CHAPTER II

REVIEW OF LITERATURE

2.1 ENVIRONMENTAL SANITATION DURING ANCIENT TIMES

“Cleanliness is next to godliness” has been an old dictum. The essence of this was aptly captured by the Dravidians, who gave due emphasis to immaculate town planning, having safe and effective sewerage systems which got rid of all solid and liquid wastes generated by the population even in 5000 BC. They were indeed, the pioneers as far as scientific waste management is considered; which is borne out from the excavations of Mohen-jo-daro and Harappa. As a matter of fact, all ancient civilizations took special care of cleanliness and hygiene.¹⁷

Little is known about the prehistoric origins of either personal or community hygiene. Some hints may be gleaned, however, from a study of tribal customs and rules of contemporary primitive groups. With few exceptions they have a certain amount of group and community hygienic sense usually derived from experience with survival. Rules against the fouling of family or tribal environments are almost universal. Many have taboos against the use of the upstream side of the campsite for excretory purposes. Burial of excreta is not uncommon. However, this practice is sometimes based on superstition rather than sanitary concepts. Many groups have elaborate provisions for disposal of the dead. Almost all primitive people recognize the existence of disease and engage in forms of voodoo or tribal dancing (psychosomatic medicine), temporary banishment (isolation and quarantine), or smoke and noise (fumigation) to drive away the evil spirits of disease.

During ‘epic’ era and later, when man settled down to follow an ‘agrarian’ way of life with surplus cultivation, ‘grain stock’ and domesticated pets, various treatise were also developed and practiced viz. Ayurveda – which embodied principles of maintaining health as a way of life – our daily routine. In addition, Manu’s code of Hygiene, Patanjali’s ashtanga yoga,
Vatsyayana’s kamasutra and Kautilya’s arthasastra defined Hindu way of leading disciplined life. All the principles enshrined in these treatises were conducive to attain good personal family and public health. In Ayurveda various herbs were prescribed for their medicinal uses. Buddhism also prescribed a way of life to attain good health.

CLASSICAL CULTURES

They had a considerable sense of personal cleanliness, possessed numerous pharmaceutic preparations, and constructed earth closets and public drainage pipes. The Hebrews extended Egyptian hygienic thought and formulated in Leviticus, about 1500 BC, what is probably the world’s first written hygienic code. It dealt with a wide variety of personal and community responsibilities, including cleanliness of the body, protection against the spread of contagious diseases, isolation of lepers, disinfections of dwellings after illness, sanitation of campsites, disposal of excreta and refuse, protection of water and food supplies, and the hygiene of maternity.

Since ancient times, human life has been threatened with diseases of all kinds. Historical records from the Egyptian, Roman, Greek, Indian, and Mayan civilizations reveal the dreadful nature of infectious diseases and how they were overcome. The teachings of Lord Buddha, as well as the Bible, the Koran, and Judaic literature, covered various aspects of personal hygiene and other public health practices, including civic duties. Sanitation measures were enforced through royal decrees.

The treatise on economics and government by Kautilya (around 300 BC), during the early Maurya dynasty in India, showed how a king ensured the health and prosperity of his subjects through various measures and regulations. Heavy punishments were imposed on those guilty of adulteration of goods, sexual violence, or of littering the streets. The royal proclamation also prescribed rules for establishing brothels and entertainment centres.

Quarantine and prohibition were major measures used historically to protect the transmission of diseases and remain as public health measures used by governments in many countries.
During middle ages major changes were witnessed in western Roman world where the Church had a major role in caring for the sick. The Church and the king were often in conflict regarding their relative supremacy in daily governance. This was reflected in the public health scene also. The goal of promoting people's health stemmed from the desire of Catholic rulers to supplant the Church as the primary regulatory agency. The industrial revolution and its aftermath in the form of deplorable health of the workers in 18th century removed the responsibility of the hospitals from the hands of the Church into those of the nation.

**THE MIDDLE AGES**

The transitional period, which lasted from about AD 500 to 1500, is especially interesting from a hygienic and epidemiological viewpoint. Classical ideology was dualistic and believed that full spirituality could be achieved only by freeing the spirit from the body and from the material world. It regarded the world and the flesh as evil.

