supreme Court ordered the installation of approximately 60 incinerators at hospitals in the New Delhi area that had more than 50 beds. Many of the incinerators that were installed are no longer functional and therefore represent a wasted investment; of the 26 incinerators that remain, all but one are substandard by today's standards. The situation with respect to investments in substandard incinerators at health care facilities in New Delhi has parallels in many other urban areas of India.

Nongovernmental organizations in India played a major role in heightening awareness of health and environmental issues related to the management of HCWs among government officials and the public. In 1995, the NGO Srishti conducted a survey that revealed unsanitary

practices and risks in dealing with HCWs. In 1996, Srishti initiated public interest litigation against the government that led the Supreme Court to reverse its order for incineration at health care facilities. The Supreme Court subsequently ordered India's Central Pollution Control Board (CPCB)—the technical arm of the Ministry of Environment and Forests—to consider alternative and safer technologies in HCW management rules and to set up technology standards. During the following two years, while CPCB was evaluating alternative HCW treatment and disposal technologies, there were consultations among the government, health care sector, scientific community, industry, and NGOs about incineration and other options. The result of this process, in 1998, was the promulgation by the Ministry of Environment and Forests of a new set of rules for handling BMW.

India's new rules—the Biomedical Waste (Handling and Management) Rules of 1998—were based on the principle of segregation of communal waste from BMW, followed by containment, treatment, and disposal of BMWs in different categories. The new rules also listed waste treatment and disposal technology options, along with standards. The rules were amended twice in 2000, primarily to address administrative matters.

The Biomedical Waste Rules still have some internal inconsistencies and deviate in some respects from the 1999 World Health Organization (WHO) guidelines for the safe management of HCWs (Prüss, Giroult, and Rushbrook 1999). Nonetheless, these rules—and subsequent national guidelines—established a national framework for HCW management and were instrumental in raising awareness in India about the health risks and good management practices of HCWs among health care facility personnel; government officials at the central, state, and local levels; and the general public.

State Strategies and Activities Related to Health Care Waste Management

The responsibility for implementing India's Biomedical Waste Rules was delegated to individual states and territories, with State Pollution Control Boards (SPCBs) in states and Pollution Control Committees in territories designated as the authorities. The national rules require that each state constitute a committee to advise the state government and the SPCBs about implementation of the rules. For such an advisory committee to function effectively, there must be close coordination and participation among different stakeholders—in particular, state environmental and health agencies, local authorities, health care facility representatives, academia, and NGOs.

Individual states have had to develop their own specific strategies for HCW management. One of the strategic decisions that state authorities had to make was how to refine the technology options included in the Biomedical Waste Rules. Another strategic decision for state authorities was whether to opt for on-site treatment of BMWs or common treatment of BMWs. Common treatment of BMWs can offer several advantages in terms of better and more efficient operation of the treatment equipment by trained personnel, reduction of the potential adverse human health impacts and waste treatment and disposal costs, and lessening of the enforcement burden on the regulatory agencies involved. For these reasons, India's central government views common waste treatment as the most appropriate approach to the treatment of BMWs generated in urban areas.

State health departments have prepared guidelines to facilitate implementation of the Biomedical Waste Rules at government hospitals. A review of these guidelines reveals a number of shortcomings. An important current need, therefore, is to improve the quality of these guidelines and identify good practices for dissemination across states.

State health departments also have provided assistance to government hospitals for HCW management in the form of personnel training, waste management auditing, preparation of hospital-specific plans, procurement of materials and supplies, and construction of on-site disposal facilities. Private hospitals in India have had to comply with the requirements of the Biomedical Waste Rules using their own resources.

Health Care Facilities' Waste Management Practices

One of India's major achievements has been to change the attitudes of the operators of health care facilities to incorporate good HCW management practices in their daily operations and to purchase on-site waste management services from the private sector. The assistance provided to government hospitals by state health departments—in part through World Bank–financed projects—has contributed to this change. National and regional workshops, training programs, and other efforts have led to an increasing recognition that hygiene and HCW management are essential to good hospital management practices. Despite the progress that has been made, however, there is room for improvement in bringing

HCW management to the attention of medical officers and doctors, improving hospital-specific plans, and conducting refresher training so that health care facility staff can fully internalize these plans.

A review of HCW management practices at government hospitals in India reveals wide differences in practices among hospitals in different states. State-level HCW management guidelines are sometimes prepared by local consultants and NGOs with no or little experience in other states, and such consultants and NGOs may vary in their interpretations of the Biomedical Waste Rules, which are themselves inconsistent. Hospital-specific HCW management plans are also prepared by local private consultants or NGOs that vary in their interpretations of state-specific HCW management guidelines.

The Private Sector's Role in Health Care Waste Management

Since the implementation of the Biomedical Waste Rules, private sector firms have become increasingly involved in providing both on-site and off-site HCW management services for health care facilities. The culture change resulting from implementation of the Biomedical Waste Rules has led some government hospitals to contract with private sector organizations for on-site waste management services previously performed by health care facility personnel. Although some facility staff concerned about losing their jobs have resisted this approach, the experience of using private contractors for on-site HCW management has yielded significant improvements in the overall cleanliness and sanitary conditions for health care facility personnel, patients, and their visitors, as well as a positive change in public opinion.

Participation by private sector firms in the provision of off-site HCW management services has been associated with the collection of segregated BMWs from the health care facilities, treatment at common waste treatment facilities (CWTFs), and disposal of the treated wastes. These services have become an integral part of a state strategy in some states of India. Major credit goes to officials in the State of Andhra Pradesh. These officials were instrumental in convincing health care facility representatives to pay for off-site treatment and disposal of their BMWs; they were also able to bring along the first investor for a CWTF with no government subsidies, just a guarantee from the state government that the CWTF will receive BMW from a specified number of care facilities with a specified number of beds. Successful experience with the first CWTF in Andhra Pradesh led to the investment of a second CWTF based on the build-own-operate model by the private sector there. The approach was subsequently replicated in Karnataka, Maharashtra, Punjab, Rajasthan, Tamil Nadu, and there are current plans for CWTFs in Gujarat, Kerala, New Delhi, Uttar Pradesh, and West Bengal.

Lessons Learned from India's Experience

Several major lessons can be drawn from India's experience:

- ***Initiating HCW management legislation and practice without adequate background work results in delay and costly readjustments.*** Preparing background studies with a situation analysis, evaluating alternatives, and involving key stakeholders in the process are integral steps to establishing a sound basis for HCW management legislation. India did not take all these steps, and the result was a rather convoluted process with delays in the preparation and implementation of India's HCW management legislation.
- ***HCW guidelines must be timely and informed by field experience.*** HCW guidelines are an important tool for implementation of the Biomedical Waste Rules by health care facilities, BMW transporters, and BMW treatment and disposal facility owners and operators. National guidelines for implementing the Biomedical Waste Rules were published at a rather late date and were not comprehensive. This situation, along with internal inconsistencies in the Biomedical Waste Rules themselves, resulted in considerable implementation difficulties.
- ***Many approaches and tools are necessary to inform opinions and change actions.*** The central and state governments, NGOs, the media, and others have played an important role in creating awareness of and sharing knowledge about HCW management issues among the general public, policymakers, and other parties in India. The tools used by these parties range from the promulgation of national rules to training sessions for the personnel of health care facilities.
- ***Hospitals can change their culture and improve HCW management practices.*** Since implementation of the Biomedical Waste Rules, and with assistance provided to health care facilities by state health departments, the culture at many health care facilities in India has changed to recognize hygiene and HCW management as essential to good hospital management practices.

- ***The private sector's role in on-site HCW management is becoming increasingly important.*** With the implementation of the Biomedical Waste Rules and increased recognition of the need for good HCW management practices at health care facilities, the private sector's involvement in providing on-site HCW management services is growing.
- ***Effective state strategies for CWTFs, with private sector involvement, are emerging.*** Management of BMWs at a CWTF has become an integral part of the state HCW management strategy in some states of India. State officials in Andhra Pradesh succeeded in convincing health care facility representatives to pay for off-site treatment of their BMWs at a privately built, owned, and operated CWTF—and their success with this approach has led other states to emulate it.
- ***Strong and clear regulatory commitment improves implementation of the Biomedical Waste Rules.*** SPCBs in the states and Pollution Control Committees in the territories are the regulatory agencies in India responsible for enforcing the requirements of the Biomedical Waste Rules. The capacity of these agencies to act—and their determination to do so—has made a major difference in the effectiveness of implementing the Biomedical Waste Rules.
- ***Information technology has a crucial role to play in HCW management.*** Information technology has great potential for creating public awareness of HCW management issues and for sharing knowledge about HCW management practices at health care facilities.

Road to the Future

Despite inefficiencies caused by weaknesses in India's legal and regulatory framework and institutions, the road to the future in HCW management in India is now clear. The diligent efforts by NGOs in India that demonstrated the unsafe conditions of on-site incinerators have resulted in guidelines that allow incineration at CWTFs but prohibit use of on-site incineration without a special permit from the CPCB. There is hope that the initial successful experience with privately built, owned, and operated CWTFs in Andhra Pradesh and other states in India will form the foundation for common practice for urban areas of India. Changes in culture regarding hygiene and HCW management practices have occurred at many health care facilities, and many facilities now accept the need to pay for off-site treatment and disposal of BMWs. The challenge now is to promote broader and better implementation of HCW management practices across India, while taking into account the wide variety of circumstances, facilities, and capabilities in the country's health sector.

CHAPTER 1

The Problem of Health Care Wastes

Health care wastes (HCWs) are all wastes generated from health care and health research facilities and associated laboratories. The different types of HCWs and examples of each type are presented in Table 1. Most HCWs are "communal waste"—solid wastes generated from administrative, housekeeping, kitchen-related, and maintenance operations of health care facilities. Such waste can usually be dealt with through the local solid waste management system. Other HCWs are sharps and wastes with infectious, hazardous, radioactive, or genotoxic characteristics that are potentially hazardous to humans and the environment. These more dangerous HCWs—called "biomedical wastes" (BMWs) in India—constitute only a small fraction of the total waste stream, but their presence demands careful management. Defining, identifying, and separating BMWs from communal wastes is central to the proper management of HCWs.

Exposure and Risks from Biomedical Wastes

Sources of BMWs in health care facilities include wards, delivery rooms, operating theaters, emergency and outpatient services, laboratories, and pharmaceutical and chemical stores. Persons at risk of exposure include health care facility employees (doctors, nurses, health care assistants, maintenance personnel, and support personnel for waste handling, transportation, and laundry), patients and their visitors, and waste management facility employees and scavengers.

Infectious wastes containing potentially harmful micro-organisms can infect hospital patients, health care employees, and patients' visitors. Used needles, syringes, and other sharps present risks of injury and infection (for example, hepatitis B and C, and HIV) for health care employees. Chemical and pharmaceutical wastes may cause intoxication or injuries such as burns. Genotoxic wastes are hazardous and may have mutagenic,[1] teratogenic,[2] or carcinogenic properties. Radioactive sources may cause severe injuries to humans such as destruction of tissue. Untreated liquid wastes from health care facilities and sewerage present risk of surface water contamination, and leachate from untreated or improperly treated HCWs may contaminate groundwater at disposal sites.

Improper disposal of BMWs in open dumps increases the risk of injury from sharps and the spread of infectious diseases to waste handlers and scavengers, and uncontrolled burning of BMWs increases the risk of exposure to hazardous emissions. In addition, poorly designed or operated BMW incinerators pose health and environmental risks to incinerator operators and nearby communities. Such incinerators may emit carcinogenic dioxins and furans,[3] formed through incomplete combustion at low temperatures of BMWs containing

1. A mutagen is an agent that can induce or increase the frequency of a mutation in an organism.
2. A teratogen is an agent that causes malfunction of an embryo or a fetus.
3. Dioxins and furans are polychlorinated hydrocarbons.

Table 1. Overview of the Types of Health Care Wastes

Types of Health Care Wastes	*Examples*
Communal waste[a] (solid wastes that are not infectious, chemical, or radioactive)	Cardboard boxes, paper, food waste, plastic and glass bottles
Biomedical wastes[b]	
Infectious waste (wastes suspected of containing pathogens)	Cultures, tissues, dressings, swabs, and other blood-soaked items; waste from isolation wards
Anatomical waste	Recognizable body parts
Sharps	Needles, scalpels, knives, blades, broken glass
Pharmaceutical waste	Expired or no longer needed medicines or pharmaceuticals
Genotoxic waste	Wastes containing genotoxic drugs and chemicals (used in cancer therapy)
Chemical waste	Laboratory reagents, film developer, solvents, expired or no longer needed disinfectants, and organic chemical wastes (for example, formaldehyde, phenol-based cleaning solutions)
Heavy metal waste	Batteries, broken thermometers, blood pressure gauges
Pressurized containers	Aerosol cans, gas cylinders (that is, anesthetic gases such as nitrous oxide, halothane, enflurane, and ethylene oxide; oxygen, compressed air)
Radioactive waste	Unused liquids from radiotherapy; waste materials from patients treated or tested with unsealed radionuclides

a. Also known as "general health care wastes."

b. Also known as "hazardous health care wastes," "health care risk wastes," or "special wastes."

