Literature Review
Waste disposal is an activity, which if not done properly, can cause great problems to the waste handlers and to the general public. The disposal of solid waste affects the air, the water and the land. Many sanitary districts and sewer boards are setting limits on the amounts of toxic agents that can be discharged into sewers, as toxic agents may have a damaging effect on the operation of the sewage treatment plants. One of the major hazards in disposing waste onto land, is the possibility of polluting ground water, one of our most valuable natural resources. Groundwater pollution is more serious than surface water pollution as groundwater is in a relatively pure state requiring very little or no treatment to be usable as drinking water and it takes a long time for the polluted ground water to regain its original quality. There are many concerns with the disposal of waste in sanitary landfills also. A significant factor when dealing with sanitary landfills is whether or not the pathogenic microorganisms can percolate into the ground water. Chemical contamination of groundwater with leachates or gases is another possible environmental hazard of sanitary landfills. Gas production can lead to explosions. The choice of disposal method is often based on cost considerations only, but along with it the environmental effects of disposal and local environmental conditions should be weighed, when a disposal method is chosen (DeRoos, 1974).

In the case of disposal of biomedical waste, the problems are manifold since in addition to the general problems of waste disposal, biomedical waste has severe effects on the health of workers and the environment due to the presence of virulent forms of microorganisms and extremely toxic chemicals or radioactive material.

Environmental and Health Effects of Biomedical Waste

Adverse impacts of Bio-medical waste are:

A. Environmental:

- Water pollution e.g. contamination of drinking water source
- Soil pollution e.g. non-biodegradable waste put in landfills
- Air pollution e.g. incinerator emissions – dioxins & furans
- Public sensitivity – Unaesthetic and Offensive
B. Health:

- Injuries due to:
  - Physical - 'Sharps'
  - Chemical - Toxic, corrosive, flammable and reactive chemicals
- Infections: Occupational hazards for healthcare professionals - Hospital acquired infections

(i) Waste water from HCEs:

A variety of studies have been undertaken on the deleterious effects of waste water from healthcare establishments. For instance, the incidence of enteric communicable diseases in 77 kibbutzim (agricultural communal settlements) practicing wastewater spray irrigation with partially treated non-disinfected hospital oxidation pond effluent was compared with that in 130 kibbutzim practicing no form of wastewater irrigation. The incidence of shigellosis, salmonellosis, typhoid fever, and infectious hepatitis is two to four times higher in communities practicing wastewater irrigation. No significant differences were found for the incidence of streptococcal infections, tuberculosis, and laboratory-confirmed cases of influenza. Nor were differences found for enteric disease rates during the winter non-irrigation season. Strong wastewater treatment measures, including effective bacterial and viral inactivation through disinfection, are recommended for all cases of sewage irrigation or land disposal near residential areas in light of the potential public health risks involved (Katzenelson, 1974).

R plasmids have been demonstrated in several group of strains of enterobacteriaceae from hospital environment. R+ enteropathogenic strains of Escherichia coli were isolated from several items of baby-care as well as from the pre-prepared baby food in a newborn unit. Strains from environmental samples were thought to be identical with those causing nosocomial gastroenteritis of babies. From hospital waste waters of another larger country hospital, R+ strains of Salmonella typhimurium and R+ protei were isolated, both associated with occurrence of gastrointestinal or urological hospital infections. R-factor-carrying strains of E. coli have been isolated also from surface water samples from the area surrounding the hospital monitored (Prikazsky, 1978).
**Pseudomonas aeruginosa** was recovered (in numbers ranging from $10^2$ to $10^5$ colony forming units/mL) from heavily contaminated hospital waste water when grown at 41.5 degrees C on a differential medium agar containing 9-chloro-9-(4-diethylaminophenyl)-10-phenylacridan (C-390) at a final concentration of 30 micrograms/mL. The medium appeared to be highly selective for *P. aeruginosa* with 95-100% of all colonies isolated from four different hospital waste waters being identified as *P. aeruginosa*. Many strains of *P. aeruginosa* isolated from hospital waste waters failed to hydrolyse casein when grown on skim milk agar and this medium appeared to restrict pigment production to only pyoverdin (detectable only under ultraviolet light). However, most strains were capable of casein hydrolysis when grown on a modified skim milk medium (Havelaar, 1986).

Hospital sewage is distinct both from that of industrial origin and that from human housing, and is unique from the qualitative and quantitative standpoints. In fact the hospital is clearly different from a residential setting for the addition of technological activities, which are realized inside it, and it is not comparable to a traditional productive complex, because of the extreme variability—from one hospital to the other—of the presence of activities themselves, and this means important qualitative differences of sewage produced from case to case. After all, the hospital cannot be compared to a centre of tertiary activities, which has, as regards sewage, the characteristics and the constancy of great inhabited places (Fara, 1989).

The classification of hospital-wastes into categories, infectious or special waste, is significant for the prevention of nosocomial infection within and outside the hospitals. Solely infectious waste is removed through secure packing and transported out for combustion or disinfection. Special wastes have to be treated under special conditions. The hygienist of the hospital classifies the wastes in the hospital and arranges for its disposal. However, effluents from hospitals escape such scrutiny and end up carrying infectious microorganisms into the environment (Knoll, 1990).

The genotoxic potential of the waste water of a hospital in Zurich, Switzerland, was evaluated by the umuC test. Within 2 years, over 800 waste water samples were analysed. Genotoxic activity was found in 13% of the samples. The highest genotoxic activity
occurred in the morning hours, but genotoxic samples were detected also during the day and at night. Ninety six percent of the genotoxic waste water samples revealed a genotoxic potential without growth inhibition of test bacteria monitored as D600, in the same way as antineoplastic drugs like mitomycin C or cisplatin. Four percent of the genotoxic waste water samples showed combined cytotoxic and genotoxic activities as seen in control experiments using glutaraldehyde containing disinfectants and certain antibiotics (Giuliani, 1996).

The mutagenic and carcinogenic antineoplastic agent cyclophosphamide (CP) is released into sewage water by cancer patient excretion. To assess the biological degradability of CP, two standardized test systems, the Zahn-Wellens/EMPA test (OECD 302B) and a laboratory scale sewage treatment plant, were used. In both test systems the agent exhibited only poor degradability. To verify the expected occurrence of CP in hospital sewage, water samples were analyzed for CP with GC/MS after enrichment by solid-phase extraction. CP could be detected in concentrations ranging from 20 ng/L to 4.5 micrograms/L. The occurrence of the agent could also be proved in samples from the influent and the effluent of the communal sewage treatment plant into which the hospital's sewage water was shed. Concentrations ranged from 7 to 143 ng/L. In an attempt to assess the contribution of CP to the genotoxicity detected in hospital waste water in a recent study, the effects of CP in the umuC test, a bacterial genotoxicity assay, were investigated. However, no genotoxic effects of CP were found up to concentrations of 1 g/L (Steger-Hartmann, 1997).

The sludge from hospital waste treatment facilities is a potential source of infectious organisms. The average numbers of micro-organisms in the sludge of hospital wastewater in Taiwan were as follows: total count $8.1 \times 10^7$ cfu g$^{-1}$ (dry weight of sludge), and $1.4 \times 10^6$, $3.6 \times 10^5$, $1.6 \times 10^5$, $2.2 \times 10^5$ and $5.5 \times 10^4$ cfu g$^{-1}$ (dry weight of sludge) for total coliforms, faecal coliforms, faecal streptococci, Pseudomonas aeruginosa and Salmonella spp., respectively. Salmonella spp. were detected in 37% (10 of 27) of the sludges from hospital wastewaters in China. Therefore, the treatment of such sludge to reduce pathogenic micro-organisms should be considered (Tsai et al, 1998).
The possible increase of antibiotic-resistant bacteria in sewage associated with the discharge of wastewater from a hospital and a pharmaceutical plant was investigated by using Acinetobacter species as environmental bacterial indicators. The level of susceptibility to six antimicrobial agents was determined in 385 Acinetobacter strains isolated from samples collected upstream and downstream from the discharge points of the hospital and the pharmaceutical plant. Results indicated that while the hospital waste effluent affected only the prevalence of oxytetracycline resistance, the discharge of wastewater from the pharmaceutical plant was associated with an increase in the prevalence of both single- and multiple-antibiotic resistance among Acinetobacter species in the sewers (Guardabassi, 1998).

Most antibiotics are metabolized only incompletely by patients after administration, and enter the municipal sewage with the patients' excretions. Little is known about their biodegradability in aquatic environments and their role with respect to growing bacterial resistance. Theoretical concentrations of the test substances in hospital effluents were calculated and compared with minimum inhibitory concentrations for susceptible pathogenic bacteria in Freiburg, Germany. None of the test compounds met the criteria for ready biodegradability. Only penicillin G was biodegradable to some degree (27%), even when the test was prolonged from 28 to 40 days (35%). CFU monitoring revealed high toxicity for sulfamethoxazole, whereas ciprofloxacin had a weak but significant effect; only for meropenem a weak but significant effect was measured in the toxicity control of the closed bottle test (CBT). MIC50 published for susceptible pathogenic bacteria were for all compounds in the same range as the concentrations expected for hospital effluents. Therefore, antibiotic drugs emitted into municipal sewage may affect the biological process in sewage treatment plants (STPs), and they may persist in the aquatic environment and contribute to the increasing resistance of pathogenic bacteria. (Al-Ahmad et al, 1999).

(ii) Toxic emissions from biomedical waste incinerators:

In 1993, the citizens of Columbus, Ohio, who were aroused by anecdotal reports of an increase in rare neurological symptoms and other illnesses, including cancer, in the vicinity of a 2000 ton per day incinerator, discovered that measurements made at the facility in 1992, but not reported to the public, indicated that nearly 1000 grams of dioxin
Toxic Equivalents (TEQs) were being emitted from the facility annually (Connette et al, 1994). However, USEPA reported at Dioxin '93, that the total quantity of dioxin emitted from all the US trash incinerators combined (about 130 at that time) was between 60 and 200 grams of dioxin TEQs (Schaum et al, 1993), which was less than the single Columbus incinerator by itself. Furthermore, the Ohio health department reported that a 1000 gram dioxin level (about one half of a Seveso accident) falling annually on their heads and surrounding areas, posed no health problems (Ohio EPA, 1994).

There is possibility of a tremendous risk to individual and environment from improper disposal or handling of hospital waste. Direct risks concern mainly the workers in this field and thus the need to be protected from the waste arises. Incineration was suggested to be the ideal method to dispose hospital waste, but at the same time the technical knowledge about the process and its products was said to be very essential. The incinerator emits 1000 times dioxins that incineration of hazardous wastes are allowed to emit. This can pose serious health consequences to those living, working and playing near the hospital smoke stacks. Equally serious is the threat posed by the medical incinerator ash (Shishoo et al, 1997).

In Japan, as a result of growing concern about the dioxin problem there, the government in 1997 limited the total dioxin emissions (i.e. air emissions plus fly ash plus bottom ash) to 5 micrograms of dioxin International Toxic Equivalents (I-TEQ) per metric ton of trash burned. This will require the fly ash from Japanese incinerators to be vitrified, which will still further escalate the costs of incineration (Abe et al, 1997; Sakai et al, 1997). Thus, even with the best designed incinerators, the public is still hostage to how well they are operated, maintained and monitored over their lifetime of 20 years or more. (Connett, 1998).

While industry spokespersons frequently argue that dioxin emissions are extremely low (especially when compared to conventional pollutants), the counter argument is to note that dioxins interfere with several hormonal systems, in which the hormones function in human tissues at parts per trillion levels. The risk of getting cancer from dioxin is 10 times higher than reported in 1994. The EPA now considers dioxin to be “carcinogenic to humans”. Dioxin’s adverse effects seems to occur at the most basic cellular level. Dioxin
alters the way genes function, turning them on or off at the wrong times or for too short or too long a time period. EPA states that “The lack of clear indication of disease in the general population attributable to dioxin-like compounds should not be considered strong evidence for no effects of exposure to dioxins. Rather a lack of clear indication of disease may be the result of the inability of our current data and scientific tools to directly detect effects at these levels of exposure” (Stop Dioxin Exposure Campaign, 2000).

According to the Biomedical Waste (Management and Handling) Rules, 1998, promulgated by the Govt. of India, it is illegal to incinerate chlorinated plastics (like PVC) and waste chemically treated with any chlorinated disinfectant. The ban on incineration of chlorinated products is to stop formation and emission of dioxins, one of the most toxic substances known to human beings (Toxics dispatch, 2002).

(iii) Infectious sharps and other waste from HCEs:
There have been reported cases of staphylococcal bacteraemia and endocarditis among housekeeping staff after a needle injury. In France in 1992, eight cases of HIV infection were recognized as occupational infections. Two of these cases, involving transmission through wounds, occurred in waste handlers. In USA, in June 1994, 39 cases of HIV infection were recognized by the Centers for Disease Control and Prevention as occupational infections, with the following pathways of transmission:

- 32 from hypodermic needle injuries
- 1 from blade injury
- 1 from glass injury (broken glass from a tube containing infected blood)
- 1 from contact with non-sharp infectious item
- 4 from exposure of skin or mucous membranes to infected blood.