So intense was the reaction that it even included a significant change in attitude toward sanitation and personal hygiene. It was considered immoral to view even one's own body; therefore people seldom bathed and wore notoriously dirty garments. This is said by some to have been partly responsible for the eventual widespread use of perfume in this period. Diets in general were apparently poor and consisted of badly prepared or preserved foods. This gave rise to the widespread use of spices and the search for trade routes to obtain them. Sanitation was ignored. Refuse and body wastes were allowed to accumulate in and around dwellings. Slops were thrown onto the roads or streets.

After the death of Mohammed, it became a religious custom to make a pilgrimage, or hajj, to Mecca, the place of the prophet's birth about AD 570. During each great hajj, among the many thousands who converged on the small city were some from far-off Asia, including India, which was and still is the endemic centre of cholera. Cholera naturally spread rapidly throughout the thousands of pilgrims, who disseminated it along their homeward routes of
travel and throughout their respective homelands. Thus, each hajj was almost invariably followed by a pandemic of cholera.

Complicating this, beginning in AD 1095, were the hordes of Christian crusaders to the Middle East from all parts of Europe whose wanderings inevitably resulted in periodic seeding of the European continent with the vibrio of cholera as well as other agents of disease.

During the early Dark Ages, leprosy spread probably from Egypt to Asia Minor and eventually throughout Europe, compounded by the Crusades and other great migrations. It apparently was a far more acute and disfiguring disease than is presently observed in most of the western world, and because of the terror to which it gave rise, laws were passed to regulate the conduct and movement of those afflicted. In many places lepers were declared civilly dead and were banished from human communities. They were compelled to wear identifying clothes and to warn of their presence by means of a horn, bell, or clapper and by crying the word unclean. This had a twofold result: it was an effective isolation measure, and it usually brought about a relatively rapid death from hunger and exposure as well as from lack of treatment and care. These measures, inhuman as they were, almost eradicated leprosy in Europe (but by no means in the world) by the sixteenth century and may be regarded as an early, although unplanned, victory in epidemiology.

THE BLACK DEATH

No sooner had leprosy passed its zenith and begun to decline than an even deadlier menace appeared in the form of bubonic plague. Its spread is illustrative of a momentous ecologic phenomenon. The origin of the source was the vast plain of central Asia. The men who were infected were Mongols whose traditional life was that of nomadic herdsmen. Their leader, Chingis Khan, lived at a tent capital, Karakorum. In 1219 he gathered an army that was rapidly mobile by means of fast ponies and began a vast sweep of conquest that eventually included western Asia, the Middle East, Egypt, the Balkans, and eastern and central Europe.20-21
From then on the spread of plague was rapid and repetitive, compounded by other military activities, crusades, dislocated populations, and trade. Probably nothing ever came so close to exterminating the human species. During the 1340s more than 13 million people died from the disease in China. India was almost depopulated. Tartary, Mesopotamia, Syria, and Armenia were said to be covered by dead bodies. At its peak, Aleppo lost about 500 people and Cairo, from 10,000 to 15,000 people daily. In Gaza 22,000 people and most of the animals were carried off within 6 weeks. Cyprus was depopulated, and ships without crews were often seen in the Mediterranean and in the North Sea, drifting aimlessly and spreading plague when they drifted ashore. It was reported to Pope Clement VI that half the population of the known world had died. The figure given was about 43 million. The total mortality from the Black Death is thought to have been over 60 million. Europe, particularly during 1348, was devastated. Florence lost 60,000 people, Venice 100,000, Marseilles 16,000 in 1 month, Sien 70,000, Paris 50,000, St. Denys 14,000, Strasbourg 9,000, and Vienna 1,200 daily. In many places in France only 2 out of 20 survived.

Plague continued to ebb and flow like a tide, periodically sweeping over the European continent. For example, in London in 1603 another sixth, and in 1665 about one fifth. During 1790 Marseilles and Toulon lost 91,000 people; in 1743 Messina lost 70,000; and in 1759 about 70,000 died on the island of Cyprus.