Source: Prüss, Giroult, and Rushbrook 1999.

chlorine-based components (such as polyvinyl chloride or sodium hypochlorite) and organic materials.[4] Emissions of particulate matter containing heavy metals (for example, cadmium, lead, and mercury) increase the risk of neurotoxic and carcinogenic effects. Acid gases (for example, hydrogen chloride and sulfur dioxide) can cause eye and respiratory irritation as well as environmental damage (acid rain) and material damage (corrosion of metals).

Health Care Waste Management Efforts

Systematic efforts to mitigate risks associated with HCWs are fairly recent. In the United States, public outcry over the discovery of hypodermic needles and other BMWs littering the New Jersey beaches in the summer of 1988 triggered legislative measures at the federal and state levels.[5] Following the U.S. trend, other industrial and most developing countries initiated a wave of regulatory actions on HCW management. In South Asia, systematic efforts to mitigate the adverse impacts of BMWs were initiated in 1995 by the Government of India. In Bangladesh, although HCW management has been addressed through specific projects since 1999, the legal framework is not yet established. In Sri Lanka, despite a late start, a strong basis was created for a legislative framework in 2001.

4. Temperatures between 200°C and 400°C are most conductive to forming dioxins and furans.

5. The U.S. Government enacted the Medical Waste Tracking Act in November 1988, and the U.S. Environmental Protection Agency promulgated the Standards for the Tracking and Management of Medical Wastes in 1989; subsequently, states passed their own health care waste management legislation.

CHAPTER 2

A National Legal Framework for Managing Health Care Wastes

India was the first country in South Asia to establish a legal framework for the management of health care wastes. The development of India's legal framework began in 1995. At that time, the scope of the HCW problem was rather large. According to the Central Pollution Control Board (CPCB)—the technical arm of India's Ministry of Environment and Forests—an estimated 150 tons/day of biomedical waste generated from health care facilities were being mixed in with communal wastes without adequate attention to proper waste management procedures (CPCB 2000).

In 1995, India's Ministry of Environment and Forests drafted rules for managing BMWs that proposed (a) that each health care facility with more than 30 beds or serving more than 1,000 patients per month install an incinerator on its premises; and (b) that smaller health care facilities set up a common incinerator facility. Shortly thereafter, in March 1996, the Supreme Court directed the Government of India to install incinerators at all hospitals in the New Delhi area that had more than 50 beds. Sixty incinerators were installed in the New Delhi area, and 26 of them are still in service. Only one of these incinerators meets today's national norms—an incinerator at RML Hospital that was re-engineered by CPCB.

Meanwhile, in 1995, Srishti, a nongovernmental organization (NGO), had taken a survey that revealed unsanitary practices and associated risks in dealing with HCWs in India. In 1996, Srishti initiated public interest litigation against the government that led the Supreme Court to revise its initial position for incineration at health care facilities by ordering India's Central Pollution Control Board (CPCB)—the technical arm of the Ministry of Environment and Forests—to consider alternative and safer technologies in HCW management rules and to set up technology standards.

A major drawback of incineration is that it produces toxic air emissions. The principal pollutants in terms of public health are heavy metals (such as cadmium, mercury, and lead), hazardous by-products from combustion (such as dioxins and furans), and particulate matter. Srishti asked the Supreme Court to require alternative and safer technologies in the rules and the setting up of standards for these alternative technologies.

At Srishti's urging, India's Supreme Court revised its initial position and ordered CPCB to consider alternative BMW treatment and disposal technologies. Between 1996 and 1998, while CPCB was evaluating alternative technologies, there were intensive consultations among government officials, health care representatives, scientists, members of the industry, and NGOs. The culmination of all these efforts was the preparation and publication by India's Ministry of Environment and Forests of the Biomedical Waste (Handling and Management) Rules of 1998. Those rules are discussed further below.

The Biomedical Waste Rules of 1998

India's Biomedical Waste Rules of 1998, which were amended twice in 2000, are based on the principle of segregation of communal waste from BMWs, followed by containment, treatment, and disposal of different categories of BMW (Box 1). The rules classify BMWs into 10 categories and require specific containment, treatment,

Box 1. Main Features of India's Biomedical Waste Rules of 1998 (amended twice in 2000)

In 1998, India's Ministry of Environment and Forests prepared and issued the Biomedical Waste (Handling and Management) Rules. The main features of the current rules are summarized here and in the table below:

- ***Definition of biomedical waste.*** Any waste that is generated during the diagnosis, treatment, or immunization of human beings or animals, or in research activities pertaining to or in the production or testing of biologicals.
- ***Application of the Biomedical Waste Rules.*** The rules apply to all persons who generate, collect, receive, store, transport, treat, dispose, or handle BMWs in any form.
- ***Duty of occupier (operator).*** It is the duty of the occupier (operator) of a health care facility—that is, hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank—to ensure that BMWs are handled without any adverse effect to human health and the environment, and according to the prescribed treatment and disposal requirements in the Biomedical Waste Rules.
- ***Prescribed authority.*** State Pollution Control Boards (SPCBs) in states and Pollution Control Committees in territories are responsible for permitting and enforcing the requirements of the Biomedical Waste Rules.
- ***Permitting.*** Each occupier (operator) handling BMWs and providing services to 1,000 or more patients per month is required to obtain a permit from the prescribed authority.
- ***Recordkeeping.*** Each occupier (operator) is required to maintain records on the generation, collection, reception, storage, transportation, treatment, and disposal of BMWs. All records are subject to inspection and verification by the prescribed authority at any time.
- ***Accident reporting.*** Each occupier (operator) is required to report any accident related to the management of BMWs.
- ***Annual reporting.*** Each occupier is required to submit an annual report to the prescribed authority to provide information about categories and amounts of wastes generated and treated, and modes of treatment.
- ***Common disposal/incineration sites.*** Local public entities are required to provide common disposal/incineration sites, and the occupiers (operators) of such sites are required to comply with the Biomedical Waste Rules.
- ***Segregation, packaging, transportation, and storage.*** BMWs are not to be mixed with other waste. According to the Rules, BMWs are to be segregated into labeled bags/containers. Transportation of BMWs is to be conducted in authorized vehicles. No untreated waste is to be stored more than 48 hours, unless special permission is obtained from the regulatory authorities.
- ***Standards.*** Technology and discharge standards for incineration, autoclaving, microwaving, liquid waste discharges, and deep burial are prescribed in the Biomedical Waste Rules.

No.	*Biomedical waste category*	*Container color*	*Treatment/disposal option*
1	Human anatomical waste	Yellow	Incineration[a]/Deep burial[b]
2	Animal waste	Yellow	Incineration[a]/Deep burial[b]
3	Microbiology and biotechnology waste (infectious wastes from laboratory)	Yellow Red	Incineration[a]/Autoclaving/Microwaving
4	Waste sharps (for example, needles, syringes, scalpels)	Blue/White translucent	Disinfection/Mutilation/Autoclaving/ Microwaving
5	Discarded medicines and cytotoxic drugs	Black	Incineration/Destruction and secure landfilling
6	Soiled waste (items contaminated with blood or body fluids such as cotton dressings, beddings)	Yellow Red	Incineration[a]/ Autoclaving/Microwaving
7	Solid waste (for example, tubing, catheters, intravenous sets)	Blue/White translucent/Red	Disinfection by chemical treatment/ Autoclaving/Microwaving
8	Liquid waste (from laboratory, washing, cleaning, housekeeping, disinfecting)	—	Disinfection by chemical treatment and discharge into drains
9	Incineration ash	Black	Municipal landfilling
10	Chemical waste	Black	Chemical treatment and discharge into drains for liquids, and secured landfills for solids

a. There will be no chemical pretreatment before incineration. Chlorinated plastics will not be incinerated.

b. Deep burial is allowed only in cities with population less than 500,000 and in rural areas.

Source: Ministry of Environment and Forests 1998.

and disposal methods for each waste category. An overview of the BMW treatment and disposal technologies specified in the Biomedical Waste Rules is presented in Box 2. BMW treatment options include autoclaving, microwaving, incineration, and chemical treatment; in addition, hydroclaving has been approved by CPCB as an alternative treatment technology. BMW disposal options include deep burial and secure and municipal landfilling for solid wastes, and discharge into drains (after chemical treatment) for liquid wastes.

India's Biomedical Waste Rules are similar to those in international practice, although they have some internal inconsistencies and deviate in some respects from the procedures the World Health Organization (WHO) recommends for managing HCWs. Appendix A highlights some of the similarities and differences between India's rules and the 1999 WHO guidelines for the safe management of HCWs (Prüss, Giroult, and Rushbrook 1999).

National Guidelines for Implementing the Biomedical Waste Rules

Each state or territory in India is responsible for implementing India's Biomedical Waste Rules, and State Pollution Control Boards in states or Pollution Control Committees in the territories are designated as the prescribed authorities. Although environmental standards and guidelines for the management of BMWs were developed by India's CPCB in 1996 (CPCB 1996), these were merely technical standards for technology options for health care facilities.

In 2000, CPCB published a manual on hospital waste management that provided technical guidance for carrying out India's Biomedical Waste Rules in the areas of HCW segregation, storage, transport, and treatment (CPCB 2000). The CPCB manual gave special emphasis to BMW incineration, covering incinerator emissions, maintenance requirements, operational problems and solutions, and pollution control systems. Suggestions regarding common waste treatment facilities (CWTFs) for BMW treatment were also included in the manual.

CPCB's manual was informative, but it was not comprehensive enough to cover all aspects of India's Biomedical Waste Rules, such as sharps management, handling of infectious liquid wastes, minimization of BMW generation, training of health care facility employees, and recordkeeping and monitoring procedures. As discussed below, a positive development is that CPCB has recently issued two sets of draft guidelines, one set pertaining to the treatment of BMWs at CWTFs (CPCB, n.d.-a) and the other pertaining to the design and construction of BMW incinerators (CPCB, n.d.-b).

CPCB's recent draft guidelines on CWTFs set out requirements for the location, land size, coverage area (in terms of the maximum number of beds served), treatment equipment, and infrastructure setup of the CWTF; collection and transportation of BMWs, and disposal of treated BMWs; and other operational issues. The listed technologies in the draft guidelines include those prescribed in the Biomedical Waste Rules, plus hydroclaving. The draft guidelines' prescriptions are not always well justified. For example, the minimum coverage of each CWTF is set at 10,000 health care facility beds, without consideration for local conditions such as the geographical dispersion of the health care facilities; the suggested land area for each CWTF is 1 acre, but no basis for this suggestion is presented. In addition, the draft guidelines propose a 150-km-radius operational area, which would cover health care facilities in rural areas. This proposal becomes more important in the current debates around sharps wastes from immunization in India as the new types of autodisposable plastic syringes are being characterized as safer options than glass syringes. Moreover, CPCB's draft guidelines appear to be prescriptive on the waste management charge scheme[6] instead of letting the optimum scheme develop on the basis of experience gained in India.

CPCB's recent draft guidelines for BMW incinerators include requirements for the incinerator design and its air pollution control device, physical structures (incineration and waste storage rooms), operator qualifications, personal protection equipment, and emergency procedures (Box 3). These guidelines restrict incineration of BMWs only at CWTFs, with the exception of on-site incineration upon special approval by CPCB. The draft guidelines' strong bias against on-site incineration at health care facilities is a major deviation from the Biomedical Waste Rules, which are equally applicable to the on-site and CWTF incinerators. It is clear that the new emphasis reflects the recent findings about the poor design and operating conditions of on-site incineration equipment at health care facilities in India vis-à-vis the requirements of the Biomedical Waste Rules.

6. The proposed scheme is based on a health care facility's estimate of the daily generation of BMW (which is provided to the SPCB while obtaining authorization), followed by a one-month tracking period of each health care facility's waste generation by the CWTF operator.

Box 2. Biomedical Waste Treatment and Disposal Technologies Specified in India's Biomedical Waste Rules

Incineration. Incineration is a high-temperature oxidation process that involves combustion of the organic portion of BMW components, producing gaseous emissions and inorganic solid residues (ash). These emissions include steam, carbon dioxide, nitrogen oxides, particulate matter, and toxic substances (for example, metals, halogenic acids). In addition, under suboptimal combustion conditions, carbon monoxide and hazardous pollutants such as dioxins and furans may be emitted. Incineration significantly reduces waste volumes (typically 85 to 95 percent), and eliminates pathogens from BMWs. Incineration is not suitable for such health care wastes as pressurized gas containers, large amounts of reactive chemical wastes, wastes treated with halogenated chemicals, halogenated plastics such as polyvinyl chloride, wastes with mercury or cadmium (such as broken thermometers, used lead or mercury batteries), or radiographic wastes. Incinerators that meet the CPCB draft incineration regulations must have a sophisticated (for example, double-chamber) design and include a scrubber as the air pollution control equipment. Ash from these incinerators must be disposed of in a secure landfill. Such incinerators are associated with high investment and operating costs and require highly skilled operating personnel.

Autoclaving. Autoclaving uses saturated steam in direct contact with the BMW in a pressure vessel at time lengths and temperatures sufficient to kill the pathogens. The Biomedical Waste Rules specify the minimum temperature, pressure, and residence time for autoclaves for safe disinfection. Autoclaving is not suitable for human anatomical, animal, chemical, or pharmaceutical wastes. Before autoclaving, BMWs require shredding to an acceptable size, an operation that would involve frequent breakdown. Autoclaving produces a waste that can be landfilled with municipal waste. A wastewater stream is generated that needs to be disposed of with appropriate controls. Autoclave operation requires qualified technicians, and medium investment and operating costs.