By June 1996, the cumulative recognized cases of occupational HIV infection had risen to 51. All cases were nurses, medical doctors, or laboratory assistants. Viral hepatitis B infections caused by occupational injuries from sharps (USA) – waste workers outside hospital:

| Annual number of people injured by sharps | 500 – 7300 |
| Annual number of HBV infections caused by injury | 1 – 15 |
In any healthcare establishment, nurses and house-keeping personnel are the main groups at risk of injuries; annual injury rates are 10-20 per 1000 workers. Highest rates of occupational injury among all workers who may be exposed to health-care waste are reported by cleaning personnel and waste handlers; the annual rate in USA is 180 per 1000 (WHO, 1999a).

As regards HBV, the magnitude of the problem (no. of cases) is more severe. In Japan in 1987, 2 interns (pediatrics) died of acute Hepatitis B. In USA, 26 - 45 nurses died of acute hepatitis outside hospital and 56-96 died inside hospitals annually. Besides these, 23-91 cases of hospital housekeepers, 24 cases of hospital technicians & EMT, 1-15 cases of waste handlers outside hospitals, 2-15 cases of lab personnel, 1 – 3 cases of physicians, 800 workers in 1995 have been documented of whom 30 - 50% developed symptoms and sero-conversion and 5 – 105 developed chronic active Hepatitis. Annually 162 – 321 were thus affected. Survival of HBV is very persistent in dry air and can do so for several weeks on a surface. It remains viable for 10hrs at 60 degrees Celsius and survives upto 7 days in a blood droplet inside syringe/needle. Risk of infection after needle stick injury - ROT to susceptible Health Care Workers (HCWs) is 6 – 30% after single needle stick exposure. HCWs who are immunized are not at risk. Post Exposure Prophylaxis (PEP) with HB Ig & HB vaccine is 90% effective. However, Pre-Exposure Prophylaxis with HB Vaccine is essential (WHO, 1999b).

Disposal of sharp instruments and needles ("sharps") is an ongoing problem in the emergency department (ED). Cleanup and disposal of needles and other sharps after a procedure is the responsibility of all ED personnel, including physicians. In a medical centre in USA, all techniques were designed to be done (1) without exposing the physician to a needle stick, (2) with equipment readily available in the ED, and (3) with containers readily seen by those disposing of the sharps and other materials. Adherence to these cleanup procedures helped lessen the problem of sharps and disease exposure in the ED (Zimmers, 1999).

The epidemic of HIV infections in Thailand has alarmed the medical profession in that country. The endemic hepatitis B infection also shows no decreasing trends. These two viral infections alone warrant the proper implementation, to prevent the spread. Therefore
the protocol for disposal of sharp items in all hospitals has been made stricter. It has been recommended that patients who are at risk and need blood-body fluid precautions are to be listed and only disposable needles, syringes and gloves are recommended to be used for these patients. Used gloves then must be disinfected in 0.5% hypochlorite solution for 30 minutes and mutilated before discarding into ordinary bags. High efficiency incinerators were recommended for the disposal of needles and syringes (The Hospital Infection, Control Group of Thailand, 1992).

HIV survives 3-7 days at ambient temperature, up to 8 days in syringe and needles. It survives 15 minutes when exposed to 70% ethanol and is inactivated at 56 degree Celsius. Retrospective case control study found risk to be higher when exposed to greater quantity of blood e.g. visibly bloody device, procedure of placing items in artery and deep injury. The risks of infection after needle stick injury as documented in the combined data of more than 20 prospective studies world-wide, are average transmission rate 0.3% per injury (WHO, 1999c).

The magnitude of problem of HCV in USA is that it is the most common blood-borne infection, affects approximately 4 million people, has prevalence in Healthcare workers (HCWs) equal to the general population (1-2%). Although, the exact number of occupationallly acquired HCVs is not known, it is known that 2-4% of total cases are due to exposure to blood in healthcare settings. They manifest often with no/mild clinical symptoms. They become a chronic infection in 75-85% patients and lead to active liver disease in 70% (10-20% Cirrhosis 1-5% CA). Survival of HCV is very high; an infected dose can survive up to 7 days in a droplet of blood in syringe/needle. Risk of infection after needle stick injury as documented in prospective studies shows sero-conversion rate 0 – 7%, mean sero-conversion rate – 1.8%. No vaccine is available currently. For Post Exposure Prophylaxis, no antiviral drugs and the Ig is not recommended. Recommendation is for early diagnosis, the method for which is rapidly evolving. Healthcare Workers (HCWs) with known exposure should have regular follow ups (WHO, 1999c).

A strong correlation between Hepatitis C infection and injection practices in Hafizabad, Pakistan community suggested that injection practices may have caused the spread. The
major cause of high frequency of infection is the belief that injections work faster and they are more powerful. A study conducted in Karachi, observing injection practices at 18 clinics in peri-urban areas have reported that 94% injections being administered were not safe. Infections to blood donors is at a rate of 9.7%. Risk of transmission of hepatitis C through HCV contaminated needles is around 6%. Similarly Egypt reported 40% hepatitis C infections attributed to unsafe injection practices (SIGN – WHO, 2001).

Documentation of needle-stick injuries was started in the Christian Medical College Hospital, Vellore in 1993. In 1995 large sharps containers were introduced, accompanied by an intensive education programme. Details of documented injuries from 1993 to 1999 were analysed using the Epi-Info software. A total of 347 injuries occurred, mainly due to improper disposal of needles, re-capping and carelessness during use. The percentage of injuries attributed to disposal fell from 69.2% in 1995 to 38.5% in 1996 (after the education programme). A further decrease was noted after the additional introduction of small sharps containers. In 1995, 73% of injuries involved housekeeping staff, this fell to 12% in 1998. Relatively simple interventions decreased the numbers of injuries, and it is recommended that all healthcare institutions should have a system of documenting needle-stick injuries, and take measures to decrease their incidence (Richard et al, 2001).

(iv) Hazardous chemical waste from HCEs:
The need for hazardous waste management in hospitals, the regulatory background, and insight into determining which hospital waste streams are hazardous or infectious, should be discussed thoroughly. The management of these waste streams including handling, packaging, storage procedures, and methods of disposal, need to be discussed along with those factors which need to be considered when choosing a disposal method (Kesner, 1986).

Public health and environmental impacts of mercury can be explained by the health care industry's extraordinary contribution of mercury pollution. A plan outlining simple, cost effective strategies to better manage, minimize and ultimately eliminate the use of mercury and mercury based products in health care settings has been put into practice in the US (Shaner, 1997).
A study has demonstrated that exposure of personnel to antineoplastic (cytotoxic) drugs, manifested by increased urinary levels of mutagenic compounds in exposed workers and an increased risk of abortion among those cleaning hospital urinals exceeded that of nurses and pharmacists; these individuals were less aware of the danger and took fewer precautions. The concentration of cytotoxic drugs in the air inside hospitals has been examined in a number of studies designed to evaluate health risks linked to such exposure (Pyy, 1988; Sessink, 1992).

It is well recognized that a large number of biological and chemical agents of diverse structural complexity, toxicity and persistence are present in many hospital and clinical environments. Exposure to some of these agents by both patients and staff and disposal of chemical and biological waste products are of global concern. One major area of concern is chemotherapy often employing a large array of anticancer drugs (cytostatic agents). Most of the cytostatic agents have carcinogenic, genotoxic and nephrotoxic properties and are also reproductive and developmental toxicants. The overall objective is the protection of the individual from chemical, biological and physical risks with emphasis on good practice and awareness of occupational hazards (Fishbein, 1998).

Genotoxicity related to waste anaesthetic gas exposure is controversial. Frequency of sister chromatid exchanges in peripheral lymphocytes of operating room personnel exposed to trace concentrations of isoflurane and nitrous oxide was investigated. Personnel were exposed to an 8-h time-weighted average of nitrous oxide 11.8 ppm and isoflurane 0.5 ppm. After exposure, sister chromatid exchange frequency was increased significantly (mean 9.0 (SD 1.3) vs 8.0 (1.4) in exposed and control personnel, respectively) (P < 0.05). It was concluded that exposure to even trace concentrations of waste anaesthetic gases may cause genetic damage comparable with smoking 11-20 cigarettes per day (Hoerauf et al, 1999).

In Brazil, one case of carcinogenic impact on the general population linked to exposure to radioactive hospital waste has been analysed and fully documented. While moving, a radiotherapy institute left a sealed radiotherapy source in its old premises. An individual who gained access to these premises removed the source and took it home. As a
consequence, 249 people were exposed, of whom several either died or suffered severe health problems (IAEA, 1988).

Radioactive contamination events in laboratories often occur either because of failure of intravenous apparatus or syringe mishandling. Lack of experience in the individual giving the injection, injection technique and most importantly radioactive syringe disposal problems arising due to unclear protocol and designation of duties are responsible for contamination and spread of radioactivity both inside and outside laboratories. A well-worked out 4-part plan consisting of a training programme, a closely inspected intravenous apparatus, a mobile radioactive waste container and a clear designation of duties for personnel along with a procedure protocol helped reduce radioactive contamination in Mayo clinic in Rochester, Minnesota, USA (Mosman, 1999).

(v) Infections from waste from HCEs:

*Staphylococcus aureus* was found in air samples collected from locations in the hospital served by the same ventilation system as in the area of the repackaging operation. The waste handling practices used in hospitals need to be reevaluated, and the definition of 'sick building syndrome' needs to be expanded beyond chemicals to include microorganisms. More research is needed to characterize bacteria in air and to determine the impact of airborne bacteria on human health (Brenniman et al, 1993).

The degree to which healthcare waste is safely handled is not known, but there is reason to believe that it is inadequately treated. Although not yet causing a significant portion of global ill health, apparent environmental links with the deadly emerging/re-emerging infectious diseases have created an urgent need to monitor and improve environmental conditions (WHO, 1997).

To determine the effectiveness of control measures for hospital acquired infection (HAI) by prevalence studies, National Hospital of Sri Lanka in Colombo (NHSL) designed a study design and method. Two prevalence surveys were undertaken, in October 1994 and in July 1997, after implementing infection control measures. The numbers of patients in the two studies were 2563 and 2865. The subjects were assessed for hospital acquired
infection through information obtained from case notes and by discussion with ward nursing and medical staff. The changes in infection control activities during this 3-year period included increasing the number of infection control nurses, educational programmes to health care workers at all levels, improvements in disposal of clinical waste, implementing published guidelines for use of antibiotics, cannula-site management and urinary catheter care. The prevalence of Hospital Acquired Infections (HAI) in the hospital decreased significantly \((p < 0.0001)\) from 13.5% in 1994 to 8.7% in 1997. A significant decrease \((p < 0.0001)\) in infection rates was observed in medical wards, but the decrease in surgical wards and the burns unit did not reach statistical significance. The intensive care units showed a weakly significant increase \((p < 0.05)\) of infection rate attributable to the large number of war injured who needed intensive care. The most significant reduction in rates of infection was seen in wound infection \((p < 0.001)\), respiratory infections \((p < 0.01)\) and in cannula site infections \((p < 0.001)\). It was concluded that implementation of infection control policies can have a significant impact on the prevalence of HAI, and their effectiveness could be measured by repeated prevalence surveys (Atukorala, 1998).

Infections caused by exposure to BMW:

<table>
<thead>
<tr>
<th>Type of infection</th>
<th>Causative organisms</th>
<th>Transm. Vehicle</th>
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<tbody>
<tr>
<td>• GI</td>
<td>Enterobacteria, V cholerae</td>
<td>Faeces/vomit</td>
</tr>
<tr>
<td>• Respiratory</td>
<td>TB, measles, S pneumoniae</td>
<td>Inhaled, secretion</td>
</tr>
<tr>
<td>• Bacteremia</td>
<td>Staph, Strepto, Kleb, Enterococcus</td>
<td>Blood</td>
</tr>
<tr>
<td>• Septicemia</td>
<td>Staphylococcus</td>
<td>Blood</td>
</tr>
<tr>
<td>• Genital</td>
<td>N gono, Herpes v</td>
<td>Genital sec.</td>
</tr>
<tr>
<td>• Ocular</td>
<td>Herpes v</td>
<td>Eye sec.</td>
</tr>
<tr>
<td>• Skin</td>
<td>Streptococcus</td>
<td>pus</td>
</tr>
<tr>
<td>• Meningitis</td>
<td>N meningitides</td>
<td>CSF</td>
</tr>
<tr>
<td>• Hmgic fever</td>
<td>Lassa, Ebola, Marburg</td>
<td>Blood, secretions</td>
</tr>
<tr>
<td>• AIDS</td>
<td>HIV</td>
<td>Blood, Sexual</td>
</tr>
<tr>
<td>• Viral Hep-A</td>
<td>HAV</td>
<td>Faeces</td>
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<tr>
<td>• Viral Hep-B,C</td>
<td>HBV &amp; HCV</td>
<td>Blood, body fluids</td>
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( WHO, 1999d).
In evaluating the survival or spread of pathogenic microorganisms in the environment, the role of vectors such as rodents and insects should be considered. This applies to management of health-care waste both within and outside health-care establishments. Vectors such as rats, flies and cockroaches, which feed or breed on organic waste, are well known passive carriers of microbial pathogens; their populations may increase dramatically where there is mismanagement of waste (WHO. 1999c).