Out of these terrifying experiences and despite the view of divine or cosmic causation of disease, certain groping attempts were made to forestall the apparent inevitability of epidemic disaster. In 1348 the great trading port of Venice banned entry of infected or suspected ships and travellers. In 1377 at Ragusa (present-day Dubrovnik) it was ruled that travelers from plague areas stop at designated places outside the port and remain free of disease for 2 months before being allowed to enter. Historically, this represents the first quarantine measure, although it involved a 2-month interval rather than the literal 40 days. This procedure is of particular interest as it implied a vague realization of the existence of an incubation period for a communicable disease.
disease. In 1383, Marseilles passed the first actual quarantine law and erected the first quarantine station. These are historic landmarks in public health administration and epidemiology, but unfortunately their effectiveness was impaired by the fact that although great attention was paid to humans, the role of the rat and the flea had not yet been discerned. 19-20

OTHER DISEASES 22-23

Some mention, even if necessarily inadequate, should be made of the rapid dissemination of syphilis throughout Europe and the Near East after the discovery of America, where it is commonly thought to have originated. Some measure of its incidence and seriousness is indicated by its vernacular name, "the great pox", which was used to distinguish it from smallpox, now considered serious enough.

Gradually, a concept emerged that certain diseases can be prevented by taking specific prophylactic action e.g. role of citrus fruits in prevention of scurvy. Bacteriologic and immunological discoveries of the late nineteenth and early twentieth centuries and their application also helped in concretizing the concept of Preventive Medicine.

Development of the Germ Theory in later part of 19th century promoted the idea that a specific organism caused a specific disease. As it became apparent that certain vehicles served as the means for the transmission of disease-producing organism, attention was directed to such specific measures as the protection of water supplies, milk, and other foods, the elimination of insects, and the proper disposal of sewage. A natural further advance was the development of laboratory procedures.

In mid-nineteenth century (1850-1880) the approach to disease control was based on the misconception that disease was caused by noxious odours, dirt, and general lack of cleanliness. Diphtheria was thought to be caused by gases associated with putrefaction. The term malaria literally means “bad air.” Because it was observed even as early as Hippocrates that people who ventured about at dusk were those who invariably contracted malaria, the common belief persisted into the late nineteenth century that the disease was
a result of the particular air existing at dusk. Here was an illustrious example of interpreting mere coincidence as a cause-and-effect relationship. Disease control efforts were directed entirely toward general cleanliness. Garbage and refuse collection became important to communities. Street cleaning was pursued relentlessly. These general cleanliness measures were not directed at the specific causes of disease and consequently were of little value in control. It was during this period when such concepts prevailed, that the concept of ‘Hygiene’ as a separate discipline/department evolved.

Louis Pasteur, Robert Koch, and other bacteriologists demonstrated that a specific organism causes a specific disease. As it became apparent that certain vehicles served as the means for the transmission of disease-producing organism, attention was directed to such specific measures as the protection of water supplies, milk, and other foods, the elimination of insects, and the proper disposal of sewage. A natural further advance was the development of laboratory procedures.

During this same period Lord Joseph Lister (1827-1912) developed the practical use of phenol (carbolic acid) as an effective antiseptic. Simultaneously, many vaccines were developed during this phase. Thus, the emphasis was on prevention of disease in the individual. This development stimulated the concept of ‘Preventive Medicine’.

Official public health departments were staffed with bacteriologists, laboratory technicians, sanitarians, sanitation inspectors, sanitary engineers, quarantine officers, and others who specialized in disease control measures.

During the eighteenth and the nineteenth centuries, the condition of the streets of most European cities became deplorable, caused in part by night men and scavengers emptying their carts in the streets instead of the places assigned for the purpose. The accumulated filth of the eighteenth-century house was in many cases simply thrown from the doors or windows.

These conditions under which so many people lived and worked had dire results. Smallpox, cholera, typhoid, tuberculosis, and many other diseases reached exceedingly high endemic levels, and the contamination of
streams became so bad as to prompt the statement in Parliament in 1859: “India is in revolt and the Thames stinks.”

**ENGLISH SANITARY REFORMS**

Concern with the economic consequences of existing social and sanitary conditions began to appear, providing leaders in sanitary reform with forceful arguments. Thus, environmental sanitation has been the dominant concern of disease and prevention throughout the human history.