Hydroclaving is similar to autoclaving except that the BMW is heated indirectly through the outer jacket of the vessel. The BMW is continuously tumbled in the chamber during the process.

Microwaving. Application of an electromagnetic field over the BMW provokes the liquid in the waste to oscillate and heat up, destroying the infectious components by conduction. This technology is effective if the ultraviolet radiation reaches the waste material. Before microwaving, BMWs require shredding to an acceptable size and humidification. Microwaving is not suitable for human anatomical, animal, chemical, or pharmaceutical wastes, or for large metal parts. Microwaving produces a waste that can be landfilled with municipal waste. The advantages of this treatment technology are its small electrical energy needs and no steam requirement. The disadvantages include the need for qualified technicians and frequent breakdown of shredders. This technology requires medium investment and operating costs.

Chemical disinfection. Addition of strong oxidants—like chlorine compounds, ammonium salts, aldehydes, or phenol compounds—kills or inactivates pathogens in the BMW. Chemical disinfection is most suitable for treating liquid wastes such as blood, urine, stools, or health care facility sewage. However, microbiological cultures, mutilated sharps, or shredded solids can also be treated by chemical disinfection. Disinfection efficiency depends on such factors as the type and amount of chemical used, and the extent and duration of contact between the disinfectant and the BMW. To enhance the contact, shredding of solid BMW would be needed. As chemical disinfectants have hazardous (in particular, toxic) properties, users should wear protective clothes. Chemical disinfectants should not be discharged to surface waters, and no large quantities should be allowed into sewers.

Deep burial. The Biomedical Waste Rules require that human anatomical and animal wastes in cities with population less than 500,000 and in rural areas be disposed of by deep burial. Accordingly, the deep burial site should be prepared by digging a pit or trench of about 2 meters deep in an area that is not prone to flooding or erosion, and where the soil is relatively impermeable, there are no inhabitants or shallow wells in the vicinity, and the risk to surface water contamination is remote. The pit should be half-filled with the BMW, then covered with lime within 50 cm of the surface, before filling the rest of the pit with soil. On each occasion when BMW is added to the pit, a layer of 10 cm of soil should be added to cover the waste.

Secure landfilling. Secure landfilling involves disposal of solid BMWs at a landfill designed and operated to receive hazardous wastes. The Biomedical Waste Rules require disposal of discarded medicines, cytotoxic drugs, solid chemical wastes, and incineration ash in secured landfills.

Municipal landfilling. Municipal landfilling involves disposal of communal HCWs and disinfected solid BMWs at a landfill designed and operated to receive municipal solid waste.

Box 3. Incineration of Health Care Wastes in India

In recent years, growing public concern about toxic air emissions has led to more stringent incineration technology standards around the world to reduce pollutants of concern to public health, including heavy metals (such as cadmium, mercury, and lead), hazardous byproducts from combustion (such as dioxins and furans), and particulate matter. The newer incineration technology standards have tightened the incinerator design and operating parameters and imposed monitoring and recording requirements for certain operating parameters and pollutant discharges. The newer standards make incineration a more costly and complex technology that requires specially trained operating personnel. These standards have led the United States and several European countries (for example, the United Kingdom, Germany, Austria, Belgium, France) to shift away from small-scale incineration of BMWs at health care facilities and to use alternative technologies such as autoclaving or microwaving, which are more cost-effective and reliable to operate.

Incineration is one of the BMW treatment and disposal technologies that is covered by India's Biomedical Waste Rules of 1998 (amended twice in 2000). In 2000, the NGO Srishti conducted a survey of the status of operating incinerators in India and presented the results to the Ministry of Environment and Forests and its technical arm—CPCB. The results indicated that most of the on-site incinerators at health care facilities in India were not in compliance with the Biomedical Waste Rules.

This finding led CPCB to issue draft guidelines allowing incineration only at CWTFs unless a special permit for on-site incineration is obtained from CPCB. The draft guidelines for BMW incinerators specify the design criteria for the incinerator and the associated air pollution control device, as well as the minimum requirements (in terms of training, personal protection equipment, emergency procedures) for the incinerator operator. The main features of the incinerator design criteria include the following:

- A minimum capacity of 50 kg/hour with high-pressure Venturi scrubbing system for air pollution control (rotary kiln design may be used for capacities above 250 kg/hour)
- Double-chamber design with "controlled air" incineration principle to minimize particulate emission (with 100 percent excess air for the overall design)
- Minimum temperature of 800±50°C in the primary chamber and 1,050±50°C in the secondary chamber
- Circular design for primary and secondary chambers (to minimize formation of air pockets observed in rectangular designs)
- A minimum of 1 sec. residence time in the secondary chamber
- A minimum negative draft of 0.05 to 0.1 inch of water column in the primary chamber to avoid leakage of gaseous emissions from the chamber (safety precaution)
- Charging of BMW into the incinerator through a conveyor or loading device (instead of manual handling) to ensure that there is no direct exposure of the operator to the furnace atmosphere
- Computerized programmable logic control (PLC) for the charging system to maintain specified temperatures in the primary and secondary chambers, to ensure complete combustion of the previous batch, and to avoid unsafe operating conditions
- Emergency bypass stack
- Graphic or computer recording devices to automatically and continuously monitor and record dates, time of day, load identification number, and operating parameters such as temperatures in both chambers, and CO and CO_2 in gaseous emissions throughout the duration of the incineration cycle
- Refractory lining of the primary and secondary chambers to sustain a minimum temperature of 1,000°C and 1,200°C, respectively.

Source: CPCB n.d.-b.

National Training and Coordination with States

India's Ministry of Environment and Forests has sponsored training programs through the Indian Institute of Technology for SPCB officials to receive training related to BMW recycling, treatment, and disposal. In addition, an international workshop on HCW management was held in New Delhi, and national workshops were held in large cities like Mumbai, Bangalore, Hyderabad and Jaipur. The benefits from such meetings can be seen in the role played by participants in influencing CPCB decisions on drafting the guidelines for CWTFs and incinerators.

India's central government could play an important role in providing leadership to the states, particularly in the assessment of treatment technologies for implementing the national BMW legislation and facilitating information sharing across the states. A recent review by the World Bank of HCW management programs in selected states of India found that comparative testing of autoclave and microwave technologies for the treatment of infectious wastes was conducted in the states of Andhra Pradesh and Punjab. In both states, the conclusion was that autoclave technology was preferred over microwave technology for environmental, operational, and cost reasons. This finding illustrates the need for states to share their professional experiences in order to learn from each other and avoid duplication of effort.

Modern tools such as the Internet could be useful for public access to HCW management information to foster public awareness and create public pressure for compliance. The Web sites hosted by the Ministry of Environment and Forests and CPCB could be used more effectively to disseminate information on national programs and to coordinate HCW management activities implemented in different states. These Web sites, in addition to posting currently available regulations and guidelines, could include announcements about national or regional training programs on HCW management, as well as information about the compliance status, research programs, and highlights of implementation of the HCW management activities in the states. Such information would enable states to keep abreast of new developments throughout the country and to strengthen their state policies and programs on the basis of lessons learned from others.

CHAPTER 3

State Strategies and Activities Related to Health Care Waste Management

As noted earlier, the responsibility for implementing the Biomedical Waste Rules in India rests with individual states and territories, and the prescribed authorities are SPCBs in states and Pollution Control Committees in territories. Each state is required to constitute an advisory committee to advise the state government and the SPCBs about implementing the rules. Constituting such a committee requires close coordination and participation at the state level among state environmental and health agencies, local authorities, health care facility representatives, academia, and NGOs.

Ideally, implementation of the Biomedical Waste Rules at the state level includes (a) the development of a state strategy for HCW management, (b) the preparation of state HCW management guidelines, (c) the provision of state assistance to government health care facilities, and (d) state enforcement of regulatory requirements. Developments in the states with respect to each of these areas are discussed below.

State Strategies for Health Care Waste Management

State authorities in India have made several strategic decisions pertaining to HCW management. One decision was how to refine the technology options included in the Biomedical Waste Rules. Although the rules list incineration as an option for certain categories of BMW,[7] concerted efforts by NGOs—including Srishti, Toxic Link, and Jyotsna Chauhan Associates—and the press have convinced some SPCBs to rule out the use of on-site incineration.

In the State of Andhra Pradesh, for example, where most health care facilities are in the heart of cities, the Andhra Pradesh Pollution Control Board prohibited incineration at health care facilities in the entire state after considering the potential adverse impacts of pollutant emissions from substandard incinerators. The Kerala Pollution Control Board recently opted for autoclaving and deep burial of BMWs instead of incineration. The Tamil Nadu Pollution Control Board has banned incineration of BMWs—except for body parts and human tissues—in favor of autoclaving and sanitary landfilling.

National and state authorities have made some technology choices for HCW management taking into account human health impacts in urban and rural areas. The Biomedical Waste Rules specify that incineration is the disposal scheme required for human anatomical and animal wastes for cities with population greater than 500,000, and deep burial is the disposal scheme required for such wastes for smaller cities and rural areas. In the State of Karnataka, however, because of the poor performance of incinerators at health care facilities, on-site

7. The Biomedical Waste Rules list as options incineration of human anatomical waste (BMW Category 1) and incineration of animal waste (BMW Category 2) in population centers of more than 500,000 habitants, and incineration of discarded medicine and cytotoxic drugs (BMW Category 5).

incineration has been prohibited within the limits of six city municipal corporations[8] and in all district headquarters. Of these locations in Karnataka, where the population exceeds 500,000, destruction of human anatomical and animal wastes is to be accomplished by incineration only at CWTFs to comply with both the Biomedical Waste Rules and state requirements. Bangalore, Hubli-Dharwad, and Mysore comply with this requirement, but in Mangalore, human anatomical and animal wastes are currently disposed of by deep burial.[9] In Andhra Pradesh, state authorities have selected deep burial as the disposal scheme for biodegradable infectious wastes[10] in areas with a population less than 500,000. This approach is not in compliance with the Biomedical Waste Rules, which require local autoclaving, microwaving, or incineration instead of deep burial, but it is in accordance with the 1999 WHO guidelines for the safe management of wastes from health care activities (Prüss, Giroult, and Rushbrook 1999).

Another strategic decision for state authorities in India was whether to opt for on-site treatment of BMWs or common treatment of BMWs. Common treatment of BMWs offers several advantages. First, a CWTF can be located away from hospital premises and urban areas, significantly reducing the potential adverse human health impacts. Second, a CWTF reduces treatment and disposal costs by treating large quantities of wastes collected from many facilities (that is, it offers economies of scale), although the savings must be balanced by the additional transportation costs from all the facilities to the CWTF.[11] Third, a CWTF can employ specially trained personnel who could not be easily supported by individual health care facilities, resulting in better and more efficient operation. Fourth, the permitting, monitoring, and enforcement efforts by regulatory agencies of one CWTF are likely to be fairly effective.

Nonetheless, there are challenges associated with a common treatment of BMWs. A CWTF approach imposes a direct financial burden on the operators of health care facilities, who previously paid minimal amounts for services associated with waste management. It also requires operational and behavioral changes by the operators of health care facility operators, who must properly segregate wastes into the types of BMW accepted by the CWTF operator. A more important concern is the difficulty of ensuring continued involvement of the private sector in a CWTF when the market is uncertain because of the absence of a culture of compliance and a weak enforcement regime.

India's central government views common waste treatment as the most appropriate approach to the treatment of BMWs generated in urban areas. Andhra Pradesh was the first state to devise and implement a CWTF scheme (Box 4). Initially, resistance to the scheme arose from doctors who were unwilling to accept a CWTF approach for the "Twin Cities" area of Hyderabad and Secunderabad and objected to the charges required for BMW treatment and disposal. Workshops were held with doctors and other facility staff to overcome their resistance, and mass awareness campaigns were conducted in Andhra Pradesh about the need for safe BMW treatment and disposal. Two privately owned CWTFs were set up in the state to treat BMWs from Hyderabad and Warangal Districts, using the same types of technologies (incineration and autoclaving) (Onursal and Setlur 2002).

The successful model for a privately owned and operated CWTF used in Andhra Pradesh was subsequently emulated in other states—including Karnataka, Maharashtra, Punjab, Rajasthan, Tamil Nadu—and plans for similar CWTFs have recently been adopted in the States of Gujarat, Kerala, New Delhi, Uttar Pradesh, and West Bengal.

- ***Karnataka.*** In Karnataka, two CWTFs—one in north and the other in south Bangalore— have been operating using incineration and microwave technologies to serve about 6,000 beds in the city.[12] Another CWTF in Mysore, which uses the incineration and autoclave technologies, was commissioned for 67 health care facilities with 7,000 beds.[13] Two additional CWTFs, both based on the incineration technology, were com-

8. These six municipal corporations are in the cities of Bangalore, Belgaum, Gulbarga, Hubli-Dharwad, Mangalore, and Mysore. Of these cities, Bangalore, Hubli-Dharwad, Mangalore, and Mysore have a population exceeding 500,000.