(vi) Importance of education and training regarding biomedical waste:
In a study done in Italy, the epidemiological monitoring of injuries and exposure to potentially infected biological liquids constituted an indispensable premise for the elaboration of strategies meant to intervene and reduce the incidence. Using an epidemiological study relative to the period January 1, 1994 to December 31, 1998 and by the use of the register of injuries deposited with the Sanitary Director, Catanzero, the prevalence of injuries in the various professional categories, the working zones, the type and form of injury, the use of individual protection devices were analyzed. The analysis of the data showed poor risk perception by the sanitary workers and a lack of application of protective measures. It is evident that there is utmost need to sensitize the workers regarding the importance of preventive measures (Greco et al, 2000).

Training and education is not the requirement of the nursing and housekeeping staff alone although the incidence of injury and infection among these two categories of HCWs in HCEs is high. It was found that not necessarily knowledge but risk perception among doctors is low too and this may lead to high rates of injury and infection among them. In a study done in Delhi, all 64 dentists working in a teaching hospital of New Delhi participated in a survey. A pre-tested self-administered questionnaire was used to assess knowledge and practices of biomedical waste management and infection control among these dentists. The results show that not all dentists were aware of the risks they were exposed to and only half of them observed infection control practices. In addition to this, a majority of them were not aware of proper hospital waste management. The dentists need to be educated on Biomedical Waste (Management & Handling) Rules, 1998 through an extensive training programme (Kishore et al, 2000).
Collection and transport of clinical specimen are a common routine in hospitals. Improper practice may result in infection in personnel who handle these specimens. The hospital infection control group takes up such matters, proposes guidelines for proper management of infectious waste generated. Labeling of the waste is indispensable for prompt identification of it. A need for special place for the storage of infectious specimen in the laboratory is also essential. The guidelines for the transportation, management of spillage and disposal of infectious specimen in the health care establishments is also essential to minimize the risk of acquiring infection at work (Toxics Dispatch 2002).

Infectious waste is potentially dangerous to hospital personnel, patients and all people concerned. Thus management of hospital waste becomes indispensable. The manner/guidelines for the collection, transportation and disposal of infectious waste are important. The infectious waste collectors should be properly equipped with heavy duty rubber gloves, masks, plastic aprons and rubber boots to protect themselves from infection that can be acquired during handling of waste. Education in disposal of infectious waste to all personnel in the hospital is essential for cooperation which can be done by training courses or distributing documents. Personnel involved in transporting or incinerating infectious waste should have regular medical check-ups and periodic evaluation of the whole process of management of hospital waste is necessary (Ibid).

Irrespective of the knowledge of dangers in the unsafe disposal, the managements of the majority of healthcare establishments do not adhere to desired norms. Perhaps they may have some problems. However the fact remains that these highly infectious material lie exposed and affect the unsuspecting public at large. Unsafe recycling is not only practiced, but is flourishing. The price differential of genuine safe material & such unsafe recycled material is perhaps too attractive for the racketeers to give it up. However it must stop. One of the solutions to the problem is to create awareness in the minds of the public at large, so that once they know of the inherent dangers, the practice can be controlled. In order to bring about the same, a public seminar should be held, with participation from all the concerned sections viz. representatives of the management of hospitals etc., doctors, govt. & civic authorities & common public (Hospital Waste Management Program Rotary Club of Pune Katraj, 2000).
Why Biomedical waste management is a contentious issue?

In spite of the fact that so much is known regarding the impacts of biomedical wastes on environment and health, biomedical waste management, in any part of the world, is a contentious issue. NGOs and regulating agencies insist that it is a public health issue, a new phenomenon responsible for re-emerging infections, while most doctors and owners of HCEs contend that infectious risks from hospital wastes have always been known, have been addressed and are now being exaggerated. According to the healthcare personnel, there is no epidemiologic or microbiologic evidence to suggest that most waste from hospitals is any more infective than residential waste. They also feel that there is no documented epidemiologic evidence that current health care related waste disposal practices have ever caused disease in the community. Only sharps and microbiological cultures are potentially infectious, but they constitute a small part of the total hospital waste and they must be autoclaved (Zanon, 1990).

In spite of the unstinting work of NGOs and regulatory agencies to bring about awareness regarding the dangers from these types of wastes, many healthcare professionals feel that instances of unnecessary and disproportionate alarm have occurred and so now it is not uncommon for local authorities either to refuse to deal with hospital waste or to make additional charges for the specific treatment required. According to the local bodies, measures to treat hospital waste can lead to substantially increased costs. They feel that the main problem with hospital waste is that it is also often aesthetically unacceptable in addition to being hazardous. According to them, aesthetically unpleasant waste appearing on a disposal site is obviously undesirable but if incineration is not possible or too expensive it should be possible to bury the waste so that reemergence is unlikely (Ibid).

Many healthcare professionals admit that as part of the overall waste stream, medical waste does contribute in a relative way to the aesthetic damage of the environment. Likewise, some small portion of the total release of hazardous chemicals and radioactive materials is derived from medical wastes. However, their contention is that these comments can be made about any generated waste, regulated or unregulated. Healthcare professionals, including infection control personnel, microbiologists, public health officials, and others, have unsuccessfully argued that there is no evidence that past
methods of treatment and disposal of regulated medical waste constitute any public health hazard (Keene, 1991).

Healthcare professionals argue that there are no entirely satisfactory definitions of clinical waste whereas municipal authorities feel that there are no methods in general use that are safe and environmentally acceptable for the storage, transport and final disposal of the ever-increasing volume of such waste that is generated by the health services. Hazardous, potentially infectious and aesthetically objectionable waste has been found on beaches and exposed on domestic refuse landfill sites, causing public disquiet about health hazards and environmental pollution. Landfill is officially discouraged, where not illegal, and many older-type incinerators cannot now be used because their emission pollutes the atmosphere. Modern and efficient incinerators are expensive and the parochial nature of health service management and accounting, mitigates against their installation and use. Laboratory waste, however, can be rendered safe and unobjectionable, aesthetically and environmentally, if the requirements and recommendations of the several Codes of Practice and technical advice, which are simple and inexpensive, are implemented by laboratory and hospital managers (Collins, 1992).

Despite this view, most people know that hospital waste does pose a serious problem. The problem is primarily caused by the diversity of the individual components of the waste which constitute a risk to health if inadequately and improperly handled. It is evident that economic and technical conditions for both, safe disposal as well as efficient steam sterilization and management practice based on legal regulations, consequently will contribute to protection of both human health and the environment (Bencko et al, 1993). While some professionals have said that hospital waste is not necessarily difficult to dispose of and that in most cases it could be safely dumped in a properly designed waste pit, others have reasoned that waste management problems at district hospitals in developing countries are usually caused more by lack of information than by financial or technical difficulties (Halbwachs, 1994).
How does quantity and quality of biomedical waste contribute to the problem?
Not only the quantity of healthcare waste generated, which may be small, but the nature of healthcare waste discarded can play an important role in spreading infections and causing injury.

As part of the waste disposal planning in the administrative districts in Nordrhein-Westfalen, Germany, from among the variety of hospital refuse, that material was selected for which, as a result of the direct contact between waste and patient, a certain hygienic risk could not be entirely ruled out. This included waste from the wards similar to private household garbage, medical soft waste (swabs, dressings etc.) medical solid waste (syringes, cannulae etc.). For waste other than this, disposal by way of garbage dumps was considered unproblematic or else such waste was to be disposed off in compliance with legal provisions (infection wards). For organ refuse, the only mode of disposal was by burying or burning. On perusal of the literature it was found that with regard to the hygienic condition of the above-mentioned waste, views differ widely ranging from "unobjectionable" to "infectious". Apart from this, these views are not supported by microbiological data ascertained experimentally. However, a reliable assessment cannot be done without such data (Althaus, 1983).

Preliminary investigations were carried out to see what waste disposal routes exist in the various hospitals; then in two hospitals the waste volume of each ward was determined on 7 workdays over a total period of approximately two months and the waste was checked for the three sorts of refuse mentioned above. It was found that the refuse averaged 0.54 or 0.56 kgs per bed per day and 5.44 or 5.43 litres per bed per day with a specific weight of 0.10 kg/l. The microbiological analyses included both hospital refuse and "normal" household garbage from three dumps. Within the first group of waste, the analyses covered not only waste conglomerates but also individual refuse ingredients (e.g. syringes). The workup comprised 264 waste samples from the hospital area and 21 samples from dumps, which were subjected to quantitative and qualitative microbiological tests and declared to be infectious (Ibid).

United States hospitals generated a median of 6.93 kg of hospital waste per patient per day and infectious waste made up 15% of the total hospital waste. Most hospitals (greater
than 90%) considered blood, microbiology, "sharps," communicable disease isolation, pathology, autopsy, and contaminated animal carcass waste as infectious. Other sources of hospital waste that were commonly (greater than 80%) designated infectious were surgical, dialysis, and miscellaneous laboratory waste. The infectious waste was normally (80%) treated via incineration or steam sterilization before disposal, whereas noninfectious waste was discarded directly in a sanitary landfill. Eighty two percent of these US hospitals are discarding blood, microbiology, sharps, pathology, and contaminated animal carcass waste in accordance with the Centers for Disease Control's recommendations, while the compliance rate for the Environmental Protection Agency's recommendations (excluding optional waste) is 75%. No hospital could identify an infection problem (excluding needle-stick injuries) that was attributable to the disposal of infectious waste (Rutala, 1989).

The total quantity of hospital waste produced in the UK has been estimated to be 430 kilotonne/yr, having a combustible content equivalent to about 190 kilotonne of coal; its average gross calorific value (GCV) depends on the type of hospital, but has been estimated to be about 14 GJ/tonne for the teaching and general hospitals which were examined (Dagnall, 1989).

In the US, use of disposable products in hospitals continues to increase despite limited landfill space and dwindling natural resources. The use and disposal patterns of disposable hospital products were analyzed to identify means of reducing noninfectious, non-hazardous hospital waste. In a 385-bed private teaching hospital in Portland, Oregon, the 20 disposable products of which the greatest amounts (by weight) purchased, were identified, and total hospital waste was tabulated. Samples of trash from three areas were sorted and weighed, and potential waste reductions from recycling and substituting reusable items were calculated. Business paper, trash liners, diapers, custom surgical packs, paper gowns, plastic suction bottles, and egg-crate pads were among the 20 top items and were analyzed individually. Data from sorted trash, documented potential waste reductions through recycling and substitution of 78, 41, and 18 tonnes per year (1 tonne = 1,000 kg = 1.1 tons) from administration, the operating room, and adult wards, respectively and total hospital waste was 939 tonnes per year (Gilden, 1992).
A study evaluated the physical and elemental composition of the hospital waste at the National Taiwan University Hospital (NTUH). The results helped design an incinerator for the treatment of infectious waste, plastic syringes, pathological waste, and kitchen waste. During the study period, the estimated daily waste generation rate at NTUH was 4,600 kg/day, which consisted of 4,100 kg/day noninfectious refuse, 340 kg/day infectious waste, 70 kg/day kitchen waste, 50 kg/day pathological waste, and 40 kg/day plastic syringes. The NTUH waste consisted of 99.02% combustible wastes and 0.97% noncombustible wastes by mass. The combustible wastes constituted paper (16.17%), textiles (9.77%), cardboard, wood, and leaves (1.12%), food waste (21.51%), and plastics (50.45%). The noncombustible waste included 0.40% metal and 0.57% glass. Furthermore, the analysis indicated that the wastes contained 38% moisture, 4% ashes, and 58% solid with an average heat value of 3,400 kcal/kg. From the elemental analysis, the dominant elements were found to be carbon (34%) and oxygen (15%) (Li CS et al., 1993).

An extensive investigation in a large sanitary district (four hospitals, 164 departments, 2500 beds, 40 analytical laboratories) in Italy, permitted the careful characterization, both quantitative and qualitative, of normal and infectious hospital waste production for several types of medical departments (e.g. surgery, rehabilitation etc.). Very large differences were found to exist in the amount, as well as in the toxicity, of wastes produced in each department and/or service depending on the nature of the specialized therapeutic or diagnostic procedures adopted at each hospital. This, in addition to social, geographical and other factors, may help explain the wide variation in the average figures on hospital waste production reported in the literature. If the origin of the hospital waste is not accounted for properly, not only the overall amount of waste produced, but also the toxicity, may provide actual results quite different from those expected on the basis of hospital size (i.e. number of beds) alone. This, in turn, will directly affect the management, waste handling procedures, disposal costs and risks posed by hospital waste disposal systems in each hospital (Liberti, 1996).