Public health went unrecognized in a legal sense in England until 1837, when the first sanitary legislation was enacted. It established a National Vaccination Board and appropriated 2,000 pounds for its support. As a result, a few vaccination stations were set up in the city of London. This modest beginning was followed in 1942 by Edwin Chadwick's momentous Report on an Inquiry into the Sanitary Conditions of the labouring population of Great Britain, one result of which was the establishment in 1848 of a General Board of Health for England.

Improvements rapidly followed. Advances in sanitation and hygiene did not go forward alone. Legislation was passed concerning factory management; child welfare; care of the aged; the mentally ill, and the infirm; education; and many other phases of social reform. It was not long before the horrors of previous conditions were forgotten and the standards of order, decency, and sanitation began to be taken for granted.

Above description of history of public health indicates the role of environment in health. In the last 200 years, hospitals have come to occupy a central place in health care of general public. Hospitals also affect environment and in turn get affected by it. Recently, a concept of ‘Health Promoting Hospitals’ has emerged.

With the advent of hospitals, came the vexed problem of safe handling and disposal of hospital wastes. Keeping in view the mindset of high and middle level managers; and, the fact that waste management was an undignified and unquestionably menial job, no wonder it was relegated to the
group ‘D’ staff who were headed by a sanitary supervisor. Even now, after widespread condemnation of hospital waste management practices and the directives of various hon’ble Courts, the interest and positive approach that is imperative for proper waste management is distinctly lacking.

The last century witnessed the rapid mushrooming of hospitals in the public and private sector, dictated by the needs of the expanding population, and the advent and acceptance of “non-biodegradable disposables” has made the generation of hospital waste a significant problem in present hospitals.

In the present scenario, hospital wastes are being considered at par with the ordinary municipal garbage. The result is that we have dangerous garbage dumps all around us, which may contain nearly 50% infectious wastes, contaminated with the disease producing pathogens. These may include waste secretions from human beings and animals, items saturated with blood and body fluids, discarded medical equipment’s, plasters, soiled cotton, dressings etc. The scientific approach to ensure a disease-free handling is missing and is not even on cards. The recommended segregation policy is said to be totally impractical. Application of disinfection techniques is confined only to papers. The front related to water contamination is equally in a dismal shape. Liquid discharges as a result of disinfecting operations etc. raise the effluent parameters substantially. The efficiency of municipal sewers and sewage treatment plants may reduce as a result of this shock loading. These hospital wastes provide fertile environs for bacteria, virus and other microorganisms to multiply. Pathogens like E-Coli, Salmonella typhi, Vibrio cholerae, Hepatitis, Shigella etc are quite prevalent and active till these wastes are properly incinerated and can be carried far away.

The list of diseases caused due to the improper disposal and treatment of hospital wastes is endless, but majority of these are deadly such as AIDS, viral hepatitis, tuberculosis, bronchitis, gastroenteritis and other skin and eye related disorders. Contamination of the ground water, soil and land may also result from all this. So-called sensitive areas in and around the hospitals are soon becoming the disease prone areas.
2.2 HEALTH FIELD THEORY-A HISTORICAL PERSPECTIVE

In context of environmental sanitation, the concept of health promotion has gained special importance over last 50 years. Health promotion is a set of activities, which are not directed at any particular disease but are intended to improve the general health and well being of the individual and the community. Health promotion implies 'those actions which are taken before disease onset to maintain and promote good health'. This includes following activities:

1. Safe water supply
2. Safe disposal of excreta and other waste
3. Arrangement of adequate health services
4. Adequate nutrition
5. Healthful housing
6. Control of insects and rodents
7. Safe working conditions
8. Recreation facilities
9. Health education
10. Marriage counseling
11. Genetic counseling
12. Sex education
13. Physical education
14. Periodic health screening
15. Improvement of standard of living of people

For example, city planners may take a conscious decision to ensure clean water, clean air, clean surroundings, regular electricity and water supply, good roads, adequate medical & educational institutions, green covers, good transport system, parks, playground etc. for the citizens. Clearly, all these services fall under health promotion as these activities are undertaken before disease onset. None of these are directed towards a particular disease. These seek to improve the living conditions of the people. These activities and facilities ensure general well being of people and strengthen their body resistance. Basically, all such activities are inherently
desirable for a healthy society (irrespective of the health directionality of such measures).