9. A CWTF project is underway for Mangalore.

10. Biodegradable infectious wastes are called "soiled wastes" (BMW Category 6) in the Biomedical Waste Rules.

11. In India, the capital cost of on-site treatment of BMWs for a 100-bed facility is reported to be about Rs. 1.4 million (about US$28,000), or Rs. 14,000/bed (about US$280/bed). The capital cost of a CWTF handling BMWs from 10,000 beds is reported to be about Rs. 15 million (about US$300,000), or Rs. 1,500/bed (about US$30/bed). In a study by the NGO Srishti, the breakeven cost between on-site treatment and off-site CWTF treatment is found to correspond to catering about 1,000–1,500 beds.

12. The CWTF in South Bangalore by Maridi Eco Industries was commissioned in August 2001, and the CWTF in North Bangalore by Medicare Incin. Pvt. Ltd was commissioned in September 2001.

13. The CWTF in Mysore by Shree Consultants was commissioned in August 2002.

Box 4. Comparison of Biomedical Waste Management Strategies in Two States: Andhra Pradesh and Kerala

The State of Andhra Pradesh and the State of Kerala have adopted somewhat different strategies for managing BMWs. The key features of their strategies are summarized below.

State of Andhra Pradesh

The BMW management strategy in Andhra Pradesh has several features:

- For the Twin Cities of Hyderabad and Secunderabad, health care facilities are required to segregate their wastes according to the Biomedical Waste Rules for transportation to CWTFs that treat and dispose of segregated BMWs. There are a total of 20,000 beds in 400 health care facilities in the Twin Cities area.
- For Visakhapatnam or other cities with populations greater than 300,000, a scheme similar to that used for health facilities in the Twin Cities is anticipated. As an interim measure, until CWTFs become available, the Andhra Pradesh Pollution Control Board requires health care facilities to segregate and disinfect their wastes according to the Biomedical Waste Rules, then hand over the segregated wastes to the municipal corporations for disposal. During August and September 2001, the Andhra Pradesh Pollution Control Board gave permits for the establishment of two additional CWTFs, one in Visakhapatnam and the other in Vijayawada.
- For health care facilities located in areas with populations less than 300,000 and with adequate space within their premises to set up treatment facilities, disinfection of BMWs followed by deep burial is required.

State of Kerala

In Kerala, the BWM management strategy applies to the entire state. At least one CWTF is envisioned for each of the four identified regions that include the following districts:

- Region 1: Alappuzha, Kollam, Pathanamthitta, and Thiruvananthapuram. There are a total of 38,474 beds in 873 health care facilities in this region.
- Region 2: Ernakulam, Idukki, and Kottayam. There are a total of 34,171 beds in 788 health care facilities in this region.
- Region 3: Malappuram, Palakkad, and Thissur. There are a total of 20,604 beds in 557 health care facilities in this region.
- Region 4: Kannur, Kassargod, Kzhikode, and Wayanad. There are a total of 21,536 beds in 599 health care facilities in this region.

Sources: Andhra Pradesh: Onursal and Setlur 2002. Kerala: Government of Kerala Directorate of Health Services n.d.

missioned recently in Belgaum and Hubli-Dhardwad.[14] Three additional CWTFs are going into place in Karnataka at Gulbarga, Mangalore, and Shimoga. All the CWTFs in Karnataka are located away from the city limits, with transportation of BMWs provided by the CWTF operator.

- ***Maharashtra.*** In Maharashtra, there are CWTFs in Mumbai, Pimpri Chinchwad, Pune, and Thane. Some of these operate only incinerators, and others incinerators along with autoclaves. In addition, procurement is underway for a CWTF in Navi Mumbai.
- **Punjab.** In Punjab, a CWTF was designed to treat and dispose of BMWs from health care facilities totaling 7,000 beds in the Ludhiana area. In response to subsequent protests by some health care facility managers concerned about the level of BMW management charge, however, the Punjab Pollution Control Board allowed them to dispose of their BMWs according to their choice, provided that the disposal is performed in compliance with the requirements of the Biomedical Waste Rules.
- **Rajasthan.** In Rajasthan, a CWTF was commissioned for BMWs from health care facilities in the Jaipur area.
- **Tamil Nadu.** In Tamil Nadu, CWTFs are in operation for 58 health care facilities in the Salem area and 78 health care facilities in the Madurai area.

14. The CWTF in Belgaum by Belgaum Doctors' Association was commissioned in February 2003, and the CWTF in Hubli-Dharwad was commissioned in July 2003.

- **Kerala.** In Kerala, the state's BMW management strategy involves use of CWTFs in the entire state—for rural as well as urban health care facilities. At least one CWTF is envisioned for each of the four specified regions (Box 4).

State Guidelines for Health Care Waste Management

Although SPCBs are the designated regulatory authorities for the Biomedical Waste Rules in the states, state health departments have the leading role in assisting government health care facilities to comply with the schedules in the rules. A few state health departments in India have prepared guidelines to facilitate implementation of the rules at government hospitals.

An initial review of some of the early state guidelines reveals that these documents do not incorporate state HCW management strategies, are inconsistent with the Biomedical Waste Rules, have internal inconsistencies, and do not provide clear and detailed instructions for implementation. An important current need, therefore, is to improve the quality of these guidelines and identify good practices for dissemination across states.

The state guidelines prepared for the Vaida Vidhana Parishad Hospitals in Andhra Pradesh and the secondary-level hospitals in Karnataka, for example, have a number of shortcomings. They do not incorporate the state strategies for HCW management; they are in some respect inconsistent with the Biomedical Waste Rules (which are themselves internally inconsistent); they exhibit incoherencies among the different sections of the same document; and they lack necessary details about management of HCWs. In addition, these state guidelines were issued more than two and a half years after the notification of the Biomedical Waste Rules and more than a year later than the compliance schedule indicated in the Biomedical Waste Rules for highest-priority health care facilities. Because of their late publication and possible misinterpretation of HCW management requirements, these guidelines are of limited value and require updating.

State Assistance to Government Health Care Facilities

While private hospitals in India must comply with the requirements of the Biomedical Waste Rules using their own resources, the government health care facilities have received assistance from their respective states. Some specific examples of HCW management program implementation activities under the World Bank–financed projects are discussed below (Onursal and Setlur 2002). State health departments in Andhra Pradesh, Karnataka, Maharashtra, Orissa, Punjab, and West Bengal have provided government hospitals with assistance in the areas of HCW auditing and training of state health officers and hospital staff under the World Bank–financed projects; they also have financed supplies and equipment for hospital waste containerization (bins, bags, labels); waste conveyance (trolleys), waste treatment (needle crushers, autoclaves); civil works for disposal facilities at hospitals (deep burial pits); and awareness efforts and additional training of health care facility personnel. In some states, hospital-specific HCW management plans were prepared on the basis of HCW audits by consultants, on-site disposal facilities were constructed by contractors, and supplies and equipment were procured by suppliers.

Training for Health Care Facility Personnel

Under the World Bank–financed projects, state health departments offered training on HCW management procedures to government hospitals. The purpose of the training was to create awareness and facilitate implementation of India's Biomedical Waste Rules. The content and duration of the training program varied with the target audience, whether this involved the administrators, doctors, nurses, or cleaning personnel.

- **Andhra Pradesh.** A three-step approach was adopted for the training program: awareness training of hospital personnel, development of training materials, and in-house training of hospital personnel. In each step, priority was given to the Twin Cities (Hyderabad-Secunderabad) hospitals, then to the 21 district hospitals (with 250–350 beds), and subsequently to the 55 area hospitals (with 75–100 beds) and 84 community health centers (with 30–50 beds). Awareness training was provided to the key personnel of all district hospitals, area hospitals, and community health centers. A training manual prepared by Jyotsna Chauhan Associates (Jyotsna Chauhan Associates 2000) was key in the training of health care facility personnel.
- **Karnataka.** Four training modules were targeted to different audiences at government hospitals (medical officers, nurses, cleaning and waste handling personnel, and patients and visitors). In addition, a fifth module was designed for local administrators and heads of key institutions. The key personnel at hospitals (nursing superintendents) were first trained by resource persons (consultants, NGOs). These key personnel, in turn, trained the remaining staff in their

respective hospitals (for example, nurses and cleaning and waste handling personnel).

- **West Bengal.** The awareness training program covered such waste minimization measures as the use of nondisposable sterilized glass syringes instead of disposable syringes, and electronic thermometers instead of mercury thermometers. In general, medical officers and doctors were reported to be the group of hospital personnel who had given the least attention to the waste management issues.

Supply of Materials for Health Care Facilities

State health departments have supplied materials for HCW management to government hospitals in India under the World Bank–financed projects. In Andhra Pradesh, more than 90 percent of district hospitals were provided with a one-year supply of HCW management materials (colored bins and bags, trolleys, protective gear, and so forth). In Karnataka, waste management materials were supplied to the Bangalore and district hospitals to coincide with the delivery of the training program. In addition, some district hospitals were provided with needle cutters and needle crushers for testing and evaluation. In Punjab, all government hospitals were provided with personal protection equipment (gumboots and gloves) and needle destroyers.

Procurement of Waste Treatment Equipment and Disposal Facilities

The Punjab and West Bengal State Health Departments procured autoclaves and microwaves for testing as BMW treatment equipment. In Punjab, autoclaves were selected on the basis of test results as the preferred technology for installation at 35 hospitals to treat BMWs from these and other hospitals. In West Bengal, autoclaves were installed at three hospitals, where they continue to be used to treat BMWs; and testing of microwaves was planned at two hospitals. In Karnataka, Punjab, and West Bengal, deep burial facilities for on-site disposal of sharps and soiled wastes were constructed on hospital premises.

State Regulatory Agencies' Enforcement of the Biomedical Waste Rules

India's regulatory agencies for the Biomedical Waste Rules—SPCBs in the states and Pollution Control Committees in the territories—are responsible for issuing initial and operation renewal permits to the entities that generate, store, transport, treat, and dispose of BMWs. In addition, SPCBs and Pollution Control Committees are responsible for determining health care facilities' compliance with the Biomedical Waste Rules.

Originally, the schedules for health care facilities to comply with the Biomedical Waste Rules ranged from 1.5 years to 4.5 years. The schedules were based on the type of health care facility, population size at the locality of the health care facility, and size of the health care facility in terms of the number of beds. Hospitals and nursing homes located in cities with more than 300,000 inhabitants, along with hospitals and nursing homes in areas with fewer inhabitants but with higher number of beds, were given a higher priority than others—and therefore less time to comply.

As implementation of the Biomedical Waste Rules lagged, the rules were amended in March 2000 to postpone the schedule for the highest-priority health care facilities to comply by six months—from December 31, 1999, to June 30, 2000. All health care facilities in India were required to comply with the rules by dates ranging from June 30, 2000, to December 31, 2002, depending on the type and size of facility.

The States of Andhra Pradesh, Karnataka, and Punjab were ahead of other states in terms of getting health care facilities to comply with the schedule specified in the Biomedical Waste Rules. The Andhra Pradesh Pollution Control Board announced that those health care facilities that did not obtain the board's permit by the first deadline indicated in the Biomedical Waste Rules would be liable for a fine of Rs. 100,000 (about US$2,000) and/or five years of imprisonment, and Rs. 5,000 (about US$100) compounding penalty fee per day. As a result of this announcement, a trickle of permit applications submitted to the board subsequently grew into a stream of applications, reaching 320 health care facilities throughout Andhra Pradesh. Only 80 of these health care facilities received a permit from the board to operate by that deadline. These observations indicate that, even with pressure from the regulatory agency, the extent of health care facilities' compliance was less than satisfactory.[15]

Implementation of the Biomedical Waste Rules in the State of Maharashtra—in terms of permit applications, permit granting, and adequacy of treatment facilities—

15. In comparison, the total number of health care facilities in the Twin City area is 375. There are, of course, more health care facilities in other parts of Andhra Pradesh that were required to comply by this deadline.

has been slow. The Comptroller and Auditor General of India's 2000–01 Audit Reports (TCAG 2001) indicates that only a small percentage (16 percent) of the 6,503 government and private health care facilities in Maharashtra had submitted their permit applications ("applied for authorization") by December 31, 2000—a situation that indicates major deficiencies in compliance with the Biomedical Waste Rules.[16] Among the defaulting health care facilities were some large government hospitals in Mumbai City. The report also states that approximately one-quarter of the applicants—278 health care facilities—were granted operating permits, and only 22 of the permitted health care facilities had adequate facilities for treatment of wastes. These observations indicate that the vast majority (98 percent) of the health care facilities that submitted permit applications lacked proper treatment procedures and were thus generating untreated BMWs that local agencies transported and deposited in dumping grounds along with communal waste (TCAG 2001). The Comptroller and Auditor General's report (TCAG 2001) also stated that not a single hospital of 14 district hospitals surveyed in Maharashtra was "following safe and effective practices in accordance with the rules, such as segregation of waste, treatment of infectious organic, pathological waste and sharp waste and provisions of protective measures for waste treatment. Liquid wastes were released into the hospital drains without any treatment, which added to the risk caused by improper solid waste disposal." The report indicated that an action plan was being prepared for small, medium, and large hospitals.

16. In urban areas where the population is more than 300,000, all heath care facilities are required to comply with the Biomedical Rules by June 30, 2000. In urban areas with less population, the compliance schedule for hospitals and nursing homes with more than 500 beds is also June 30, 2000; for hospitals and nursing homes with fewer beds, the date for compliance is December 31, 2000.