Comprehensive healthcare facilities to cater to different areas of specialization and to different target groups, has resulted in more clinics, laboratories, dispensaries and hospitals. Consequently there is an escalated amount of medical waste generation in the
environment. In most of the Indian hospitals, there is no proper system of hospital waste disposal (Shishoo et al, 1997).

In the issue of bio-medical wastes, the important questions that determine the extent of danger posed by them are the different kinds of wastes that constitute bio-medical wastes namely solid, liquid, gaseous or aerosolic, the quantity of wastes generated and their nature - whether they are infectious, potentially infectious, chemically hazardous or radioactive. The main characteristics of hospital waste that determine their hazardous nature and the treatment required to make them innocuous, are the source where they are generated, their quantity, density and the constituents. There is a tremendous risk to individual and environment from improper disposal or handling of hospital waste (Ibid).

When talking of quantity, the estimates often refer to the quantity of waste generated per patient or quantity per bed per day and these vary across the country, among and within states in the same region. It was estimated that the quantum of healthcare waste generated in a large teaching hospital in South India was 0.775 kg/patient/day. Of this, the biomedical waste constituted only 6.27 per cent (Basu, 1996). Only a tenth of the 10 tonnes or so of hospital waste churned out daily by the 815-odd hospitals in Ahmedabad goes into the two large incinerators the city has. However, since it is not known whether rest of the healthcare waste is segregated, infectious or treated, it is of great concern that some 9 tonnes of healthcare waste is being heaped on to its general environment daily (Chavda, 1998). According to the Mumbai Medi-waste Action Group (MMAG), about 55 tonnes of bio-medical wastes are being generated daily in Mumbai alone (Francis, 2000). It has been estimated after a detailed study in Delhi regarding the quantity, quality and treatment practices of healthcare wastes, the generation in Delhi is 1.414 kg/bed/day of which the bio-medical or the infectious waste is about 0.434 kg/bed/day - about 31% (Mani et al, 2001). While the total healthcare waste in Delhi amounts to 58 to 60 tonnes per day, 26 to 27 tonnes are biomedical in nature about half of which is contributed to, by the large hospitals and the other half by the smaller HCEs (Ibid).

**Importance of segregation of waste**

According to some researchers, hospital wastes from a surgical department (operating unit, intensive care unit, nursery) and household refuse were examined with respect to
their bacterial concentrations and species' pattern, the waste samples processed by active suspending - a new method in the field of waste examination - which allowed gentle homogenization and quantitative microbial counts, among several, established features - the most relevant ones like bacterial concentration and relative frequency of bacterial groups - aerobic bacteria, (facultative) anaerobic bacteria, gram negative bacteria and streptococci indicated, that hospital wastes were not more contaminated than household refuse. Under this aspect, the present practice of hospital waste management, whose main concern is the spread of infectious agents outside the hospital, deserves a reevaluation (Kalnowski, 1983).

The reason for refuse from households taken from common bins being as contaminated as healthcare wastes is because of the intractable problem in the disposal of waste from the hospitals, of improper segregation of the hospital waste into clinical and non-clinical waste (Townend, 1984). Some countries feel that, provided waste from patients with known transmissible infections, e.g. hepatitis B, pulmonary tuberculosis or enteric fever is handled with the appropriate special precautions, the risks of infection from hospital waste is small (Anon, 1984). They also feel that if necessary healthcare waste can be segregated using colour coding and labeling. However they have also made certain groups of staff increasingly aware of the potential risk of handling waste, which has both advantages and disadvantages (Ibid).

As the epidemic of the acquired immunodeficiency syndrome (AIDS) expands, the prevalence of the human immunodeficiency virus (HIV) infection in health care environments will increase and HCWs in many locations are likely to be at increased risk for exposure (Becker 1989).

Implementation of universal blood and body fluid precautions was agreed to as an appropriate method of preventing exposure to HIV, especially for preventing needle-stick accidents. Current standards for hospital waste disposal in the US were judged to be adequate to prevent transmission of HIV, and confidential testing for HIV antibody in health care workers with follow-up counseling was recommended where indicated (Ibid).
Because the health care team cannot totally eliminate the source of medical waste, they must learn to more effectively manage and control it. Health care professionals must encourage industry and government to work together to develop standards for products and materials used as barriers and use more biodegradable materials. Health care facilities must learn to minimize the amount of medical waste designated as regulated or infectious. Segregating potentially infectious material from clean waste at the point of generation may reduce both volume and cost (Fay et al, 1990).

In Thailand, although there are common facilities for treatment of Bio-medical wastes, many hospitals do not practice the segregation process properly. The bags are not tightly secured, thus creating a problem of disposal of waste for the collecting agency. Information on proper management of infectious waste and co-operation from all the hospitals and clinics is the cornerstone for the success of management of medical waste programmes (Suttapreyasri, 1992). Many private healthcare establishments have a better system of segregation and therefore the treatment of their wastes is carried out in a better way. There are over 300 private hospitals in Thailand of which more than 80 are in Bangkok. The infectious wastes from these HCEs are collected in red bags and subjected to incineration by the Department of Public Cleansing. The sharps are collected in hard boxes once in a week. About 70% of the private hospitals have waste water treatment plants (Vitayakorn, 1992).

After segregation, labeling of the waste is indispensable for prompt identification of and a need for special place for the storage of infectious specimen in the laboratory has also been stressed. Infectious waste is potentially dangerous to hospital personnel, patients and all people concerned and therefore should be labeled and kept separately. Thus management of hospital waste in a segregated manner becomes indispensable (The Hospital Infection Control Group of Thailand, 1992).

There is no reason to assume that there may be universal, standard regulations to be used and accepted unanimously and consistently valid for all countries. It is necessary to honour the specific, social and economic background of every country (Culikova, 1995).
A study investigating medical waste practices used by hospitals in Oregon, Washington, and Idaho, which includes the majority of hospitals in the U.S. Environmental Protection Agency's (EPA) Region 10, reported on infectious waste segregation practices, medical waste treatment and disposal practices, and the operating status of hospital incinerators in these three states. Hospitals were provided a definition of medical waste in the survey, but were queried about how they define infectious waste. The results implied that there was no consensus about which agency or organization's definition of infectious waste should be used in their waste management programmes. Confusion around the definition of infectious waste may also have contributed to the finding that almost half of the hospitals are not segregating infectious waste from other medical waste (Klangsin, 1998).

A historic agreement signed in July 1998 between the American Hospital Association (AHA) and the US EPA signaled change in waste management in the healthcare industry. The agreement, which calls for a fifty percent reduction of hospital waste by 2010, will not only have an impact on hospital facility managers, but throughout the entire healthcare supply chain. Improving the environmental impact of the healthcare industry should start with the healthcare delivery institutions themselves. The healthcare industry has a long way to go in addressing its environmental impacts, compared to the energy and chemical industries, for example. One reason is that these industries are raising their suppliers' environmental performance. Healthcare delivery institutions can effectively pull environmental performance requirements through the entire supply chain as well. This can be accomplished by examining supply chain strategies of leading industries and firms and considering the role of environmental management systems such as ISO 14001 throughout the entire chain (Messelbeck, 1999).

**Technologies for collection, storage, transport and disposal:**
They are several technologies for collection, storage and treatment of biomedical waste but the importance is in recognizing the different categories, separating them and treating them as is appropriate for that category of waste.

About ten years ago, it was felt that hospital waste is becoming increasingly complex due to changing technologies and increase in the services that the hospitals perform for the community. Out of the available technology for the final disposal of solid wastes,
incineration was found to be best suited for hospital waste as it rendered the waste nontoxic, non-hazardous, non-putrescible and reduced the volume of material for ultimate disposal. A study carried out in a service hospital to analyze the requirement of incinerator considering the state of art available in the country revealed that a multi-chambered oil fired incinerator installation as an on-site facility for hospital solid waste disposal could be recommended as an 'environment friendly' option (Rao et al, 1994).

Those people involved in specifying, designing and building hospital waste incineration systems need to have a reasonably clear understanding of the material they intend to burn. With the advent of energy recovery systems, however, a greater level of attention was given to estimate the gross calorific value such that the amount of recoverable energy etc. The general hospital waste has an average gross calorific value somewhere in the range of 15120 KJ/Kg to 19770 KJ/Kg with 17450 KJ/Kg being a good figure to use if any. Most plastics, polythene and polypropylene will have a gross calorific value in excess of 45360 KJ/Kg. Everybody felt that the popular misconceptions about the toxic nature of combustion product arising from the incineration of plastic waste should be clarified. Most plastics are relatively pure hydrocarbon, e.g. polythene, polypropylene etc. Polyvinyl chloride is extensively halogenated, being 57% by weight chlorine and it is the PVC and other halogenated plastics that give rise to toxic combustion products like hydrogen chloride. To ensure acceptable exhaust gas conditions the presence of PVC and other halogenated material had to be kept to a very low level (Browes, 1983).

The major response from consultants representing the incinerator industry was to claim that as long as the incinerator furnace was operated at a high temperature all the dioxins and furans would be destroyed (Hasselriis, 1984), however these claims were subsequently found to be based on fraudulent manipulation of the data (Commoner et al, 1984). In 1985, the reason why high temperatures alone could not solve the dioxin problem was revealed at the International symposium on Dioxin held in Bayreuth, Germany. Two groups showed that dioxins could be reformed after the flue gases left the combustion chamber (Ozvacic, 1986; Vogg, 1986). It is now well established that if the flue gases from an incinerator are passed through air pollution control devices operating at temperatures in the range 200-400 degrees Celsius, more than a hundred fold increase in dioxin and furan formation can take place (US EPA, 1989). A strategy that would
successfully minimize post combustion formation of dioxin would require the quenching of the flue gases immediately after they emerge from the combustion chamber. However, this strategy conflicts with the aim of generating electricity, because this requires the flue gases to go through boilers to generate steam to drive turbines, thus delaying the moment when flue gas quenching occurs (Ibid).

Without immediate quenching system, the fly ash collected in the scrubbing devices will be contaminated with dioxins and furans. A hundred times more dioxin may leave the facility on the fly ash, than from the air emissions. However, until recently, regulatory agencies, particularly the US EPA, had turned a blind eye to the dioxins and furans left on the fly ash, even though in some cases the combined ash (a combination of bottom ash and fly ash) was being used as daily cover in some US landfills. In Japan, as a result of growing concern about the dioxin problem there, the government in 1997 limited the total dioxin emissions (i.e. air emissions plus fly ash plus bottom ash) to 5 micrograms of dioxin International Toxic Equivalents (I-TEQ) per metric ton of trash burned. This requires the fly ash from Japanese incinerators to be vitrified, which will still further escalate the costs of incineration (Abe et al, 1997; Sakai et al, 1997).

The exhaust gases from an oil-fired hospital waste incinerator were examined during normal incinerator operation. The design-specified operating temperature was 800 degrees C in the primary combustion chamber and 1000 degrees C in the secondary chamber. Flue gas temperatures, measured from the sampling point at the base of the exhaust stack, varied over the range 186-305 degrees C, and bacteria were recovered from this position in numbers up to 400 cfu m\(^3\) (mean 56 cfu m\(^3\)). No sampling was performed at the top of the stack where flue gases were discharged to the atmosphere. Isolates were predominantly gram positive, i.e. *Bacillus* spp., *coagulase negative staphylococci and Staphylococcus aureus*, although low numbers of gram negative species (*Pseudomonas fluorescens and other pseudomonads*) were also recovered. The results suggest that incineration may not constitute an absolute method of sterilization for clinical waste (Blenkharn et al, 1989).

Some studies have been found in the literature, which provide indication of the effectiveness of incineration for rendering infectious hospital waste innocuous. Although
there is an indication from these studies for release of bacteria in stack gas, none of the studies identified the bacteria or determined the source of bacteria. The purpose of the study was to investigate the potential for a hospital incinerator to release human pathogenic bacteria into the ambient environment. In this study, waste spiked with Bacillus subtilis was burned in a hospital incinerator. Although bacteria were found in the incinerator stack gas, (concentrations ranged from not detectable to 1157 colonies/m3 of air) no Bacillus subtilis was recovered from the stack gas. The results suggest that the source of the stack gas bacteria was not from unburned waste or from outdoor air. Analysis of samples of air from the incinerator room (not simultaneous with the stack gas samples) indicates that the source of the stack gas bacteria was most likely the combustion air (Allen, 1989).