The Ottawa Charter (WHO, 1986; Health Promotion, 1986) provided an international clarion call for action towards a new public health. It embodied the principles of health promotion; its major thrust was for social change and political activity.

### 2.2.1 The Anatomy of Health Promotion

Tannahill has developed an elegant model in which health promotion is viewed as a number of different combinations of prevention, health protection and health education (Downie, Fyfe and Tannahill, 1992). The model however, differs in its concern to emphasize and explicate the contribution made by education; its structure represents a development of the familiar health field concept (Figure 2.1).

**Figure 2.1**

The Health Field Concept
The health field concept was popularized in a working document on the health of Canadians, which became widely known as the Lalonde Report (Lalonde, 1974). In fact, this is derived from a conceptual scheme outlined by LaFramboise(1973) which provided a simple map of ‘health territory’. Health and illness are considered to result from the interplay of four key influences: genetic factors, the environment, lifestyle and medical services. Although this formulation was hardly novel, it acquired a special status when endorsed by a government agency.

‘Anatomical’ analysis of health promotion. The three central elements of the health field concept (i.e. those which are potentially amenable to influence) may be readily identified. They comprise first of all, environmental influences, which are depicted as under the control of ‘healthy public policy’. Secondly, the impact on health of individual choice of lifestyle and, third, an expanded health services input may be seen. Thus, hospitals and environment are important determinant in individual health.

Concept of health promotion can be simplified into an essential ‘formula’ as follows:

Health Promotion = Health Education × Healthy Public Policy

Health is substantially influenced by environmental factors: physical, socio-economic and cultural. The influence may, of course, be positive or negative. One key aim of health promotion is to ‘engineer’ these various environmental factors in order to maximize opportunities for health and the avoidance of disease and disability. In so doing, ‘healthy’ decision-making is potentiated: the healthy choice becomes the easy choice. The process of social engineering may literally involve environmental engineering, for instance, the construction of cycle tracks within ‘healthy cities’. It may, on the other hand, require fiscal or economic measures. Legislation may or may not be involved in both of the instances cited above. Again, legislation, financial commitments and the like require the formulation of health policy or broader social policies, which have implications for health.

Healthy public policy, then, is necessary for environmental change. Clearly, a health-promoting environment may operate at a macro level: for
example, at national and international level. Additionally, the development and implementation of health policies will operate at local levels and at the level of organizations; for instance, the importance of having no smoking and healthy food policies within hospitals has long been acknowledged.

Healthy public policy is at the heart of an ecological approach to health promotion. It includes: food and education; shelter; a stable ecosystem and sustainable resources; peace; equity and justice. Central to the attainment of all these policy goals is the imperative of redistributing economic resources.

A comprehensive approach to health promotion requires environmental modifications, such as provision of safe water; installation of sanitary latrines; control of insects and rodents; improvement of house, etc. The history of medicine has shown that many infectious diseases have been successfully controlled in western countries through environmental modifications, even prior to the development of specific vaccines or chemotherapeutic drugs. Environmental interventions are non-clinical and do not involve the physician.

An ecological model of health promotion says that health is the product of the individual’s continuous interaction and interdependence with his or her ecosphere this is, the family, the community, the culture, the societal structure, and the physical environment. Characteristic modes of interacting over time constitute a life-style, as distinct from discrete acts or behaviors. The determinants of a life style must be seen as a combination of interpersonal and external environmental forces, continuously interacting. In some instances, health promotion programs need to emphasize the individual or behavioural side, in others; the environmental side needs emphasis as the point of intervention. If the individual has a sense of harmony with, or a degree of mastery over, the everyday environment, then his or her health is likely to be good. But with oppression, poverty, limited opportunity, and lack of mastery, health will suffer.