CHAPTER 4

Health Care Facilities' Waste Management Activities

India's Biomedical Waste Rules of 1998 make the occupier (operator) of each health care facility responsible for proper management of BMWs. Thus, although national, state, and local regulations create a framework and incentives for sound HCW management in India, what is most important is the implementation of sound waste management practices by health care facilities.

Health care facilities in India increasingly recognize and accept the importance of incorporating good HCW management practices in their daily operations. In fact, this change in culture—due in part to the assistance provided to government hospitals by state health departments in the form of personnel training, HCW management auditing, preparation of hospital-specific plans, procurement of materials and supplies, and construction of on-site disposal facilities—is one of India's major achievements. As discussed below, however, additional efforts are needed to bring HCW management to the attention of medical officers and doctors, improve hospital-specific plans, and offer refresher training so that health care facility staff can fully internalize these plans.

Health Care Facilities' Commitment to Managing Wastes

Proper HCW management at a health care facility requires full commitment by senior management and a carefully designed HCW management organizational structure with clearly defined responsibilities. It also requires a good plan for HCW management. Rather than rush ahead with a deficient plan that will require revisions, it is advisable for hospitals in India to take the time to develop a comprehensive HCW management plan.

The 1999 WHO guidelines for the safe management of waste from health care facilities recommends that the head of the hospital chair the hospital's HCW management organization and name in writing a waste management officer responsible for the development and day-to-day implementation of a HCW management plan for the institution. Hospital staff who should serve on the hospital's HCW management committee, under the waste management officer, should include the heads of the hospital's departments, the nursing superintendent, the head nurse, the sanitary inspector (infection control officer), the chief pharmacist, the radiation officer, the supply officer, and the financial officer of the hospital (Prüss, Giroult, and Rushbrook 1999). The exact composition of the hospital's HCW management committee depends on the hospital size and structure. All hospital staff—including doctors, nurses, cleaning staff, and so forth—involved in HCW generation and management within the hospital premises are members of the HCW management team.

The following mission statement of one district hospital in Karnataka reflects the hospital management's commitment to HCW management:

> "The management of this hospital is committed to providing a comprehensive quality health care to the community it serves, through a team of committed professional health workers who will keep in their mind the interest of patients

at all times and render treatment and carry out procedures in a clean, healthy and pleasant hospital environment which they pledge to maintain at all times. "

This district hospital in Karnataka outlined its immediate and long-term HCW management objectives as follows:

- "Immediate objectives:
  - To ensure safe, efficient, cost-effective disposal of hospital waste by developing a waste disposal plan
  - To train hospital workers on waste management
- Long-term objectives:
  - To develop strategies for reduction of waste generation in the hospital
  - To create awareness among workers about healthy hospital surroundings
  - To create community awareness on environmental issues in hospital surroundings."

These objectives suggest a lack of clear understanding by the hospital staff of what the implementation of HCW management in a hospital requires. Awareness of issues among hospital personnel should be created before such personnel are trained—not after. And strategies for reduction of waste generation in the hospital should be developed early on as part of a waste management plan (not a waste disposal plan)—not just as a long-term objective. The district hospital in Karnataka did name a waste management officer and form a HCW management committee, as recommended by WHO, but it did not make the appointments in writing and there were no written management responsibilities for each member. A management organization with joint responsibility for an entire committee undermines accountability. Posting information about the HCW management organization at prominent places within the hospital could strengthen the image of careful management for the entire institution. Making the entire hospital staff aware of the hospital's HCW management organizational structure, with listings of responsibilities for each member, would reflect a well-defined, transparent management system.

Health Care Facilities' Waste Audits

Before the Biomedical Waste Rules were required at the institutions, HCW audits were conducted at 25 government hospitals with 30–561 beds in three states: Karnataka, Maharashtra, and West Bengal (Onursal and Setlur 2002). The purpose of the HCW audits was to determine the amount of HCW generated and the composition of BMW in terms of the categories specified under the Biomedical Waste Rules at each hospital. To allow for factors affecting fluctuations in waste generation, the HCW audits were carried out around the clock for a period of 3–31 days.

Results from the HCW audits of the 25 government hospitals in Karnataka, Maharashtra, and West Bengal are shown in Table 2. As can be seen, there were wide variations in total waste generation rates and waste composition at different hospitals. More detailed results from the HCW audits of these hospitals are presented in Appendix B.

The audit results indicate that BMWs made up 19–78 percent of HCWs at these 25 hospitals. In comparison, in Hyderabad (Andhra Pradesh), the contribution of BMWs is reported to be 15–20 percent of HCWs after implementation of waste management plans by trained health care facility personnel. The data for Hyderabad are consistent with information commonly cited in the literature that BMWs contribute a maximum of 20 percent of HCWs. The difference between the audit results and other information may be attributed to the level of segregation of BMWs from HCWs. Personnel training at health care facilities and implementation of a hospital-specific waste management plan by such personnel are key in proper waste segregation.

BMW generation rates depend on such factors as waste management methods, type and specialization of health care facilities, extent of reusable items employed in health care, and proportion of patients treated on a day-care basis (Prüss, Giroult, and Rushbrook 1999). The BMW generation rates from the audited 25 hospitals were in the range of 0.05–0.40 kg/day/bed (or 0.09–0.50 kg/day/occupied bed). These rates are similar to those obtained through wastes audits (0.11–0.65 kg/day/bed) conducted at hospitals in Bhopal and Kanpur (Table 3).

The HCW audits conducted in eight hospitals in West Bengal also included determination of the composition and generation rates for communal waste. The results for the eight hospitals, shown in Table 4, indicate that food and vegetable wastes constituted most of the communal waste from these hospitals (66–84 percent). Other constituents of the communal waste from the hospitals were paper and cardboard (10–24 percent), plastics (3–12 percent), and glass (0.4–1.3 percent). The generation rates for communal waste ranged from 0.19 to 0.41 kg/day/occupied bed (or 0.13–0.37 kg/day/bed).

Table 2. Composition and Amount of Health Care Waste Generated by 25 Government Hospitals in 3 States before Implementation of the Biomedical Waste Rules

Health care wastes	*Karnataka hospitals, by number of beds*			*Maharashtra hospitals, by number of beds*			*West Bengal hospitals, by number of beds*		
	100	*50*	*30*	*384–561*	*127–272*	*30–46*	*381–520*	*100–195*	*30*
Biomedical wastes (%)	19	56	48	41–54	32–78	31–75	37–38	28–40	29
Infectious wastes (%)	8	33	30	21–34	12–43	15–53	31–33	24–36	23
Human anatomical waste (%)	—	—	—	—	—	—	1.3	2–3	4
Plastics (%)	6	17	5	4–19	4–26	5–22	1–3	1–2	1
Sharps (%)	5	6	13	1–8	5–10	3–31	1	0.3–1	0.7
Communal waste (%)	81	44	52	45–59	22–68	25–69	62–63	60–72	71
Kg/day:									
Biomedical waste	10.4	4.5	2.9	35–68	41–87	1.8–9.4	37–52	14–31	1.6
Health care waste	55.5	7.9	6.2	77–164	101–211	2.5–16.4	99–141	51–77	5.6
Kg/day/bed:									
Biomedical waste	0.10	0.09	0.10	0.09–0.16	0.22–0.40	0.06–0.31	0.08–0.10	0.14–0.16	0.05
Health care waste	0.56	0.16	0.21	0.18–0.39	0.41–1.04	0.08–0.55	0.23–0.28	0.38–0.51	0.19
Kg/day/occupied bed:									
Biomedical waste	0.14	0.13	0.21	0.09–0.16	0.24–0.50	0.11–0.50	0.12–0.15	0.14–0.16	0.10
Health care waste	0.77	0.22	0.45	0.21–0.38	0.41–1.31	0.15–0.87	0.31–0.42	0.35–0.57	0.35

Note: For data from West Bengal, "infectious waste" includes animal waste (Category 2), microbiology and biotechnology waste (BMW Category 3), and soiled waste (BMW Category 6). For data from Karnataka and Maharashtra, "infectious waste"—besides these categories—also includes human anatomical waste (BMW Category 1).

Information on generation rates of different constituents of communal waste improves planning for recycling opportunities, as well as for treatment and disposal options (Onursal and Setlur 2002).

Planning for Managing Wastes at Health Care Facilities

HCW management plans were prepared by private consultants or NGOs for government hospitals in India with the assistance of the state health departments. In the State of Karnataka, an evaluation of the implementation of the HCW management plans in government hospitals revealed several deficiencies, among them (a) improper segregation of waste at source, (b) mixing of sharp waste with other recyclable waste, (c) ambiguity about final disposal of sharps and plastics, (d) inadequate information about the use of landfill and deep burial pits, (e) disposables not being mutilated, (f) inappropriate location of bins, (g) biodegradable waste in deep burial pits not being covered with soil, (h) untrained contractual waste handlers handling the waste, and (i) ineffective disinfection of waste. These deficiencies were attributed to the attitudes of the administrative medical officers and staff involved in HCW management. The lessons drawn from this evaluation were used as the basis of retraining for staff from these hospitals.

A review of HCW management practices in India reveals wide differences among government hospitals located in various states. Appendix A summarizes several states' actual practices for the treatment, containerization,

Table 3. Biomedical Waste Generation Rates at Selected Hospitals in Madhya Pradesh and Uttar Pradesh

Hospital, by location	*Number of beds*	*BMW generation (kg/day/bed)*
Bhopal, Madhya Pradesh		
Kasturba Hospital	429	0.14
Ayushman Hospital	65	0.61
Kanpur, Uttar Pradesh		
Lala Lajpat Rai Hospital	1,055	0.22
Mariumpur Hospital	210	0.11
Regency Medical and Diagnostic Center	61	0.65

Source: CPCB 2000.

and disposal for specific HCW categories (Onursal and Setlur, 2002); the appendix also summarizes the requirements of India's Biomedical Waste Rules and the 1999 WHO guidelines for safe management of wastes from health care activities (Prüss, Giroult, and Rushbrook 1999). Examples of different HCW management practices in hospitals in various states include (a) treatment and recycling of plastic materials (this option is not mentioned under the Biomedical Waste Rules); (b) containerization of sharps (cardboard boxes are used, although puncture-proof containers are required under the Biomedical Waste Rules); (c) deep burial of infectious (soiled) waste (not authorized under the Biomedical Waste Rules, but recommended as an option in the WHO 1999 guidelines for safe management of wastes from health care activities); (d) returning of discarded medicines to suppliers (not authorized under the Biomedical Waste Rules, but recommended as an option in the WHO guidelines); (e) disinfection of infectious (soiled) waste followed by collection by municipality (not prescribed under the Biomedical Waste Rules); and (f) use of a different color container from what is prescribed by the Biomedical Waste Rules. In the case of plastics, disinfection by chlorination at hospitals followed by recycling through a thermal process (by a recycler) may generate hazardous chemicals (for example, dioxins)—a health issue that may be at least as serious as exposure to infectious wastes.

To a great extent, different waste treatment and disposal practices in different states reflect differences in the interpretation of the Biomedical Waste Rules, which include some inconsistencies. State-level HCW management guidelines are sometimes prepared by local consultants and NGOs with no or little experience in other states, and such consultants and NGOs may vary in their interpretations of the Biomedical Waste Rules. Hospital-specific HCW management plans are often prepared by local private consultants or NGOs that vary in their interpretations of state-specific HCW management guidelines.

To minimize generation of expired drugs, health care facilities have instituted measures that involve preparation of a list of drugs with an expiration date of six months and circulation to other hospitals. A computer-based waste exchange program may be built upon the existing system, not only to improve the efficiency of the current system (which uses the drugs for a good cause), but to reduce wastage and associated environmental problems. For any expired drugs generated, disposal at a secure landfill or incineration at a CWTF would be options.

Two issues related to human hygiene at health care facilities, although not covered in the Biomedical Waste Rules, are the quality of water supply and treatment of sewage. The results of water quality monitoring in different states indicate poor water quality in urban areas, mainly as a result of cross-contamination from sewage. Mitigating the adverse effects of poor quality water on the general population is an important concern that must be addressed in the entire country, particularly in urban areas. An immediate need is to reduce adverse impacts on the sick, who are the most vulnerable

Table 4. Composition and Amount of Communal Waste Generated by Eight Hospitals in West Bengal

	Hospital, by size							
	520 beds	*500 beds*	*498 beds*	*381 beds*	*195 beds*	*195 beds*	*100 beds*	*30 beds*
Basic data on hospital:								
No of days audited	3	3	3	3	3	3	3	3
Bed occupancy (%)	55	67	89	73	93	113	89	53
Composition of hospital's communal waste:								
Food/vegetable (%)	83	83	81	84	78	81	66	66
Paper/cardboard (%)	13	10	12	11	12	10	22	24
Plastics (%)	3	6	7	4	9	8	12	10
Glass (%)	0.6	1.3	0.5	0.6	1.1	0.5	0.4	0.6
Hospital's communal waste generation rate:								
Kg (in 3 days)	219	269	254	186	135	138	110	12
Kg/day	73	90	85	62	45	46	37	4
Kg/day/bed	0.14	0.18	0.17	0.16	0.23	0.24	0.37	0.13
Kg/day/occupied bed	0.26	0.27	0.19	0.22	0.25	0.21	0.42	0.25

portion of the population. Health care facilities need to develop and implement water quality monitoring programs at their facilities and, if necessary, take the mitigation measures to comply with national drinking water standards. Sewerage is also a problem; prototype designs for various groups and types of health care facility facilities could be developed and implemented for adequate drainage and on-site disposal or treatment arrangements, as well as a protocol for routine operation and maintenance. Furthermore, instituting a statewide systematic effort for collection and analysis of information on hospital effluents, and the associated water quality and health impacts, would improve the basis of sound decisionmaking.