Based upon an overview of the technology of incineration and the nature of hospital waste, it was suggested that old retort or other excess air incinerators should be replaced regardless of age. Even if emissions control equipment and monitoring devices can be retrofitted, excess-air incinerators are no longer cost-effective in terms of capacity, fuel consumption, and heat recovery. Auditing one’s waste stream thoroughly and consulting a qualified engineering company experienced in hospital installations to get a system specified as exactly as possible to one’s individual conditions and needs would make sure that the capacity of the incinerator will meet projections for future use. The cost of emissions control and monitoring devices should be anticipated and whether the state currently requires them or not. The incinerator installation should be engineered to accept required equipment in the future. A strong community relations programme and a proactive positioning by inviting neighbours during the planning stage should be conducted well in advance of committing to incinerator installation. The contract governing incinerator purchase and installation should have a cancellation clause, preferably without penalties, in case community action or a change in state regulations makes installation and operation impractical. The technology is available to enable hospitals to burn waste effectively, efficiently, and safely. It was felt that when emissions are under control and heat is recovered, both the environment and the bottom line are healthier (Anon, 1990).
At Kaiser Permanente in San Diego, plasma pyrolysis was proposed to be used instead of incineration to treat hospital waste without creating corrosive gases, PVCs or groundwater-contaminating ash. Here again it was recommended that plasma pyrolysis offered so much promise for waste treatment and hospitals should follow this project closely (Ibid).

Ten years back, incineration was being used for disposal of about 10% of the solid waste generated in the United States, and this percentage increased as land disposal declined. Siting new incinerators, however, was often controversial because of concerns related to the possibility of adverse health effects and environmental contamination from long-term exposure to stack emissions. Specific concerns related to the adequacies of a) stack emission testing protocols, b) existing regulations, and c) compliance monitoring and enforcement of regulations. U.S. Environmental Protection Agency laboratories conducted research aimed at developing new testing equipment and procedures that would allow a more comprehensive assessment of the complex mixture of organics that was present in stack emissions specifically toward developing source testing equipment and procedures, analytical procedures, and bioassay procedures (Watts et al, 1992).

In the US, on-site incineration was considered an important alternative for the treatment and disposal of institutional waste. Incineration reduced the weight and volume of most institutional solid waste by 90 to 95 percent, sterilized pathogenic waste, detoxified chemical waste, converted obnoxious waste (such as animal carcasses) into innocuous ash, and provided a substantial reduction in off-site disposal costs, making on-site incineration highly cost effective. Many systems have payback periods of less than one year. In addition, on-site incineration reduced the need to depend on off-site disposal contractors, which, in turn, minimized potential exposures and liabilities associated with illegal or improper waste disposal activities. However, it was not a perfect method, but it was felt that all current technologies have limitations. There are several promisingly innovative approaches being pursued; however, they are only in developmental stages. For instance, once the waste is run through the microwave system, the infectious content is destroyed. As a result, ninety percent of the hospital's infectious waste can be sent to the local landfill, which saves more than $200,000 a year in transport and disposal costs.
It is hoped that these new technologies will progress into reliable treatment options for medical waste during the 1990s (Brewer, 1993).

About fourteen years ago there were over 150 small incinerators located on hospital premises throughout Scotland. The majority were operated by portering staff, had poor combustion and no gas cleaning equipment. At that time alternatives to incineration were in their infancy and relatively expensive. Funding for major capital projects lay with the Government, and a strategic study suggested the installation of 12 centralised modern incinerators on the mainland and three on the islands: one per Scottish Health Board. Some health boards proceeded with new installations well ahead of deadlines for closure of old plant. Others adopted a 'wait and see' policy and were overtaken by political changes. These resulted in a cutback in government-funded capital investment and a shift of non-core services to the private sector. Clinical waste disposal was contracted out as a service contract and some private sector companies offered alternative low-temperature technologies for clinical waste treatment. As a result there is now the opportunity to compare the advantages and disadvantages of incineration, sterilization, dry heat disinfection and other techniques. Technological change has also required revised waste segregation methods within the hospitals. In parallel with this there has been an overall reduction in waste quantities. The remaining incinerator operators were now faced with more stringent emission limits implemented in June 2000. This is resulted in closures of incinerators that had been operating for a few years (Wassermann, 1999).

The technology and the ability to cut dramatically the amount of disposable waste that health care generates, in practically every case, the lower-waste options also save the institution, money. It is time that healthcare establishments challenged their need for today's convenience at the expense of tomorrow's quality of life (Whitaker, 1992).

Waste minimization can be done in so many ways. For instance, using reusables instead of disposables can help reduce waste to a great extent. Both re-usable and disposable systems have their merits and problems. The disposable system, being fully integrated, appears to be steadily gaining market share compared with the re-usable system. Since its introduction, the success of the re-usable system has been limited by the use of bed pans not designed for automatic processing. Where the 'perfection' pan has been superseded by
'open' shaped receptacles and those used in commode chairs, cleaning effectiveness can be improved by a factor of 10. For this and other reasons, nursing involvement in the re-usable system can be high while the 'perfection' pan is in use. A work study exercise to compare nursing involvement in re-usable and disposable systems is reported (Rollnick, 1991).

Using the 'waste' as resource and deriving benefits from it by segregating it at source and carefully preserving it before extracting something useful from it, is another way of reducing waste. Human placenta is an available hospital waste which is known to contain many valuable biochemicals that may be commercially exploited. Using placental tissue previously extracted for haemo-derivatives, the basic fibroblast growth factor (bFGF), a soluble protein, and placental alkaline phosphatase (PALP), a membrane-linked protein, as a coupled process, were purified. bFGF purification comprised three steps: extraction and chromatographies on S-Sepharose and heparin-Sepharose. The final product included a major 17 kDa and a minor 16 kDa component with a specific activity of $8.0 \times 10^6$ units/mg yielding 0.5-1.0 microgram/kg of placenta. PALP purification comprised four steps: acidic butanol-I extraction and chromatographies on Q-Sepharose, concanavalin A-Sepharose and Q-Sepharose. The purified PALP had a molecular mass of 70 kDa, a specific activity of 800 units/mg and yielded 50 micrograms/kg of placenta. The results showed the possibility of purifying substances in placental haemolysed blood, soluble products from placental cellular mass and proteins from the cellular membrane in a one-stream process (Costa et al, 1993).

Minimization of total drug expenditures within the health care system, without affecting patient outcome has become a rational goal in today's economic environment and can help reduce chemical waste such as expired medicines especially the highly hazardous cytotoxic drugs. The objective was to observe the effect of extending the shelf-life for three chemotherapy medications, [doxorubicin, epirubicin and mitoxantrone] on wastage of these medications. Prior to and following the introduction of new, longer, shelf-lives for these three medications, prospective, non-randomized, unblinded four-month chemotherapy wastage audits for all chemotherapy medications were completed at 18 institutional sites within Ontario (six Ontario Cancer Treatment and Research Foundation clinics, ten Ontario hospitals and two preparation sites in a large cancer treatment centre).
Data were provided by 18 sites in 1989 but from only 12 sites in 1990. Ten of the 12 sites extended their shelf-lives for each of doxorubicin, epirubicin and mitoxantrone, and on average, waste at these sites was reduced to less than 1% of the 1989 total for epirubicin, less than 15% for doxorubicin and 35% for mitoxantrone. Many sites eliminated waste entirely for these drugs. For sites which did not extend their shelf-lives, the waste remained unchanged. It was concluded that appropriate extension of the shelf-life for chemotherapy medications can reduce waste, and is a relatively simple method of reducing expenditures without affecting health outcomes or adding additional complications to IV chemotherapy (Walker, 1994).

Besides minimizing, alternative technologies like sterilizing can help in treating biomedical waste and cut down incineration. Laboratory wastes and sharps known to be highly infectious and hazardous should be collected separately and stored safely before treatment. Autoclaves are one of the ways in which laboratory infectious wastes and sharps can be treated effectively.

The temperature profile of infectious laboratory waste being autoclaved was examined relative to the type of containers used in the process. A standardized waste load (1,750 +/- 4 g) placed in the container was evaluated by using a direct readout thermocouple. The sensor of the thermocouple was placed within an unused and outdated agar plate, centrally located about 5 cm from the bottom of the container. The gravity displacement autoclave tested reached 121 degrees C within 30 min. Waste within a steel container (plus 1 liter of water) reached 108, 120, and 122 degrees C at 12, 30, and 50 min, respectively. Without the addition of water, the corresponding temperatures were 60, 110, and 120 degrees C, respectively. With a steel container, "autoclavable" plastic bags, and no additional water, the temperatures were 36, 71, and 105 degrees C, respectively. When 1 litre of water was placed in the autoclavable bag, the temperatures were 98, 115, and 121 degrees C, respectively. Waste within a polypropylene container (dimensions similar to those of the steel container) with and without the addition of 1 litre of water, reached a maximum temperature of 108 degrees C at 50 min. With a polypropylene container, autoclavable plastic bag, and 1 litre of water, the corresponding temperature was 99 degrees C. Without the addition of water, the temperature was 92 degrees C. The
importance of container, moisture, and material in autoclaving was demonstrated (Lauer et al, 1982).

A steam sterilizer (autoclave) was tested to determine the operating parameters that affected sterilization of microbiological waste. Tests involved standardized loads (5, 10 and 15 lb [ca. 2.27, 4.54, and 6.80 kg, respectively]) contaminated petri plates in autoclave bags placed in polypropylene or stainless steel containers. Thermal and biological data were obtained by using a digital potentiometer and a biological indicator containing spores of Bacillus stearothermophilus, respectively. The transfer of heat was more efficient when smaller loads of microbiological waste were tested and stainless steel rather than polypropylene containers were used. A single bag with the sides rolled down to expose the top layer of petri plates allowed heat to pass better than did a single bag with the top constricted by a twist-tie. The presence of water in the autoclave bag did not significantly improve heat-up time in stainless steel or polypropylene containers. The results of biological tests substantiated the temperature data. When 10 or 15 lb of microbiological waste was exposed to various test conditions, the only condition that ensured the destruction of B. stearothermophilus involved the use of a stainless steel container (with or without water) for 90 min. Autoclaving for 45 min resulted in the destruction of bacteria included in 10 lb (136 +/- 3 plates) or 15 lb (205 +/- 6 plates) of microbiological waste when stainless steel containers with or without water or polypropylene containers with water used, whereas 60 min was required to kill all bacteria if polypropylene containers without water were used (Rutala et al, 1983).

One form of medical waste known to be capable of transmitting disease is the contaminated sharp. Safe handling and disposal of sharps is an essential element of any infection control programme. Many areas allow the on-site treatment of sharps containers. In a study intended to evaluate the effect and treatment, various autoclaves had on bacterial endospores present on strips or needle syringes, a gravity-displacement autoclave and a high-vacuum autoclave were used. Strips and syringes were placed within sharps containers three quarters filled with representative materials. Six types of containers were tested. Containers were processed sitting up or on their sides. Processed strips and needles were aerobically cultured at 56 degrees C for 7 days. If sterilization was not accomplished initially, additional exposure time was added. It was found that (1)
Soiled syringes were more difficult to sterilize than strips (2) Capping or the presence of blood did not affect sterilization efficiency (3) Container positioning was important only for the gravity-displacement autoclave (4) Additional exposure time was required in the gravity displacement autoclave when sterilizing soiled syringes but not strips (5) High-vacuum autoclaving killed all spore challenges within the normal processing interval. The data indicated that processing of sharps containers within a gravity-displacement autoclave appears to require extended exposure intervals to achieve sterilization (Palenik, 1993).

Over the past ten years, the treatment of medical waste has received much attention. During this time, an entire new industry to develop "alternate medical waste treatment technologies" has emerged. Much of this has been in response to increasingly stringent air quality standards along with the public sentiment opposed to incineration, with a resultant decline in the use of on-site medical waste incinerators. However, in between incinerators and alternative treatment systems is a technology that is as much a part of American healthcare as hospitals themselves. Medical waste regulation in all fifty states recognize steam sterilization as an acceptable method of treatment prior to disposal. Within this category of medical waste treatment technology, there is a wide array of systems available, many of which have altered the basic, simple principles of steam treatment to make it more conducive to this application (Urbanowicz, 1998).

A method is described for autoclaving low levels of solid, infectious, radioactive waste. The method permits steam penetration to inactivate biologic waste, while any volatile radioactive compounds generated during the autoclave process are absorbed. Inactivation of radiolabeled infectious waste had been problematic because the usual sterilization techniques result in unacceptable radiation handling practices. If autoclaved under the usual conditions, there exists a high probability of volatilization or release of radioisotopes from the waste. This results in the radioactive contamination of the autoclave and the laboratory area where steam is released from the autoclave. The method described using Bacillus pumilus spore strips and vaccinia virus used as more heat-resistant surrogates of the human immunodeficiency virus (HIV) provide a practical method to inactivate and dispose of infectious radioactive waste. The autoclave method is time efficient and can be performed by laboratory personnel with minimal handling of the
waste. Furthermore, waste site handlers are able to visually inspect the solid waste containers and ascertain that inactivation procedures have been implemented (Stinson et al, 1990).