Health promotion concept is now being sought to be applied in all spheres of our lives and in all settings. The settings approach implies that health promotion principle can be applied in all organizations and at all levels.
viz., home, school, and even hospital. This approach seeks to substantially change the image of hospitals. As per this approach, the hospitals are not just seen as curative centres, but also as a place, which actually promote healthful living. Thus, health promotion concept can be gainfully applied in hospitals. It has been documented in context of Ottawa Charter that though health promotion concept is costly as it involves infrastructure development related non-recurring expenditure; it can be converted into an earning venture.

2.3 HISTORY OF HOSPITALS

The word ‘hospital’ originates from the Latin word ‘hospice’. In fact, the words hospital, hostel and hotel are derived from the common Latin root ‘hospice’. The place or establishment where a guest is received was called the hospitium or hospitale. The term ‘hospital’ has at different times been used to refer to an institution for the aged and infirm, a place of rest, a hostel where people lived as a small community, and an institution for the care of the sick and wounded. Lodging for the pilgrim and the wayfarer was also one of the primary functions of the early hospital. Hospitals in the past were set-up primarily as charity institutions for poor and weaker sections of society, giving the aura of an ‘almshouse’. The only function of such institutions was the care of the sick and the poor. The hospital was considered only a shelter for the socially unfit.

In the early Greek and Roman civilizations, the temples of the gods were used as hospitals. These hospitals were not separate entities but formed an integral part of the temples. Little distinction was made between the disease and the supernatural powers that caused diseases, where mysticism and superstition saddled medical practice, and where more soul healing than physical healing was practiced. The Greeks and Romans considered the temples of gods and their priests responsible for providing shelter and sustenance to the sick. Charity was the principal source for defraying illness costs of the poor. It was in Greece that Hippocrates, universally acknowledged as the father of western medicine was born, in 460 BC.
With the birth and spread of Christianity there was an impetus to hospitals, which became an integral part of the Church and its monasteries. Gradually, these Christian hospitals replaced those of Greece and Rome. During the crusades. (Christian expeditions to recover the Holy land from Mohammedans, 1100-1300AD) over 19,000 hospitals were founded in Europe to cater for those suffering from war injuries and diseases. The order of St. John was one such sect, responsible for creating chains of hospitals. This order has survived all these centuries and still functions as St. John Ambulance Corps in England with its branches all over the world, including India.

Subsequently, certain decrees issued by the Church for divesting religion from medical succor had the effect of lowering the status of the entire medical profession and stopping the monks from practicing medicine. In 1163AD, the Church formally restricted the clergy from working as physicians, and this restriction heralded the beginning of the end of hospitals towards the end of the Crusades (around 1300AD). During early nineteenth century, lay people who treated patients badly replaced nurses of religious orders. Patients were crowded together in common beds, and infection and gangrene were commonplace all over the hospitals. Hospitals were equated to death houses since most of the poor and serious patients who got admitted there, eventually died. Family members dumped their relatives with no hope of cure in hospitals.

Some of the notable hospitals established in the Western world date back to the ancient times. In 542 AD the earliest hospital was founded at Hotel Dieu in Paris. St. Bartholomew’s hospital in London dates from the year1123AD. In keeping with the hospital philosophy then prevalent, there was a general tendency to lump together the sick, the physically handicapped, the socially unwanted and the pauper all together. The Spanish built the first hospital in Mexico city in 1524 and the French in Canada. In North America, the first general hospital, Pennsylvania Hospital, opened in 1751, Bellevue Hospital in New York in 1736 and Massachusettes Hospital in 1811 AD. This
was followed by establishment of hospitals in quick succession in many other places in U.S.A.\textsuperscript{25}

**Nineteenth Century**

The middle of the nineteenth century saw the arrival of Florence Nightingale on the hospital scene. It fell upon Florence Nightingale to revolutionize nursing by supplementing good intentions and humane concern with scientific approach to nursing through training. The working of hospitals underwent a sea change as a result of her efforts when she was sent to attend to the sick and wounded at the Crimean War (1853-1856 between the joint forces of Britain and France with Russia. Total casualties: Allies—2,52,000, Russian—2,56,000) in 1854. This was the turning point in the history of hospitals in the Western World.\textsuperscript{25}

Various developments in medical sciences gave impetus to further progress in the hospital field. Discovery of anaesthesia and the principles of antisepsis (asepsis was to follow later) were two most important influences in the development of hospitals. Discovery of steam sterilisation in 1886, X-ray in 1895 and rubber gloves in 1890 revolutionised surgical treatment and gave further fillip to hospital development. Great progress was made in cellular pathology, clinical microscopy, and bacteriology and so on during the period from 1850 to 1900, and each one of these had a definite impact on hospital progress.