CHAPTER 5

The Private Sector's Role in Providing Waste Management Services

The private sector has become increasingly involved in providing HCW management services, as discussed below. Still, the public sector is also involved, typically at rural health care facilities and some urban government-owned health care facilities. Designated staff in health care facilities, after training, are generally involved in the segregation, transfer, storage, treatment, and disposal of waste within their premises. Incinerators in government health care facilities have been operated by their own staff. Some government health care facilities with excess capacity for treating BMWs have provided services to other health care facilities in their vicinity. In Gulbarga, Karnataka, there are indications that an organization funded by the Government of India, Center for Environment Education, plans to build and operate the CWTF for BMWs. In Thane, Maharashtra, a CWTF was established in 2003 at a municipal hospital complex (Chattrapati Shivaji Municipal Hospital) through a joint public sector-NGO initiative.[17] The CWTF commissioned in 2003 includes an incinerator (with an energy recovery feature) and an autoclave to treat segregated BMWs received from 5 government and 70 private hospitals. The charges for waste treatment are reported to be Rs. 5.70/bed/day (about US$0.12/bed/day) for a general hospital or clinic and Rs. 7.70/bed/day (US$0.15/bed/day) for facilities with obstetric and gynecological services.

On-Site Waste Management Services

As part of the culture change resulting from implementation of the Biomedical Waste Rules in India, the private sector involvement in providing on-site HCW management services has gained importance in the Indian health sector. Some government hospitals have contracted with private sector organizations for on-site waste management services previously performed by health care facility personnel. In West Bengal, for example, cleaning services in all 75 government hospitals with more than 100 beds has been contracted out to the private sector. So far, the experience of using private contractors has been generally positive. The significant improvements in the overall cleanliness and sanitary conditions are appreciated by health care facility personnel, patients, and their visitors and have led to a positive change in public opinion. Resistance to the privatization of services from health facility staff concerned about losing their jobs can be expected. In West Bengal, in an effort to reduce staff resistance, the contracting out of cleaning services was extended to indoor areas in only 10 government hospitals (Onursal and Setlur 2002).

Off-Site Waste Management Services

Recently, there has been increasing participation by private sector firms in the provision of off-site HCW management services. In the Twin City area of Andhra

17. The initiative has been between the Thane Municipal Corporation and Enviro-Vigil Corporation, a Thane-based NGO.

Pradesh, for example, the state government has encouraged the adoption of a scheme in which a private sector firm builds, owns, and operates two CWTFs with no direct subsidies. The government incentive has been a guarantee on the number of health care facilities and associated beds served by the investors. Accordingly, one privately owned CWTF serving the Twin Cities (Hyderabad and Secuderabad) was assigned 125 government and private health care facilities for a total of 10,000 beds (Box 5); the other privately owned CWTF was assigned 250 government and private health care facilities with the same number of beds.

Each private CWTF operator in Andhra Pradesh is responsible for collecting BMWs from the assigned facilities, transporting them to the respective CWTF, and treating and disposing of the treated wastes in compliance with India's Biomedical Waste Rules and state requirements. In Andhra Pradesh, each health care facility served by the CWTF operated by GJ Multiclave Pvt. in the Twin Cities was required to do the following:

- Obtain an operating license from the Andhra Pradesh Pollution Control Board. This requires payment of an authorization charge of Rs. 100/bed/year (about US$2/bed/year) (regardless of bed occupancy status) to the Andhra Pradesh Pollution Control Board.
- Sign a one-year agreement with the CWTF for collection, transportation, treatment, and disposal of BMWs at a fixed rate, irrespective of the type of the health care facility (government or private) or bed occupancy at the health care facility. The rate for hospitals with beds started with Rs. 2/bed/day (about US$0.04/bed/day) in 2001 and increased to the current level of Rs. 3.25/bed/day. For health care facilities without beds (for example, clinics and blood banks), the rate is Rs. 400 to 500/month (about US$8–10/month).
- Purchase and use nonchlorinated yellow bags for safe incineration of anatomical and soiled wastes;[18]
- Use the waste management schemes according to the guidelines prepared by the state health department; and
- Pay the municipality a monthly flat charge for collection of the segregated communal waste in green bags. The charge in 2001 was Rs. 1,000 (about US$20) for health care facilities with more than 100 beds and Rs. 250 (about US$5) for health care facilities with a greater number of beds (Onursal and Setlur 2002).

CWTF operators need to receive properly segregated and containerized BMWs from health care facilities to assure the smooth operation of their facilities. One CWTF operator in the Twin Cities used his own resources to improve waste management practices at each health care facility. The operator conducted audits and made specific suggestions before signing a contract, and subsequently provided HCW management training to the health care facility staff and supplied safe HCW management posters.

In Karnataka, the two CWTFs in Bangalore and the one in Mysore all use the private sector build-own-operate model. The rate structure in Karnataka for BMW collection, treatment, and disposal services is the same as in Andhra Pradesh. For health care facilities with beds, the rates are Rs. 3.25/bed/day (about US$0.07/bed/day) in Bangalore and Mysore, and Rs. 1.25/bed/day in Belgaum. For health care facilities without beds (for example, clinics), the rate is Rs. 300/month (about US$6). The rates are established through negotiations between the CWTF owner and the Indian Medical Association–Private Doctors' Association.

In Kerala, the state government constituted an advisory committee[19] to select private sector investors for CWTFs through a competitive bidding process. Under the adopted scheme, the private sector builds, owns, and operates or leases CWTFs in four identified regions of the state (both urban and rural areas). The private sector is also responsible for collecting and transporting BMWs from the designated facilities to the CWTF. There are no subsidies involved, except for a grant from the state government of five acres of land for each CWTF. In addition, the state government provides incentives to the private sector by guaranteeing the number of health care facilities and beds to be involved and by training the health care facility staff on HCW management. Having fixed the user charge for private health care facilities, the state chooses private investors to build and operate

18. Nonchlorinated bags are more expensive than regular bags. Nonchlorinated bags cost Rs. 65–85/kg (about US$1.3–1.7/kg) and regular bags cost Rs. 40/kg (about US$0.8/kg).

19. The advisory committee constituted by the state government in Kerala is led by the health department and includes representatives from the Urban Development Department and the State Pollution Control Board. Kerala's health department is responsible for ensuring consultation with all stakeholders, including the Indian Medical Association, and for developing a joint project implementation plan.

Box 5. A Privately Owned CWTF in the Twin Cities Area of Andhra Pradesh

In the Twin Cities (Hyderabad and Secunderabad) area of Andhra Pradesh, GJ Multiclave Pvt. owns and operates a CWTF that BMWs generated from 125 health care facilities—private, semi-private, and government hospitals as well as nursing homes—with a total of 10,000 beds. The CWTF, established in mid-2000, is located about 55 km from the city of Hyderabad on a 12-acre parcel of land purchased for Rs. 3.8 million (about US$76,000).

The equipment at the CWTF consists of two autoclaves, a microwave, and an incinerator, all made in India. In addition, an effluent treatment plant and a secured landfill are part of the CWTF. The total investment for structures and equipment amounts to about Rs. 12.5 million (about US$250,000). After initial operation, use of the microwave was discontinued as it was found not to be as economical as the autoclave and not suitable for handling metals.

GJ Multiclave has two trucks that collect the segregated BMWs from all subscribed health care facilities during the day (6 am–4 pm) and bring these BMWs to the CWTF at about 6 pm. The trucks have four separate chambers—each chamber dedicated to a waste category—and a disinfectant storage tank to handle any spills. The CWTF operates with eight workers only at nighttime. At the CWTF, the waste bags are removed from their barrel and checked. If wastes are observed not to be properly segregated, then GJ Multiclave brings this problem to the health care facility's attention. If the problem persists, then GJ Multiclave informs the Andhra Pradesh Pollution Control Board for enforcement.

Two 30- and 60-liter capacity autoclaves at the CWTF are used for treatment of recyclable HCWs (glass and plastics such as gloves, aprons, syringes, catheters, I.V. tubing, blood bags—all received in red bags). Each autoclave operates at 121°C temperature and 15 psi pressure, and has a residence time of one hour. During the first year of the CWTF's operation, sharps (received in puncture-proof containers after disinfection at health care facilities with a 1 percent hypochlorite solution) were also autoclaved before being encapsulated in manufacturing bricks—for wall construction at the CWTF—on an experimental basis. Although encapsulation is not listed as an option under India's Biomedical Waste Rules, it is one of the options considered under the WHO's 1999 guidelines for the safe management of HCWs (Prüss, Giroult, and Rushbrook 1999). After inauguration of the first secure landfill in Andhra Pradesh, sharps are sent to this secure landfill.

Following autoclaving, the bags are opened and the contents are transferred into a large tub for segregation of glass and different types of plastics.a The segregated plastics are then shredded and sold to the manufacturer for recycling. Recycling involves first converting the plastic into granules and then molding the granules into the desired forms. GJ Multiclave is planning to purchase a granulating machine.

The anatomical and soiled wastes are received in nonchlorinated yellow bags for incineration. The incinerator has a capacity of 100 kg/hr and is equipped with dual chambers operating at temperatures of 850–900°C in the primary chamber and 1,050–1,100°C in the secondary chamber. The residence time in the incinerator is about 1.0–1.5 seconds. The flue gases from the incinerator are removed with a dilute caustic solution in a wet scrubber. The scrubbed gases are emitted to the atmosphere through a 30-meter-high stack. Temperatures in the primary and secondary chambers as well as the discharged pollutants are continuously monitored. The incinerator ash is disposed of in a secure landfill.

At the CWTF, the bins are washed with water and disinfected, the trucks are washed with hot water, and concrete floors are disinfected. All wash waters and the scrubber water are collected in the effluent treatment plant designed for a capacity of 6,000 liters/day, but operated only at 25 percent of this capacity (1,500 liters/day). The wastewater is treated with caustic and alum, aerated at a pH of 7, clarified, and filtered. The treated water is used for scrubbing the incinerator off gases, and the balance is used for gardening.

GJ Multiclave has engaged an environmental consultant. The weekly samples collected from the scrubber off gases are analyzed for HCl, particulate matter, and SO_2. In addition, the consultant collects weekly samples of the effluent treatment plant.

a. The plastic types include low-density polyethylene (LDPE such as plastic IV bottles), high-density polyethylene (HDPE such as syringes), polyvinyl chloride (PVC such as blood bags), and rubber (rubber tubing from syringes).

Source: Onursal and Setlur 2002.

CWTFs based on the lowest charge bid for the government health care facilities.[20] After the CWTF is constructed, it is to be granted a provisional permit for a trial period of three years, and during this trial period, the CWTF is expected to be operating in full compliance with the Biomedical Waste Rules. In the event the authorization is not renewed, the operator would be offered the price of the CWTF after depreciation.

The Jamalpur CWTF in Punjab is another example of the private sector build-own-operate scheme for HCW management. The private sector is responsible for transporting about 5,000 kg/day of BMWs from the Ludhiana area health care facilities (with a total 7,000 beds) to the CWTF. The selected treatment technologies at the CWTF are incineration and autoclaving. The capital investment of the CWTF is Rs. 10 million (about US$200,000). The established charge to the health care facility is Rs. 2.7/bed/day (about US$0.05/bed/day) and free transportation up to a distance of 25 km to the CWTF. The transportation cost increases to Rs. 0.5/bed/day (about US$0.01/bed/day) for up to 100 km and to Rs. 1.0/bed/day (about US$0.02/bed/day) for greater distances.

In Sewri, Maharashtra, a CWTF was established at Guru Teg Bahader Hospital's premises by the private sector[21] on a build-own-operate-transfer basis under a 10-year contract with the Brihanmumbai Municipal Corporation. This facility, which required an investment of Rs. 57 million (about US$1.1 million) to treat 3.5 tons/day of BMWs, includes an incinerator for human anatomical and animal wastes, discarded medicines, and cytotoxic drugs and an autoclave for other BMWs. The private sector was guaranteed a fixed fee for BMW treatment, whether BMWs come to the CWTF or not. Brihanmumbai Municipal Corporation engaged a transport service provider for collection and delivery of segregated BMWs from health care facilities to the CWTF as well as the disposal of the treated wastes. A total of 425 health care facilities (214 municipal and 211 private) have signed a memorandum of understanding with Brihanmumbai Municipal Corporation to send their BMWs to the CWTF. The charges to health care facilities are Rs. 3.50/kg (about US$0.07/kg) for transportation of the segregated BMW to the CWTF, and Rs. 18/kg (about US$0.36/kg) for treatment at the CWTF and land disposal of the residual wastes. Since the introduction of the billing system in August 2001, the amount of BMWs received by the CWTF has diminished drastically to 1.5 tons/day (most companies reduced their BMWs by 50 percent). The state authorities involved are speculating that health care facilities are deliberately mixing BMWs with communal wastes to escape Brihanmumbai Municipal Corporation's charges.