A model system has been developed for disposal of solid laboratory waste that is both radioactive and heat sensitive, e.g., HIV. A double polypropylene bag with charcoal vent filter and absorbent was designed to meet requirements for both steam sterilization and disposal as solid radioactive waste. Earlier work demonstrated the effective containment of radioactive gases by the filter and inactivation of organisms as heat sensitive as HIV. The application of this model was broadened to ensure inactivation of microorganisms that are more heat resistant than HIV. The efficacy of steam sterilization using water or solutions of iodophor, hypochlorite, or hydrogen peroxide was studied under constant temperature and time conditions. The systems were monitored with internal probes, physical, chemical, and biological indicators. Biological indicators documented inactivation when bags containing hydrogen peroxide (3%) were autoclaved for 60 min at 121 degrees C. Synergistic activity between hydrogen peroxide and autoclave conditions significantly reduced processing time (Stinson et al, 1991).

Dentists and dental offices are regarded as one of the potential sources of transmission of HIV, Hepatitis B and C etc., due to the high use of sharps and the nature of operations performed which involves a lot of blood and oral secretions. In the US, the management of waste in the dental office is dictated by the federal, state, and local ordinances in force in the locale in which the office is located. The dentist must first determine what the laws require and then implement the changes in waste management into the office setting. The local component society of the American Dental Association (ADA) often provides such information; otherwise, the health department of the government branch having jurisdiction over the office locale will either have the information or know how where to find it. Once it has been established what constitutes hazardous waste, the next steps are to contain it, store it, and finally dispose of it according to the information gained from the authorities. Storage of sharps should be accomplished in "hard-walled, leak-proof containers," usually red, which can be closed securely when they have been filled, and which are located as close to the point of use as possible. Solid waste should usually be contained in red bags, which are then bagged in a second bag when full or in a hard-
walled container. Waste may then be hauled away for disposal by a qualified company that keeps the required records of the waste from the time it leaves the office until final disposal by incineration or burial in an approved landfill. The company chosen to do the hauling should be able to demonstrate that they have appropriate insurance to indemnify your office in the event of a problem while they have the waste in their possession (Shaefer, 1991).

Endospores present on strips or placed inside of dental anesthetic cartridges held within sharps containers and strips with $1.7 \times 10^5$ Bacillus stearothermophilus endospores were used to test the effect of treatment in a gravity steam autoclave, high-vacuum steam autoclave, or an unsaturated chemical vapor sterilizer. Neither the presence of blood or anesthetic solution nor the position of the container affected the efficiency of sterilization. Soiled cartridges were much more difficult than strips to sterilize. Intact cartridges could not be sterilized by two runs in a gravity steam autoclave or an unsaturated chemical vapor sterilizer or one run in a high-vacuum steam autoclave. Sterilization occurred after two runs in the gravity steam autoclave and unsaturated chemical vapor sterilizer only when one end of the cartridge was removed prior to processing. Results indicated that unopened spore-soiled cartridges are not readily sterilized by commonplace office sterilizers, even after extended exposure (Sheldrake et al, 1995).

A modification of the direct air displacement system of processing laboratory discard material in an autoclave has been reported (Line, 1995). The method overcomes many of the drawbacks encountered previously with existing laboratory sterilizers and yet provides an effective means of replacing air with steam in difficult laboratory discard loads. Plastic Petri dishes were used as the standard load and plastic boxes as the container. Thermocouple results indicate that the described method gives good steam penetration of the load and allows safe handling by the operator (Ibid).

A study conducted to evaluate two steam autoclaves and an unsaturated chemical vapour sterilizer for killing bacterial endospores present on commercial spore strips or applied to sterile anesthetic injection systems placed within sharps containers, revealed that of the three types of sterilizers used, the gravity steam autoclave and the unsaturated chemical
vapor sterilizer could not routinely sterilize spore soiled injection systems even after three consecutive sterilization cycles. The microbial challenge for the sterilizers were *Bacillus stearothermophilus* spores present on commercial spore strips or drawn into and applied onto sliding sheath anesthetic injection systems with anesthetic carpules attached. Spore-soiled items were placed into the middle of sharps containers three-quarters-filled with representative clinical waste and sterilized. If, after culturing, sterilization of all test items in a group was not achieved, additional sterilization time was applied. Spore strips were killed within a single cycle of each sterilizer. However, spore-soiled injection systems and carpules were sterilized by exposure to a single-treatment cycle in a high-vacuum steam autoclave. Results indicated that routine sterilization of spore contaminated anesthetic carpules or injection systems could not be accomplished in a reasonable amount of time using sterilizers commonly found in dental offices (Palenik, 1997).

Despite the development of on-site treatment technologies, the most frequently used practice of treating and disposing of medical waste was the use of private haulers that transport medical waste to treatment facilities (61.5%). The next most frequently reported techniques were pouring into municipal sewage (46.6%), depositing in landfills (41.6%), and autoclaving (32.3%). Other methods adopted by hospitals included Electro-Thermal-Deactivation (ETD), hydropulping, microwaving, and grinding before pouring into the municipal sewer (Klangsin, 1998).

For radioactive liquid waste, an underground system of tanks in Oman was installed to delay the discharge of T^131 waste from the thyroid therapy unit to the on-site sewage treatment plant. As a consequence, the level of radioactivity discharged to sewage has fallen by a factor of 530, reducing the radiation dose to hospital and auxiliary service staff. Cancer patients are no longer required to collect their urine, hence increasing the hygiene for all concerned. A model was developed of iodine waste which estimates the dose rate above the delay tanks and the activity of iodine discharged. The maximum effective dose to a member of the public due to the holding tanks is 40 microSv.year⁻¹. There is now better management of the radioactive waste from the iodine therapy ward (Goddard, 1999).
New equipment with technologies using steam, dry heat and microwave sterilization are being brought into the market with great frequency these days. To evaluate the ability of a new apparatus (Dipsys 25, Societe SGN, Bagnols sur Ceze, France) to disinfect biomedical waste in France, including both potentially infectious agents and the normal saprophytic flora of the waste, disinfection was assessed using standard methods (reference strains were fixed on reference carriers according to the French AFNOR methods) and non-standard assays. Assays in conditions of hospital use, evaluations of bacterial survival during storage, sporidical effect, and spore survival during storage were performed in parallel. Finally, bactericidal effect in extreme conditions (association of high contamination and high bacterial protection conditions) was tested with normal fecal flora. Bacterial counts were performed after treatment by the apparatus and without treatment (controls). All tests were carried out in triplicate. In all treated carriers, a bacterial population decrease of at least 5 log10 was obtained. Assays performed in hospital-use conditions did not show any bacterial growth. Concerning the evaluation of sporidical effect and spore revival during conservation, a minimum reduction of 5 log10 was observed in all assays performed, without survival. Finally, concerning assays in extreme conditions, the decrease of bacterial population was between 5 log10 and 10 log10 for vegetative anaerobes of normal fecal flora. Under the study conditions, the study apparatus reduced the tested microbial populations by a minimal factor of 5 log10. The main advantage of the apparatus was the opportunity to treat contaminated waste inside hospital wards, at the point of initial collection, without pulverization, by non-specialized staff (Eveillard et al, 2001).

**Biomedical waste and Environmental Health**

As proposed in the WHO’s constitution, the definition of health is not just the absence of disease. Health does not imply, as is often made out, absence of infectious organisms or malnutrition or the symptoms thereof. Health is the development and maintenance of a living being to be able to face adverse situations which may lead to “illness” and its ability to fight them and survive.

Ironically, health is the greatest casualty in India’s march towards development. Any study on health will suggest that there is no substitute to environmental cleanliness and safety to ensure sustainable and long lasting health for all. Unfortunately, health planners
in the country measure health only in terms of increased allocation or expenditure for immunization notwithstanding the fact that even increased immunization in slums to cover all the vulnerable groups from the deadliest communicable diseases with no change in the environmental conditions will not decrease morbidity or mortality in our cities.

It is also ironical that health of an individual is often perceived to be something that can be degraded only by an external agent such as a microbe. Degradation or destruction of one’s body’s ability to fight these microbes due to presence of chemicals, radiations and stress is often not taken seriously. It is important to note that microbes like the HIV virus which causes immunodeficiency syndrome in humans adds to the burden already created by chemicals and radiations. According to recent reports, the genetic make-up of South Asians which may make them more susceptible to heart disease and cancer is yet another burden that people in this region bear. Therefore the so-called dual burden of disease that is used in describing the health situation in India – a developing country, is actually a triple or a quadruple burden since an urban slum dweller faces filth, has no access to clean water or sanitation, breathes polluted air, gets only polluted water and food, is plagued by poverty, poor housing, pesticides and other environmental toxins and also sorts medical waste which has needles used on infected HIV or Hepatitis B patients. His or her immune system is already severely damaged due to various reasons including presence of chemicals, gaseous fumes, malnutrition and repeated infections. Immunity is lost without even being infected with the HIV. And those whose immune systems are not damaged, nevertheless, have to face the infectious organisms and may still succumb to it because of the fact that the microbe has mutated and will not respond to immunization or antibiotics.

Therefore, we really now need to monitor the health of the environment in our cities and peri-urban areas which are so severely stressed and “ill” that any individual, with or without an intact immune system is no match for its infectivity or ability to cause illness. For example, Delhi is reported to have the highest incidence of multi-drug resistant TB cases in the world (TOI, November 1997). And yet unlike in the US or other developed countries, these are not necessarily associated with HIV infected cases nor are they linked only to poor socio-economic strata. Even in fairly well-to-do citizens, incidence rates of TB in men and women younger and older than 30 years is similar, increases with
advancing age and is three times higher in men than women (Gopi, 1997, National Tuberculosis Institute, Bangalore, 1974). Approximately 7% of all deaths and 26% of preventable deaths in developing countries are caused by TB (Kochi, 1991, Murray, 1990). In India, over half the adult population is infected with *Mycobacterium tuberculosis* (Swaminathan, 2000).

**Monitoring the environment:**
There is sometimes an unstated presumption that environmental health deals only with those aspects of the environment that are affected measurably by human activities and not those due to nature in the raw. Indeed the term 'natural' has come to imply clean and safe to many people. This view could only develop in recent history in rich countries, however, because most of humanity has spent most of history protecting itself from a range of far-from-benign natural environmental conditions, some of which are as follows: Constant search for sufficient food and water while avoiding natural toxins, infections and parasites that spread from person to person or animal to person through air, food, water or insects, dust, damp, wood-smoke, pollen, and other airborne hazards, injuries from falls, fires and animal attacks, heat, cold, rain, snow, wind, natural disasters, and other adverse conditions (Smith et al, 1999).

If a sufficiently long time horizon is taken, all disease is environmental, even that related to genetic factors. If causation is confined to an extremely limited period, however, long term environmental health threats such as climate change would be excluded. Some intermediate choice seems most appropriate (Ibid).

What can then be included as environmental risk factors especially those caused by improper management of healthcare wastes?

**Risks caused by poor management of health-care wastes:**
Poor management of health-care waste causes serious disease in health-care personnel, waste workers, patients and the general public. The main cause of illness from infectious waste is probably injuries with used needles, which can cause hepatitis and HIV. There are however numerous other diseases which could be transmitted by contact with health-care wastes (WHO, 1999a).
Occupational Risk

In the course of health care administration, health-care personnel and waste workers (within and outside the HC) are in contact with waste, if it hasn’t been packaged safely. Many injuries occur because syringe needles or other sharps have not been collected in safety boxes, or because these have been overfilled. Furthermore, contact with other infectious waste that has not been packaged or treated adequately may cause a risk. On landfills and dumpsites, waste recyclers or scavengers may be in contact with infectious wastes and especially those which have been disposed of without prior treatment.

Medical staff is exposed to needle stick injuries and infections due to contact with patients suffering from highly infectious diseases. They may also develop other complications like allergies and reactions to chemicals or radioactivity due to insufficient care during administration of medical treatment. Medical staff working in surgical wards of hospitals, people that work on transport or storing of gases and liquids, employees working on gas tanks and gas installations, mechanics for anesthetic devices and employees in the process of production of these substances are professionally exposed to anesthetic gases or and fumes that are released in their working environment (Prokes, 1998).

Risk to the public

The reuse of syringes by the general public represents one of the greatest public health problems in the developing world related to health-care waste. Worldwide, an estimated 10 to 20 million infections of Hepatitis B and C and HIV occur annually from the reuse of discarded syringe needles without prior sterilisation. If health-care waste is dumped on sites or in other areas which can be accessed by the public, and in particular children, they will be in contact with infectious wastes and toxic chemicals, which may cause accidents (Ibid).
Indirect risks via the environment

Besides risks from direct contact with health-care waste, waste can also contaminate the environment, such as the water, soil or the air, for instance during or after waste treatment, and so indirectly impact on health. The choice of disposal methods is often based on cost considerations alone and necessarily involves subjective judgements. Consideration to waste minimization and resource recovery so as to minimize the waste problem is the ideal approach (DeRoos, 1974, Shishoo et al, 1997, Das et al, 2001, Nijagunappa et al, 2001, Shekdar, 2001).