Besides the scientific advances during this period, rapid industrialisation during the last quarter of 19\textsuperscript{th} century generated enormous funds in the Western World. Hospital development in the 20\textsuperscript{th} century has, therefore, been explosive, especially in the USA and Europe. A hospital was no longer a place where people went to die. The advances in medical science brought about by antibiotics, radiation, blood transfusion, improvement in anaesthetic techniques and the spectacular advances in surgical techniques and medical electronics brought about tremendous growth and improvement in hospital services.
Early Indian rulers considered the provision of institutional care to the sick as their spiritual and temporal responsibility. The forerunners of the present hospitals can be traced to the times of Buddha, followed by Ashoka. India could boast of a very well organised hospital and medical care system even in the ancient times. The writings of Sushruta (6th century BC) and Charaka (200 AD), the famous surgeon and physician respectively were considered standard works for many centuries with instructions (in Charaka Samhita) for creation of hospitals, for provisions of lying-in and children rooms, maintenance and sterilisation of bed linen with steam and fumigation, and use of syringes and other medical appliances. Medicine based on the Indian system was taught in the ancient university of Taxila. Charaka Samhita, a treatise on medicine based on the teaching of Charaka was written around 600 AD and Sushruta Samhita, a treatise on surgical knowledge, was compiled during 400 AD.

The most notable of the early hospitals were those built by King Ashoka (273-232 BC). There were rituals laid down for the attendants and physicians who were enjoined to wear white clothes and promised to keep the confidence of the patients.

However, the age of Indian medicine started its decline from the Mohammedan invasions in the tenth century. The Mohammedans brought with them their Hakims who followed the Greek system of medicine, which came to be known as “Yunani”. This system and its physicians started to prosper at the expense of Ayurveda continued in the South.

The modern system of medicine in India was introduced in the 17th century with the arrival of European Christian missionaries in South India. In the 17th century, the East India Company, the forerunner of the British empire in India, established its first hospital in 1664 at Chennai for its soldiers and in 1668 for civilian population. European doctors started getting popular and during the later part of 18th and early 19th century, there was a steady growth of modern system of medical practice and hospitals, pushing the indigenous
system to the background. Organized medical training was started with the first medical college opening in Calcutta in 1835, followed by Mumbai in 1845 and Chennai in 1850.

As the British spread their political control over the country, many hospitals and dispensaries originally started to treat the army personnel were handed over to the civil administrative authorities for treating civil population. Local government and local self-government bodies (municipalities, etc.) were encouraged to start dispensaries at tehsil and district level. In 1885, there were 1250 hospitals and dispensaries in British India. But the medical care scarcely reached 10 percent of the population.

Emergence of Health Care Delivery System and Hospitals in Independent India-The early phase

The health scenario when the country became independent in 1947 was, to say the least, unsatisfactory. The bed to population ratio was 1:4000, doctor to population ratio 1:6300 and nurse to population ratio 1:40,000. Although the population was distributed in urban and rural areas in the proportion of 20:80, a great disparity existed in the facilities available in urban and rural areas. The medical resources were polarised in the ratio of 80:20. The indicators of health spoke of a poor state of health of the people as depicted below:

Health indicators in India during 1947

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Crude death rate</td>
<td>27.2 per 1000</td>
</tr>
<tr>
<td>2. Infant mortality rate</td>
<td>162 per 1000 live births</td>
</tr>
<tr>
<td>3. Death less than 10 years of age</td>
<td>48 percent of the deaths</td>
</tr>
<tr>
<td>4. Expectancy of life at birth</td>
<td>30.9 years</td>
</tr>
<tr>
<td>5. Infectious disease accounted deaths</td>
<td>Over 50 percent of total</td>
</tr>
</tbody>
</table>
On the eve of independence in 1947, there were 7,400 hospitals and dispensaries in the country with 11,000 beds giving a bed to population ratio of 0.25 per 1000. There were 47,000 doctors, 7000 nurses, 19 medical schools and 19 medical colleges in the country.