This experience illustrates the importance of careful consideration in defining the structure of the charge system to the health care facilities, as well as the specific role of the CWTF operator. A fixed-charge structure using Rs./bed/day for health care facilities with beds and Rs./month for health care facilities without beds would have eliminated the observed problem. In addition, inclusion of the CWTF operator in waste collection services would have improved interaction between the CWTF and health care facility operators in achieving the desired waste quality. In Andhra Pradesh, this interaction resulted in the CWTF operator providing training to the health care facility personnel for joint benefits. The lessons learned from the Sewri experience were incorporated into the Thane CWTF project in Maharashtra.

The draft guidelines for CWTFs, issued by the CPCB, provide clear guidance for BMW management for health care facilities located within a 150-km radius of urban areas in India. Accordingly, installation of new incinerators at health care facilities will be subject to much greater scrutiny with the CPCB's special approval process. Human anatomical and animal wastes, which require incineration in large urban areas, will probably be sent to CWTFs for incineration wherever possible. For soiled, microbiology, and biotechnology wastes, on-site versus CWTF options will need to be evaluated, considering the state or local BMW management strategy as well as the relative costs. For example, the Tata Mumbai Memorial Hospital in Mumbai voluntarily closed down its on-site incinerator because its air emissions were not in compliance with the Biomedical Waste Rules. Human anatomical wastes are now sent to a crematorium, chemicals to a municipal incinerator, and other BMWs to a new hydroclave on the hospital premises. In New Delhi, there are at least eight hospitals (including the Sanjay Gandhi Memorial Hospital) operating autoclaves for BMW treatment.

20. The financial analysis assumes a charge of Rs. 3.50/bed/day (US$0.07/bed/day) for private health care facilities with beds, Rs. 2.00/bed/day (US$0.04/bed/day) for public health care facilities with beds, and Rs. 6.67/day (US$0.13day) for public health care facilities without beds.

21. This is a joint venture between Environmental Monitoring Services and the Canadian-based Anderson Operation, Inc.

The initial approaches described here show interesting ways of tackling the "chicken and egg" problem of encouraging private provision of CWTFs before the commercial market for such facilities is fully demonstrated. Experience gained from these systems, after the first few years of operation, will be useful in expanding the coverage of properly operated and regulated CWTFs.

CHAPTER 6

Lessons from India's Experience

India has made significant progress in managing HCWs, despite delays in the implementation of its policies caused by weaknesses in the country's legal and institutional framework for HCW management. The central government has strengthened the legal framework for HCW management through the Biomedical Waste Rules and national guidelines. States have devised their own HCW management strategies and guidelines and provided assistance to government hospitals to implement HCW management initiatives. NGOs have played a major role in bringing HCW management issues to the attention of government officials and the public. A cultural change has occurred at many health care facilities, which now accept the need to adopt good HCW management practices and to purchase HCW management services from the private sector. Finally, successful experience with privately built, owned, and operated CWTFs has led to increasing acceptance of CWTFs as the way to manage hazardous BMWs in urban areas. Coupling the current HCW management knowledge base with more effective use of information technology could help health care facilities in India internalize good HCW management practices as an essential component of their operation.

Several major lessons can be drawn from India's experience:

- **Initiating HCW management legislation and practice without adequate background work results in delay and costly readjustments.** Preparing background studies with a situation analysis, evaluating alternatives, and involving key stakeholders in the process are integral steps to establishing a sound legislative basis for HCW management legislation. India did not take all these steps—and the result was a rather convoluted process, with delays in the preparation and implementation of India's HCW management legislation. In 1995, the Ministry of Environment and Forests drafted rues for managing BMWs that identified incineration as the BMW technology of choice for health care facilities, failing to take into account growing concerns about hazardous pollutant emissions from municipal and BMW incinerators. A subsequent order from the Supreme Court led to the installation of 60 incinerators in the New Delhi area, only one of which—after re-engineering by the CPCB—could meet today's national norms. In many urban areas of India, the situation with respect to investments in substandard incinerators at health care facilities has not been much different from that in New Delhi. A local NGO's efforts revealed unsanitary practices and associated risks in dealing with HCWs and opened a forum about the consideration of alternative technologies to incineration—such as autoclave and microwave treatment technologies. As a result, in 1998, the Ministry of Environment and Forests issued the Biomedical Waste (Handling and Management) Rules. These rules (amended twice in 2000) are a significant improvement over the 1995 draft legislation and have been instrumental in raising awareness in India about the health risks and good management practices of HCWs among the health care facility personnel; government officials at the central, state, and

local levels; and the general public. Nonetheless, the Biomedical Waste Management Rules do contain some internal inconsistencies and deviate in some respects from the 1999 WHO guidelines for the safe management of HCWs (Prüss, Giroult, and Rushbrook 1999).

- **HCW guidelines must be timely and informed by field experience.** HCW guidelines are an important tool for the implementation of the Biomedical Waste Rules by health care facilities, BMW transporters, and BMW treatment and disposal facility owners and operators. National guidelines for implementing the Biomedical Waste Rules were published at a rather late date and were not comprehensive. This situation, along with internal inconsistencies in the Biomedical Waste Rules themselves, resulted in considerable implementation difficulties. Weak institutional capacities at the state level compounded these difficulties. HCW management guidelines prepared at the state level suffered from internal incoherencies; did not specify detailed procedures; did not incorporate the state HCW management strategies; and were inconsistent in some respects with the Biomedical Waste Rules. In addition, the state-level guidelines were issued too late to assist health care facilities in meeting the implementation schedules prescribed in the Biomedical Waste Rules. A positive development is that CPCB recently issued two new sets of guidelines that were prepared taking into account the findings of a national survey of health care facility incinerators in India, views of the national experts based on experiences regarding the incineration technology and CWTFs, and related international experience. One set of guidelines issued by CPCB pertains to the treatment of BMWs at CWTFs (CPCB, n.d.-a), and the other pertains to the design and construction of BMW incinerators (CPCB, n.d.-b).
- **Many approaches and tools are necessary to inform opinions and change actions.** Notification and implementation of India's 1998 Biomedical Waste Rules were instrumental in raising awareness in India about the health risks and good management practices of HCWs among the health care facility personnel; government officials at the central, state, and local levels; and the general public. NGOs in India have played an important role in guiding the policymakers through situation analyses, sharing international experiences, creating awareness of HCW management issues among the general public, conducting training related to HCW management, and providing consulting services to health care facilities. In addition, the HCW management information presented by the media (television, radio, newspapers) and by SPCBs through the Internet has raised public awareness. National and regional workshops, along with training programs, have been instrumental in creating awareness of and sharing knowledge about HCW management among the government officials, the scientific community, and personnel at health care facilities.
- **Hospitals can change their culture and improve HCW management practices.** The culture at many health care facilities in India has changed to recognize the importance of hygiene and HCW management as essential to good hospital management practices. This culture change is attributable in part to assistance provided to government hospitals by state health departments (in part through World Bank–financed projects) in the form of personnel training, HCW management auditing, preparation of hospital-specific plans, procurement of materials and supplies, and construction of on-site disposal facilities. The application of a "train the trainers" approach was beneficial in imparting a leadership role for key hospital staff and obtaining their commitment to implement the HCW management programs at the health care facilities. It is important to note, however, that even though health care facilities have made progress, there is still room for improvement in bringing HCW management to the attention of medical officers and doctors, enhancing hospital-specific plans, and conducting refresher training so that health care facility staff can fully internalize these plans. Private hospitals in India, which must comply with the requirements of the Biomedical Waste Rules using their own resources, have had mixed results in terms of changing their culture and improving HCW management practices.
- **The private sector's role in on-site HCW management is becoming increasingly important.** The private sector's involvement in providing on-site HCW management services has gained importance in the Indian health sector since implementation of the Biomedical Waste Rules and subsequent changes in culture at health care facilities. Some government hospitals have contracted with private sector organizations for on-site waste management services previously performed by health care facility staff. So far, the

experience of using private contractors has yielded significant improvements in the overall sanitary conditions for health care facility staff and a positive change in public opinion. Some resistance during the privatization process may be expected from health care facility staff concerned about losing their jobs.

- **Effective state strategies for CWTFs, with private sector involvement, are emerging.** Management of BMWs at a CWTF has recently become an integral part of a state HCW management strategy in some states in India. The credit for spurring this development goes to state officials in Andhra Pradesh. That state's success in convincing health care facility representatives to pay for off-site treatment and disposal of BMWs at a privately built, owned, and operated CWTF has led other states to emulate its approach. A similar CWTF approach to HCW management has been adopted in Karnataka, Maharashtra, Punjab, Rajasthan, Tamil Nadu, and there are now plans for CWTFs in Gujarat (in Surat), Kerala, New Delhi, Uttar Pradesh (in Noida), and West Bengal (in Howrah). In most states, the CWTF scheme serves only health care facilities at selected urban areas; in Kerala, however, it serves all health care facilities in the entire state, both urban and rural. In Sewri, Maharashtra, a charge system to health care facilities based on BMW weight (that is, Rs./kg) has resulted in nearly a 50 percent reduction in the expected amount of BMWs received at the CWTF. This experience illustrates the importance of selecting the most appropriate structure for waste charges to facilitate the flow of properly segregated BMWs to CWTFs. India's recent experience with CWTFs is also reflected in CPCB's two recently issued sets of draft guidelines: one set bringing close scrutiny to on-site incineration at health care facilities and the other detailing requirements for CWTFs for BMWs.
- **Strong and clear regulatory commitment improves implementation of the Biomedical Waste Rules.** SPCBs in the states and Pollution Control Committees in the territories are the regulatory agencies in India responsible for enforcing the requirements of the Biomedical Waste Rules. The capacity of these agencies to act—and their determination to do so—has made a major difference in the effectiveness of implementing the Biomedical Waste Rules. In Maharashtra, about 98 percent of health care facilities that submitted permit applications in 2001 did not have proper BMW treatment schemes in place. As compliance with the Biomedical Rules by health care facilities lagged and no drastic measures were taken by SPCBs, the implementation schedule specified in the Biomedical Waste Rules was amended. In Andhra Pradesh, the SPCB announced its tough stand of fines to noncompliant health care facilities, and a trickle of permit applications grew into a stream of permit applications, although the level of compliance was still unsatisfactory.
- **Information technology has a crucial role to play in HCW management.** Information technology has great potential for creating public awareness of HCW management issues and for sharing knowledge about HCW management practices at health care facilities. Currently, CPCB uses its Web site to present the draft guidelines on incinerators and CWTFs. In addition, some SPCBs—including the Andhra Pradesh Pollution Control Board and the Karnataka Pollution Control Board—use their Web sites to disseminate information on HCW management, including lists of permitted health care facilities and downloadable HCW permit application forms. Information technology has the potential to be used more extensively at the central environmental agencies for disseminating information on national programs (for example, training programs, workshops, symposia) or coordinating BWM management activities in states (for example, compliance status, research programs, and national database compiled from state-level health care facility, CWTF, and BMW-related information). Information technology also has the potential to be used at the state level to increase public awareness of regulatory requirements, environmental concerns, technology options, and good management practices; to publicly disclose information about permits for health care facilities and CWTFs; to provide health care facilities with downloadable permit forms; and to offer news about state training programs, workshops, conferences, best practices, and close-to-expiration medicine exchange programs among health care facilities.