When liquid wastes from healthcare establishments are let off into sewers or wastes are disposed in a pit which is not lined, the surface and groundwater may become contaminated (Guardabassi et al, 1998). As the same water source may be used as a resource for drinking water, irrigation or for other purposes, wastes may indirectly impact on health via the water (Katzenelson et al, 1976, Reed et al, 1994). If waste is burned or incinerated in an incinerator which does not have emission control (which is the case with the majority of incinerators in developing countries), the air may be contaminated by a large number of pollutants and cause serious illness in people who inhale this air (Collins, 1991). While choosing a treatment or disposal method, environment-friendliness is an important criteria (WHO, 2002).

Environmental improvements are crucial to significant and long term reduction in the morbidity (WHO, 1997). Poor environmental quality is directly responsible for around 25% of all preventable ill-health in the world today, with diarrhoeal diseases and acute respiratory infections (ARI) heading the list (Smith et al, 1999). The urban poor are potentially at greatest risk: firstly their living environment suffers as a result of locally poor waste management and secondly, many people are forced to work with waste to provide a livelihood. It is believed that the highest risk groups are those involved informally in reclaiming and recovering used healthcare waste material. Infectious
hospital waste has the potential to cause a range of diseases ranging from HIV and Hepatitis to TB, cholera and diphtheria (Appleton, 2000).

In the course of their work, the waste recycling community handles blood in syringes, soiled cotton and waste, urine bags, suffers cuts from surgical blades. Needle stick injuries are a daily phenomenon. Children were also noticed in this hazardous activity (Krishnamurthy, 2001). Pulmonary tuberculosis (TB) is the leading cause of mortality in India (WHO, 1997). In a study conducted in the slums of Delhi, TB was more common in women than men – about 4% of women who were ill had been diagnosed with TB (Gupta et al, 1998). Other diseases such as malaria, schistosomiasis, other vector-borne diseases, chronic respiratory diseases and childhood infections are also strongly influenced by adverse environmental conditions, as are injuries. On an average, the individual burden of diarrhoeal diseases and ARI is about 100 times greater in the least developed countries than in developed countries. These diseases are particularly serious among children.

Hazardous chemicals and various forms of hazardous waste, especially chemicals in healthcare, are growing health-and-environment concerns. Evidence is mounting that in developed countries, the human exposures and health risks arising from existing hazardous chemicals (such as lead, cadmium, mercury, DDT and polychlorinated biphenyls) have been brought under control, but that this is not the case in developing countries. Of particular concern are exposures to dioxins, mercury and persistent organic pollutants. Dioxin is created as a by-product in many industrial processes including waste incineration. USEPA has determined that medical waste incinerators are among the top two or three sources of dioxin contamination (Toxics Despatch, 2002). Peer-reviewed research has documented that dioxin causes cancer, affects the immune system, causes birth defects – including foetal death – increases female and male reproductive dysfunction and adversely affects a variety of hormonal processes involving insulin, thyroid hormones, and steroid hormones. Few chemicals cause such a wide variety of effects, and none exhibit dioxin’s astonishing toxicity (Ibid).
Environmental Health scenario in India

“Developing countries like India typically experience an epidemiological transition from a communicable disease profile to one characterized by non-communicable diseases on their path to economic development. India faces a complex situation with the increasing incidence of non-communicable health problems without a considerable reduction in the prevalence of communicable diseases” says The Economic Times Healthcare (ET HC) 2002.

If we were to examine the reason for this, especially in conjunction with the fact that there has been almost no reduction in the prevalence of communicable diseases in India since 1973-74 with the share of deaths due to communicable diseases even in 1997 being 43.3%, of which, deaths due to infectious and parasitic causes being 23.4% and due to respiratory infections 11.7% besides well-known ones like maternal causes 1.4% and prenatal causes 6.9% (FRCH, 1997), the situation is alarming. Deaths due to non-communicable diseases have also risen to 50.2% in the same period and have been increasing at 13 and 14% rate respectively in rural and urban India (Census of India, GOI, 1980, 1992, 1998). Therefore, it becomes obvious that this is because governmental emphasis and consequently the expenditure on public health have not been very high. Average government spending on health as a percentage of their GDP, for low human development index (HDI) countries is about 1.5% as against 2.2% in medium HDI and 6.1% in high HDI countries and often more than 9% in the most developed and OECD countries. In India, the trends in government spending show that the expenditure on health has not been encouraging over the plan periods. It had dropped from 3.3% in the first plan to 1.7% in the 8th plan (ET HC 2002). At present in the 10th plan period, it is envisaged to be 5.5% of the Net National Product (NNP) (COI, 2001) but what has been achieved is 4.9% of the GDP in 2000 which is again a decline from 1997 figures when the total health care expenditure was 5.3% of the GDP (WHO, 2000). Expenditure on preventive care has been moderate. The largest part of the spending has been for curative care. Furthermore, expenditure reflects an urban bias. As against 75% of the population living in the rural areas, only 25% of the spending has been made in rural areas. Salaries and establishment costs constitute major component of the government health spending - 40-59% during 1974-1991 (ET HC 2002).
Health is linked to other amenities like clean drinking water, sewerage systems, poverty, literacy levels and infrastructure. Higher government spending on healthcare can result in lower incidence of diseases especially communicable diseases. Tuberculosis (TB) alone accounts for a loss of approximately 11 million disability adjusted life years (DALYs). It remains one of the leading causes of disease and death in India in spite of the National TB programme (NTP) being in place for over 30 years (ET HC, 2002).

Similarly, there are an estimated 3.9 million people infected with HIV in India today (UNAIDS, 2003). Nearly one in every 150 adults in India is infected. Prevalence of HIV infection has been on the rise practically in all states and all population groups in India. HIV is also spreading rapidly in rural India as in urban areas (AIDS Prevalence, 1999, ET HC, 2002). New health problems such as drug resistant forms of several communicable diseases have emerged, including malaria, filariasis and TB. Hepatitis B is another major health problem with an estimated 350 million carriers in the world. Of these, 43 million are in India and 2 lakh people die every year due to this deadly disease according to the Foundation for Research in Community Health (FRCH), 1997.

Many of the communicable diseases are spread through the environment, through particulate matter or aerosols in the air, through water and food. They are also transmitted through untreated waste – biomedical and others which often act as carriers or vehicles for microorganisms and cause injury to the people handling these wastes, creating a portal for entry for these pathogens. The environment is also the reservoir for many unwanted chemicals which are genotoxins and these contribute to the decline of immunity amongst humans, animals and even damage the ecosystem’s ability to control or stabilize pathogenic micro-organisms.

**Morbidity and Mortality status in India**

The morbidity or prevalence of illness in both rural and urban areas is quite high with the average for all ages in rural areas amongst males is 105.5/1000 and amongst females is 108.1/1000. Similarly in urban areas, the average for all ages amongst males is 98.2/1000 and amongst females is 108.4/1000 according to the NCAER Household survey of healthcare utilization and expenditure, 1995.
In the death rates by sex per 1000 population for all ages in selected countries of the South East Asia Region, death rates in India is 9.1 (10.2 acc to WHO, 2000) for males and 8.9 (9.1 acc to WHO, 2000) for females. This is considered quite high since even Thailand and Sri Lanka have lower mortality rates than India. Although, the general life expectancy is said to have gone up from 49.1 in 1947 to 60.8 in 2001 with 60 years in males and 61 years in females in India being the average, the disability adjusted life expectancy (DALE) is at an average of 53. The percentage of population above the age of 60 years has increased from 6.9% in 1991 to 7.7% in 2001. By 2020, life expectancy is projected to reach 70 years (WHO 2000, Census, 2001, ET HC, 2002). The probability of dying under 5, is 89 for males and 98 for females per 1000 and for ages 15 to 59, it is 291 for males and and 222 for females per 1000 which does not reflect a good performance (WHO 2002).

*Morbidity and Productivity in India*

A nation usually pays for ill health in terms of increased costs and lower growth. According to studies conducted by the WHO, poor health in the form of disability, reduces wages by as much as 12 per cent and has negative consequences on labour productivity (ET HC 2002).

Typically, in low-income countries, the greatest burden of disease results from communicable diseases like respiratory illness and measles, malnutrition and complications of pregnancy and childbirth. The worst scenario is a partial transition wherein a large part of the society makes a transition and begins requiring costly hospital treatment for chronic illness. On the other hand, the very significant balance remains mired in an earlier (communicable) disease profile. India is currently in this stage.

*Growth of healthcare industry in India*

Although 60 per cent of the beds in India are in the government sector, the main factor in the growth of the healthcare industry is the demand for services – a factor of health indicators and the disease burden. Although government expenditure on health is around 5% of the GDP, more than 80% (82.2% in 2000) of the expenditure on health is privately funded and of this 85% of the expenditure is out of pocket, which highlights the
considerable pressure on individuals while also highlighting a dismal picture of health status and lack of importance accorded to environmental and public health in India (WHO, 2000).

This poor health status and demand for services has also led to a phenomenal growth of private healthcare establishments in the country. Delhi has nearly 9000 establishments of which more than 50% are in the private sector (Mani et al, 2001). Ninety nine per cent of the healthcare establishments in Delhi are the smaller ones including nursing homes, dispensaries and clinics of private practitioners, laboratories etc. (Ibid). Although larger hospitals especially those providing secondary and tertiary care generate large amounts of infectious wastes, the scattered smaller establishments contribute to one third of the healthcare wastes and a half of biomedical waste produced in Delhi and since none of them segregate their wastes, decontaminate or disinfect them before discarding their wastes in municipal bins, their entire waste is infectious and hazardous (Ibid). Furthermore, since many of the pathogens can breed and multiply in the organic matter present in the municipal garbage, they render the municipal wastes in the bin also infectious, thus increasing the total quantity of infectious wastes which can contribute to the increased morbidity in the city (Ibid).

**Delhi’s environmental health status**

Notwithstanding the change in fuel in many public transport vehicles, the air quality status of Delhi remains highly polluted. Many more vehicles will have to be converted to CNG before the positive effect is felt on the general pollution level. Generation of particulate matter is at present about 1500 tonnes per year and nitrous oxide emissions are 9.7 lakh tones per year. The ambient respirable suspended particulate matter (RSPM) is 346µg/m$^3$ still two to three times above the acceptable limits of 100µg/m$^3$ (CPCB, 2002).

RSPM causes asthma and respiratory diseases and sustained exposure can cause lung cancer. The toxicity of the particulate matter depends on the source, for e.g. diesel emits particulates containing polyaromatic hydrocarbons which are carcinogenic. In fact, according to the WHO, there can be no permissible limits for RSPM as it is dangerous in very low concentrations.
Similarly, other pollutants like sulphur dioxide, oxides of nitrogen, carbon monoxide, lead and benzene are still way above acceptable or safe limits in Delhi, often touching alarming levels. Sometimes, the level of carbon monoxide reaches $4,141 \mu g/m^3$ more than double the recommended maximum limit levels of $2000 \mu g/m^3$. Nitrogen dioxide is just above the mark at $76 \mu g/m^3$. Besides these, there are hundreds of chemicals and dusts from vehicles, different types of industries, power stations and the service sector, which are constantly being dumped into the city’s atmosphere so much so that it is estimated by an NGO that the “city’s air kills a person every hour” (CSE, 2002). The Central Pollution Control Board (CPCB) too admits that many of these pollutants released into the atmosphere every day like benzene are extremely carcinogenic while lead damages kidneys, nervous and reproductive systems besides causing mental retardation in children. RSPM and sulphur dioxide aggravate respiratory and cardiac problems, while these along with oxides of nitrogen lead to different allergies and burning sensation in eyes, cause headaches and increased susceptibility to viral infections (Ibid).

Delhi’s soil and water contamination has also reached enormously toxic levels. Of the 1367 km from Yamunotri to Allahabad, the Yamuna receives 80% of its pollutants in the 22km stretch that it traverses in Delhi. Of the approximately 300 million litres per day (MLD) of industrial waste water generated in the city every day, the Common Effluent Treatment Plants (CETPs) manage to treat less than one fifth while most of it is either let into the Yamuna through the various open drains or dumped into the ground through holes dug in the industrial estates (Times of India (TOI), 2002, 2003). Of the approximately 1800 million litres per day (MLD) of sewage produced in the city, only about two thirds is being treated although there are 12 sewage treatment plants commissioned since 2001 capable of treating all the sewage produced. However, since the system of taking sewage to the plants has not been rectified and there are leaks in many places, it is the ground water in different parts of Delhi that is getting contaminated and has different levels and types of contaminants in it.

A study done by the Central Ground Water Board and the Delhi Pollution Control Committee in 1998 showed that the sub-soil water reserves in parts of southwest, east and northeast Delhi was unfit for drinking. Apart from these areas, some other parts also had excessively high levels of contaminants like pesticides, nitrate, fluoride and salinity (TOI,
Samples collected by Food Research and Analysis Centre (FRAC), a laboratory run by the Federation of Indian Chamber of Commerce and Industry, revealed that several samples of drinking water, seven of which were samples of ground water, had pesticides lindane, Chlorpyrifos and malathion. Pathogens were found in eight samples. Coliform bacteria was found in two samples; fungi like yeast and moulds were found in six (TOI, 2003).

Fluoride concentration has been found to be high in soil and water in areas, which once housed brick kilns, in industrial belts and close to highways. These areas also exhibit very high levels of heavy metals like hexavalent chromium, cadmium and lead (TOI, 2003). Delhi generates an estimated 6000-7000 tonnes of solid wastes per day of municipal solid waste, of which hardly 15% may be segregated either for recycling or composting, while the rest is dumped indiscriminately in Ghazipur, Bhalsawa and Okhla garbage dumpsites. Although 55 to 60% of Indian garbage is made up of putrescible, organic matter, it also includes other toxic substances like batteries, paints, pesticides and plastics which are acted upon by the acids in the natural decomposition process and cause leaching of these toxins and heavy metals into the soil and underground water (Mani et al, 2001). Garbage dumping, fertilizer runoffs, open defecation, dumping animal wastes and leaking septic tanks, lead to excess nitrates and nitrites in soil and ground water. While a high fluoride content in water leads to dental and skeletal fluorosis, bone deformation etc., excess nitrites are known to be responsible for the ‘blue baby syndrome’ -- a condition wherein babies are born with holes in the heart (defective interventricular septum). Excess nitrates are also known to cause skin discolouration and digestive system disorders while salinity in water due to high dissolved solids can cause salt imbalance among humans and animals (TOI, 2003).

In a study done by the Department of Microbiology, University of Delhi, to assess the microbial load of different types of water in the national capital territory of Delhi, the geometric mean of the total coliform count (TCC) and the Fecal Coliform Count (FCC) in the river Yamuna were $6.4 \times 10^6 / 100\text{ml}$ and $3.2 \times 10^6 / 100\text{ml}$ respectively which was approximately 1000 times more than $7.8 \times 10^3 / 100\text{ml}$ and $4.2 \times 10^3 / 100\text{ml}$ respectively of the samples collected upstream of Delhi. In ground water, the number of TCC and FSC (Fecal Streptococcal Count) varied between $2.3 \times 10^3 / 100\text{ml}$ and $1.1 \times 10^3 / 100\text{ml}$, and with FCC as much as $1.4 \times 10^2 / 100\text{ml}$. The presence of fecal coliforms even in the
deeper segments (> 60-70 ft) indicated that even ground water could not be regarded as free from contamination by disease causing microorganisms (Singh et al, 2001).

Similarly, in a study on genotoxicity of the concentrated water samples from the river Yamuna at Delhi done by the Department of Agricultural Sciences, Aligarh Muslim University (AMU), the damage brought about in the DNA repair defective strains in the presence of XAD concentrated water samples was found to be remarkably high as compared to liquid-liquid extracted water samples at the dose level of 20 l/ml. All the mutants invariably exhibited significant decline in their colony forming units compared to their wild type counterparts. The survival was decreased by 76.8% (lex A+) and 86.3% (pol A+) after six hours of treatment with XAD concentrated water samples while in case of liquid-liquid extracted water samples, the survival was decreased by 56.7% (lex A+) and 68.5% (pol A+) after six hours of treatment under the same experimental conditions. Test water samples also exhibited significant decline in plaque forming units, the damage was more pronounced in lex A+ mutant when the phage was treated with XAD concentrated water samples. The results suggest that the damage to DNA of the exposed cells as well as role of rec A+, lex A+ and pol A+ genes to cope with the hazardous effect of the pollutants. These genes believed to initiate the SOS response are important in the context of the ecosystem. Genotoxins in the river water may be transported to the food chain, may contaminate drinking water and may damage aquatic ecosystem (Aleem, 2001).

Mortality and morbidity status in Delhi

The Morbidity Prevalence Rates (MPR) for urban India from the NCAER study (COI, 1998) was 101 per thousand, indicating a morbidity rate of 10.1 per cent. However, another study (Gupta et al, 1998) yields a much higher rate of 61 per cent especially in Delhi. Some difference in these rates can be expected because in the latter study sample comprised only slum dwellers who belonged to a much lower socio-economic category. However, the difference is too large to be explained only by the sample, unless it is also true that the health status of these slum dwellers is indeed a cause for alarm (Ibid).

Low income areas in Delhi have a morbidity rate of 52%, middle income areas of 43% and high income areas of 33%, significantly higher than the national average of 10-11%
amongst urban population (Gupta et al, 1998), indicating the contribution of poor environmental quality to morbidity and the susceptibility of the urban poor, in fact of the entire population of large metropolises to illnesses leading to not only just double burden (infectious as well as chronic diseases) but also triple and quadruple burdens of disease and disability due to dangers posed by hazardous chemicals and HIV. As regards healthcare wastes management, the people most at risk are healthcare workers, waste handlers and hospital maintenance personnel. “Scavengers” who comb waste sites for articles that can be recycled and reused may sustain injuries and come into direct contact with infectious microorganisms, dusts and disease vectors such as rats and flies.

According to WHO published ‘Health and Environment in Sustainable Development’, 1997, health surveys show that the health status of all those who handle waste especially the scavengers and their families is extremely poor especially those who build their homes very close to, if not, on landfill sites. As well as being exposed to a wide variety of waste induced health hazards, they are also frequently subject to social and economic abuses from waste recycling traders. Hence their health is very poor and their life expectancy far below national averages. As is well known, 40% of Delhi’s population lives in slums and most of these slum-dwellers are at least part time “scavengers” or help in sorting or reprocessing the waste which includes a sizeable amount of healthcare waste. It has been shown in the survey conducted by the Institute of Economic Growth in 1998, that the health of the less privileged population remains poor. This is especially true among those handling waste and especially bio-medical waste (Krishnamurthy, 2000).

The death rates by sex per 1000 population for all ages in Delhi, both in rural and urban population is 5.4. There are other states in India where the death rates are higher, the highest being in Bihar, Uttar Pradesh, Madhya Pradesh and Orissa with total death rates ranging from above 10 (COI, 2001).

Although biomedical waste management may not be altogether a new topic, one can say that due to a phenomenal growth in the healthcare industry, proliferation of healthcare establishments, the nature and the amount of healthcare waste being discarded in the general environment today, it is contributing to a new form of the traditional communicable diseases problem in our cities, towns and rural areas and also adding to
the chemical burden and increasing our susceptibility to chronic diseases. This leads to increasing morbidity in all classes and sections of the society and needs to be addressed urgently.

**Biomedical waste management status in Delhi**

A large hospital in Delhi dumps infectious/hazardous waste in the municipal bin situated some distance away from the hospital. The Municipal Corporation of Delhi (MCD) bin or ‘khatta’ in the local parlance, is a fairly large room enclosed on all sides with doors in front. It receives not just infectious/hazardous waste from the hospital but also waste bags from another nearby large hospital and domestic waste from hospital staff quarters nearby. Inside the ‘khatta’ two to three persons sift through whatever waste is brought from the hospital on a daily basis and pick out syringes (some with blood, the needles are tossed onto the pile of rubbish which are picked up by MCD workers), IV bottles, tubes, soiled cotton, medicine vials. Half-filled urine bags, mattresses also find their way into the kabari regularly, through the safai karamchari route. The incinerator is shut down on Sundays and the ash is removed. The ash is probably sold or taken away by the kabari’s employees. Thus on three Monday mornings of the month, during which the study was conducted in this area, mounds of incinerator ash was also seen at the kabari. The ‘utility’ of the ash stems from the resale value of the half burnt materials found in it. Half burnt bottles, vials, metallic objects – anything is pulled out of it (CEC, 2001).

A woman who stayed in the hut adjacent to the kabari’s along with her children, a girl aged seven and a five year old boy were seen digging into the ash and pulling out half burnt items on one occasion. On yet another occasion, a seventeen-year-boy was at the task. Entire bags of infectious waste including blood soaked cotton, syringes, (some with needles intact) and tubes with blood, blades, tube like contraptions, whole gloves besides paper and canteen waste comes out of the hospital premises twice a day. These bags in a closed ‘thela’ are taken by the ‘kabari’s employees’ to the sorting area in nearby Taimoor Nagar (a slum). The quantum of waste coming out is quite substantial as big plastic tubs get filled with needles, syringes, tubes, IV bottles etc., in half a day. The waste provides employment to 4-6 people daily. Apparently, the cotton is further sold to people in the same basti, where it is washed. The blood is drained out of syringes at the time of segregation and emptied into the ‘nallah’ outside (through which children and adults
wade everyday). (In another large hospital)..., it was noticed that the incinerator was shut down in the afternoons leading to a pile-up of bags. Pilferage of bags from the incinerator area is a regular feature. Conversation with a kabari behind the hospital revealed that the means of getting the waste out was illegal and it makes its way to a particular kabari. (Ibid).

How does the local body deal with this issue? They have an assembly line system of operation wherein four of their employees shovel the waste in the bin into wicker baskets with spades. Their forearms and even hands sometimes come in direct contact with the waste. It is then loaded onto the heads of the three waiting and thrown into the lorry outside. Their salary is Rs.2500 a month. When they get needle stick injuries, the Municipal Corporation of Delhi (MCD) does not provide any medical facilities. They have to get treated at their own expense. Sometimes when the wound is painful or deep, they go to a neighbourhood doctor and pay Rs10-15 for an injection (Ibid).

The situation in other municipal dumps catering to hospitals across the country is probably no different. Thus one can see how irresponsible methods of waste management by the hospitals lead to not just environmental and public health hazards but also have the potential to severely affect the health of an unsuspecting population that handles hospital waste for a livelihood.

**Role of legislation in Biomedical Waste Management**

The need for hazardous waste management in hospitals, the regulatory background, insights for determining which hospital waste streams are hazardous or infectious, and practical aspects of hazardous waste management for hospitals need to be legislated. In the study (Mokler 1987), the author focused on the requirements of the federal Hazard Communication Standard, its relationship with state and local "right to know" laws and actions and the reason why a hospital should institute a hazard communication programme.

A number of incidents involving improper handling and disposal of hospital waste have prompted the demand for more stringent legislation to cover the management of infectious hospital waste. Resolution 53 (December 1987 Interim Meeting) called for the
American Medical Association to promote the passage of federal legislation for the proper disposal of infectious hospital waste. This resolution prompted a Council on Scientific Affairs report on the current status of infectious hospital waste management and of state and federal regulations to control such waste. The Council has concluded that existing federal and state regulations for the management of hazardous waste—in conjunction with the accreditation program of the Joint Commission on Accreditation of Healthcare Organizations and the guidelines of the Environmental Protection Agency and the Centers for Disease Control, if adhered to and properly enforced—should be adequate to ensure that the public and environment are not endangered. Therefore, the Council did not favor additional federal legislation at this time and recommended that this report be accepted in lieu of Resolution 53 (Rutala, 1989).

Several laws and guidelines on the disposal of waste from hospitals and practices differentiate between diverse types of waste. The LAGA instruction sheet in Germany lists five types: type A = hospital waste, type B = medical waste, type C = infectious waste, type D = chemical waste, and type E = human-pathological material. Especially the basis of differentiation between medical and infectious waste is the list of notifiable infectious diseases according to section 3 of the Federal Law on Epidemic diseases. Section 10a confines the list to contagious infectious diseases (Muller, 1992).

The Government of India came out with a Bio-Medical Waste (Management and Handling) Rules following a Supreme Court ruling in this regard to bring an end to this problem. However, support from various state governments to enforce these Rules have not been forthcoming. No state government can claim to have implemented these Rules totally as yet. The first deadline for enforcement of these Rules was set in December, 1999. The deadline was subsequently extended to June 30, 2000 for hospitals with a bed capacity of over 500 following requests from several large private and government hospitals. The deadline for hospitals with bed capacity from 200 to 500 was set at December 31, 2000 while hospitals with a bed capacity ranging from 50 to 200, it was December 31, 2001. Large hospitals with bed capacity above 500 were also required to follow a set of detailed norms regarding collection, transportation and treatment of biomedical wastes. Even after the June, 2000 deadline, most of the large hospitals have not complied with these Rules. As there is no specified authority to monitor the
implementation of these Rules, whatever enforcement of these Rules is possible is being done by the state pollution control boards. But, the fact is that in most of the states, the pollution control boards do not have adequate powers to enforce the Rules. In short, strict implementation of this set of Rules is not going to take place that easily in most parts of the country even after expiry of the new deadlines. In a situation like this, NGOs and other voluntary bodies have to come forward and compel the hospitals and nursing homes to fall in line with the Rules (Francis, 2000).

The present status is that the final deadline of December 31, 2002 for all categories of healthcare establishments is also gone without the complete implementation in any city, town or state. However, the PCBs are finding new methods of implementing the Rules and a lot of training combined with stricter penalties have helped at least some states to move forward in this area (Mani et al, 2002).