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APPENDIX A

India's Health Care Waste Management Practices and Requirements

No.[1]	*Waste Category Type*	*Examples*	*Waste Management Practices in Five States*					*Waste Management Requirements/Guidelines*	
			Karnataka	*Punjab*	*Andhra Pradesh*[2]	*West Bengal*	*Maharashtra*	*India's Biomedical Waste Rules*[3]	*WHO Guidelines (Prüss, Giroult, and Rushbrook 1999)*
	Communal waste	Recyclable: paper,cardboard material, metal tins/cans	Sold for recycle	Sold for recycle	Collected by municipality for landfilling	Sold for recycle	Secured landfilling	Not a biomedical waste	
		Nonrecyclable: kitchen waste	Worm composting pit	Collected by municipality	Collected by municipality for landfilling	Urban areas: collected by municipality for landfilling Rural areas: composting at hospital premises for gardening			
		Color of bag/ container	White	Green	Black	Black	Green		Black
1	**Human anatomical waste**	Human tissue, organs, body parts	Deep burial	Deep burial	In Twin Cities: Incineration/ Deep burial (only for fetuses) In rural areas: Deep burial	Urban areas: incineration Rural areas: deep burial at hospital premises	Incineration/ deep burial	Incineration/deep burial (only in cities with population less than 500,000 and in rural areas)	Incineration/ Safe burial at hospital premises
		Color of bag/ container	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow

No.[1]	Waste Category Type	Examples	Waste Management Practices in Five States					Waste Management Requirements/Guidelines	
			Karnataka	Punjab	Andhra Pradesh[2]	West Bengal	Maharashtra	India's Biomedical Waste Rules[3]	WHO Guidelines (Prüss, Giroult, and Rushbrook 1999)
3	**Microbiology and biotechnology waste**	Laboratory cultures, stocks, or specimens of micro-organisms; live vaccines, cell cultures	Deep burial			Disinfected[4] solids are put in the red bin with infectious wastes, and liquids are discharged into the sewer	Autoclaving/ Microwaving/ Chemical treatment	Autoclaving/Microwaving/—Red bag Incineration—Yellow bag	Incineration/ Chemical disinfection/ Autoclaving/ Microwaving/ Safe burial at hospital premises/ Sanitary landfill
		Color of plastic bag/container	Yellow			Red	Red	Red/Yellow	Brown
4	**Waste sharps**	Needles, syringes, scalpels, blades, broken glass, slides	Needle destruction/ Disinfection with 1% sodium hypochlorite/ Recycling (sold to a recycler)	Needle destruction/ Needles and other sharps are put in a container for deep burial at hospital premises. Syringes are disposed with Category 6 wastes	Needle destruction/Disinfection with 1% sodium hypochlorite solution for 1 hour, then disposal in a safe pit	Needle destruction/Disinfection with a bleach solution, and solids are placed in a box for deep burial at municipal landfill	Autoclaving/ Chemical treatment/ Recycling	Disinfection by chemical treatment/ Autoclaving/Microwaving and mutilation/Shredding	Incineration/ Chemical disinfection/Autoclaving/ Microwaving/ Encapsulation/Safe burial at hospital premises
		Color of plastic bag/container	Blue	White	Translucent PPC[5]	Cardboard box put in blue bag	Transparent blue PPC	Blue/White translucent PPC	Yellow PPC
5	**Discarded medicines and cytotoxic drugs**	Wastes comprising outdated, contaminated and discarded medicines	Engineered landfilling	Disposal in the sharps-pit in hospital premises	Landfilling	Return to supplier	Incineration/ Secured landfilling	Incineration/ Destruction, and drugs disposal in secured landfills	—Small quantities may be collected with infectious waste. —Large quantities should be returned to pharmacy for disposal.
		Color of plastic bag/container	Black		Black		Black	Black	

No.[1]	Waste Category Type	Examples	Waste Management Practices in Five States					Waste Management Requirements/Guidelines	
			Karnataka	Punjab	Andhra Pradesh[2]	West Bengal	Maharashtra	India's Biomedical Waste Rules[3]	WHO Guidelines (Prüss, Giroult, and Rushbrook 1999)
6	**Soiled waste**	Items such as cotton, dressings, soiled plaster casts, linens, and bedding contaminated with blood or body fluids	Deep burial	Disinfection and collection by municipality	In Twin Cities: incineration at CWTF In rural areas: deep burial	Autoclave if available. Urban—deep burial at municipal landfill Rural—deep burial at hospital premises	Autoclaving/ Microwaving/ Chemical treatment	Incineration—Yellow Autoclaving/Microwaving—Red	Incineration/Safe burial at hospital premises
		Color of plastic bag/ container	Yellow	Red	Yellow	Red	Red	Yellow/Red	Yellow
7	**Solid waste**	Wastes from disposable items such as other than sharps (for example, tubing, catheters, blood bags)	Disinfection/ mutilation/ Recycling	Mutilation, disinfection, and sanitary landfilling by municipality	In Twin Cities: Shredding/Autoclaving at CWTF In rural areas: Destruction/Disinfection with a bleaching powder solution/ Recycling	Autoclaving if available. Urban—disposal in a municipal burial pit Rural—deep burial at hospital premises	Autoclaving/ Microwaving/ Chemical treatment/ Recycling	Disinfection by chemical treatment/ Autoclaving/Microwaving and mutilation/shredding	Incineration/ Chemical disinfection/Microwaving/ Safe burial on hospital premises/ Sanitary landfilling
		Color of plastic bag/container	Blue	Red	Red	Red	Blue	Blue/White translucent PPC/ Red	Yellow
8	**Liquid waste**	Waste generated from laboratory and washing, cleaning, housekeeping, and disinfecting activities		Disinfection by chemical treatment and discharge into drains	Disinfection by chemical treatment and discharge into drains		Will be collected in leak-proof buckets and neutralized before discharge into drains.	Disinfection by chemical treatment and discharge into drains	

No.[1]	Waste Category Type	Examples	Waste Management Practices in Five States: Karnataka	Punjab	Andhra Pradesh[2]	West Bengal	Maharashtra	Waste Management Requirements/Guidelines: India's Biomedical Waste Rules[3]	WHO Guidelines (Prüss, Giroult, and Rushbrook 1999)
9	**Incineration ash**	Ash from incineration of any biomedical waste			Disposal of incineration ash from Category 6 wastes in a secured landfill		Will be collected in bags for disposal in secure landfill	Disposal at a municipal landfill black plastic	
10	**Chemical waste**	Chemical used in production of biologicals; chemical used in disinfection, as insecticides		Neutralize and discharge into drains			Will be collected in black plastic bags for disposal in secure landfills.	Chemical treatment and discharge into drains for liquids; secured landfilling for solids	

Source: Onursal and Setlur 1992.

1. Waste Category Type 2: Animal wastes—not addressed by health care facilities surveyed and not included in this assessment.
2. Information obtained from GJ Multiclave (India) Pvt. Ltd., a common waste treatment facility in Hyderabad.
3. Notes for India's Biomedical Waste Rules:
   - Chemical treatment using at least 1 percent hypochlorite solution or any other equivalent chemical reagent.
   - Mutilation/shredding should prevent unauthorized reuse.
   - There will be no chemical pretreatment before incineration. Chlorinated plastics shall not be incinerated.
   - Deep burial shall be an option available only in towns with population less than 500,000 and in rural areas.
4. The laboratory glass waste and the biological material after the laboratory tests are decontaminated by complete immersion in a 10 percent bleach solution and left to stand overnight. The following morning, the decontaminated solids in the bucket are put in the red bin, and the liquid is discharged to the sewer.
5. PPC: puncture-proof container.

APPENDIX B

Results of Health Care Waste Audits for Government Hospitals in Three States

HCW Audit Results in Karnataka Hospitals

	100 beds		*50 beds*		*30 beds*	
Health care waste (HCW)	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*
Biomedical waste (BMW)	321.0	18.7	129.4	56.3	91.1	47.6
Plastics	108.9	6.3	39.1	17.0	8.8	4.6
Sharps	81.9	4.8	14.8	6.4	24.7	12.9
Infectious waste	130.2	7.6	75.5	32.9	57.6	30.1
General (communal) waste	1,400.0	81.3	100.4	43.7	100.1	52.4
Total HCW	**1,721.0**	**100.0**	**229.8**	**100.0**	**191.2**	**100.0**
No. of days audited	31		29		31	
Bed occupancy (%)	72		72		46	
Kg/day						
BMW	10.4		4.5		2.9	
HCW	55.5		7.9		6.2	
Kg/day/bed						
BMW	0.10		0.09		0.10	
HCW	0.56		0.16		0.21	
Kg/day/occupied bed						
BMW	0.14		0.13		0.21	
HCW	0.77		0.22		0.45	

HCW Audit Results in Maharashtra Hospitals

	561 beds		*426 beds*		*406 beds*		*384 beds*		*272 beds*		*241 beds*		*202 beds*		*127 beds*	
Health care waste (HCW)	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*
Biomedical waste (BMW)	1,665.8	54.4	1,755.3	41.1	1,055.4	43.5	1,091.3	47.4	2,609.5	77.8	1,556.9	32.3	2,399.7	62.1	1,217.0	40.2
Plastics	482.6	15.7	806.8	18.9	181.1	7.5	97.5	4.2	873.5	26.1	636.2	13.2	233.7	3.7	284.8	9.4
Sharps	210.0	6.9	44.9	1.1	187.6	7.7	141.4	6.2	290.0	8.6	314.9	6.6	288.0	4.5	288.5	9.5
Infectious waste	973.2	31.8	903.6	21.1	686.7	28.3	775.8	33.7	1,446.0	43.1	599.0	12.4	1,878.0	29.7	643.7	21.3
Pharmaceutical waste	0.0	0.0	0.0	0.0	0.0	0.0	76.6	3.3	0.0	0.0	6.8	0.1	0.0	0.0	0.0	0.0
General (communal) waste	1,396.2	45.6	2,517.0	58.9	1,371.6	56.5	1,211.6	52.6	745.0	22.2	3,268.0	67.7	3,931.0	37.9	1,812.0	59.8
TOTAL HCW	**3,062.0**	**100.0**	**4,272.3**	**100.0**	**2,427.0**	**100.0**	**2,302.9**	**100.0**	**3,354.5**	**100.0**	**4,824.9**	**100.0**	**6,330.7**	**100.0**	**3,029.0**	**100.0**
No. of days audited	30		26		30		30		30		30		30		30	
Bed occupancy (%)	64		101		96		78		100		75		80		136	
Kg/day																
BMW	55.5		67.5		35.2		36.4		87.0		51.9		80.0		40.6	
HCW	102.1		164.3		80.9		76.7		111.8		160.8		211.0		101.0	
Kg/day/bed																
BMW	0.10		0.16		0.09		0.09		0.32		0.22		0.40		0.32	
HCW	0.18		0.39		0.20		0.20		0.41		0.67		1.04		0.80	
Kg/day/occupied bed																
BMW	0.15		0.16		0.09		0.12		0.32		0.29		0.50		0.24	
HCW	0.28		0.38		0.21		0.26		0.41		0.89		1.31		0.58	

HCW Audit Results in Maharashtra Hospitals, Cont.

	46 beds		*30 beds*		*30 beds*		*30 beds*		*30 beds*		*30 beds*	
Health care waste (HCW)	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*
Biomedical waste (BMW)	252.3	73.78	252.8	53.1	117.2	31.1	203.3	74.7	55.0	73.3	280.5	57.1
Plastics	74.2	21.7	86.5	18.2	25.0	6.6	37.0	13.6	4.0	5.3	36.0	7.3
Sharps	89.7	26.2	56.0	11.8	35.0	9.3	22.0	8.1	23.0	30.7	15.0	3.0
Infectious waste	88.4	25.9	110.0	23.1	57.0	15.1	144.0	52.9	28.0	37.3	229.5	46.8
Pharmaceutical waste	0.0	0.0	0.3	<0.1	0.2	<0.1	0.3	0.1	0.0	0.0	0.0	0.0
General (communal) waste	89.6	26.2	223.0	46.9	260.0	68.9	69.0	25.3	20.0	26.7	210.4	42.9
Total HCW	**341.9**	**100.0**	**475.8**	**100.0**	**377.2**	**100.0**	**272.3**	**100.0**	**75.0**	**100.0**	**490.9**	**100.0**
No. of days audited	29		30		30		30		30		30	
Bed occupancy (%)	72		70		100		60		55		63	
Kg/day												
BMW	8.7		8.4		3.9		6.8		1.8		9.4	
HCW	11.8		15.9		12.6		9.1		2.5		16.4	
Kg/day/bed												
BMW	0.19		0.28		0.13		0.23		0.06		0.31	
HCW	0.26		0.53		0.42		0.30		0.08		0.55	
Kg/day/occupied bed												
BMW	0.26		0.40		0.13		0.38		0.11		0.50	
HCW	0.36		0.76		0.42		0.50		0.15		0.87	

HCW Audit Results in West Bengal Hospitals

	520 beds		*500 beds*		*498 beds*		*381 beds*		*195 beds*		*195 beds*		*100 beds*		*30 beds*	
Health care waste (HCW)	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*
Biomedical waste (BMW)	131.9	37.6	155.6	36.7	154.1	37.8	109.8	37.1	87.0	39.1	93.0	40.3	42.3	27.8	4.8	29.0
Plastics	5.3	1.5	7.6	1.8	9.4	2.3	5.3	1.8	3.6	1.6	4.2	1.8	1.4	0.9	0.2	1.4
Sharps	3.9	1.1	3.8	0.9	4.9	1.2	2.7	0.9	2.4	1.1	1.2	0.5	0.5	0.3	0.1	0.7
Infectious waste	113.0	32.2	132.3	31.2	133.3	32.7	98.0	33.1	74.9	33.7	82.6	35.8	36.8	24.2	3.9	23.3
Human anatomical waste	9.8	2.8	11.9	2.8	6.5	1.6	3.8	1.3	6.0	2.7	5.1	2.2	3.6	2.4	0.6	3.6
General (communal) waste	219.0	62.4	316.5	63.3	253.6	62.2	186.2	62.9	135.4	60.9	137.7	59.7	109.7	72.2	11.9	71.0
Total HCW	**350.9**	**100.0**	**424.1**	**100.0**	**407.7**	**100.0**	**296.0**	**100.0**	**222.4**	**100.0**	**230.7**	**100.0**	**152.0**	**100.0**	**16.7**	**100.0**
No. of beds	520		500		498		381		195		195		100		30	
No. of days audited	3		3		3		3		3		3		3		3	
Bed occupancy (%)	55		67		89		73		93		113		89		53	
Kg/day																
BMW	44.0		51.9		51.4		36.6		29.0		31.0		14.1		1.6	
HCW	117.0		141.4		135.9		98.7		74.1		76.9		50.7		5.6	
Kg/day/bed																
BMW	0.08		0.10		0.10		0.10		0.15		0.16		0.14		0.05	
HCW	0.23		0.28		0.27		0.26		0.38		0.39		0.51		0.19	
Kg/day/occupied bed																
BMW	0.15		0.15		0.12		0.13		0.16		0.14		0.16		0.10	
HCW	0.41		0.42		0.31		0.35		0.41		0.35		0.57		0.35	