Many committees and study groups were appointed by Govt.of India from time to time to review hospital services. The following two were notable among them for the conceptual changes in the hospital services.

1. The Hospital Review Committee (Dr. K N Rao Committee) 1968 while reviewing Delhi Hospital made the following general recommendations.
   a. That the hospital should function as an integral part of the comprehensive health service, both curative and preventive.
   b. That the office of the medical superintendent should be a full-time appointment with administratively qualified doctor with no clinical responsibilities.
   c. That the administrative structure should be tripartite:
      i. Clinical,
      ii. Nursing, and
      iii. Business administration.

2. The Study Group on Hospital (1968) appointed by Central Government had recommended the following.
   a. By 1971 the following bed capacity should be attained:
      Teaching hospitals --- At least 500
      District hospitals --- At least 200
      Tehsil/Taluka hospitals --- At least 50

   b. The projected bed capacity of 4.2 lakh beds in 1976 should be raised to 6.3 lakhs bringing the bed: population ratio to one bed per thousand population by 1976.

   c. A regular system of giving liberal grants-in-aid to voluntary organisations to open institutions for giving medical care on nonrestrictive basis.
d. In difficult areas and in areas where distances are long and communications difficult, such as hilly districts, certain tehsil/taluka hospitals should be developed as full-fledged referral centers.26

2.4 THE CHANGING ROLE OF HOSPITALS

From its gradual evolution through the 18th and the 19th centuries, the hospital both in the eastern and the western world-has come of age only recently during the past 50 years or so, the concept of today’s hospital contrasting fundamentally from the old idea of a hospital as no more than a place for the treatment of the sick. With the wide coverage of every aspect of human welfare as part of health care viz. physical, mental and social well-being, a reach-out to the community, etc., the health care services have undergone a steady metamorphosis, and the role of hospital has changed, with the emphasis shifting from:

i. Acute to chronic illness
ii. Curative to preventive medicine
iii. Restorative to comprehensive medicine
iv. Inpatient care to outpatient and home care
v. Individual orientation to community orientation
vi. Isolated function to area-wise or regional function
vii. Tertiary and secondary to primary health care
viii. Episodic care to total quality care.

A hospital can be variously described as a factory, an office building, a hotel, an eating establishment, a medical care agency, a social service institution and a business institution. In fact it is all of these in one, and more. Sometimes it is run by business means but not necessarily for business ends. This complex character of the hospital has fascinated social scientists as well as lay people.

With the advances in and applications of management science in various spheres of life, hospital as an organization has also been visualized as a ‘system’. Management science defines a system as “a collection of
component subsystem which, operating together, perform a set operation in accomplishment of defined objectives. A system is viewed as anything formed of parts placed together or adjusted into a cohesive whole. Every system is therefore a part of a large system and has its own subsystem.\textsuperscript{24}

A system is construed as having inputs which undergo certain processing and get transformed into output, the output itself in turn sending feedback to the input and the process, which can be altered to achieve still better output.\textsuperscript{25} A system is therefore a continuous and dynamic phenomenon as depicted in the figure (2.2) below:

\textbf{Figure 2.2}

\textbf{Conceptual Representation of a System}

\begin{center}
\begin{tikzpicture}
  \node (input) at (0,0) {INPUT};
  \node (process) at (2,0) {Process (TRANSFORMATION)};
  \node (output) at (4,0) {OUTPUT};
  \draw[->] (input) -- node[pos=0.5,above] {FEEDBACK} (process);
  \draw[->] (process) -- (output);
\end{tikzpicture}
\end{center}

Management of such a complex organization requires blending of technical and administrative competence in the right quantity, at the right time, at the right place, by the right men and in the right way or process. The basic purpose of the hospital is “better patient care” and returns the patient back to the community as a productive unit of that community. Hospital administration is, therefore, an activity to secure maximum output through optimum utilization of inputs.\textsuperscript{27}

Against this background, there have been efforts since last 2-3 decades to reorient and revise the image of hospitals in the society. There has been deliberate emphasis on improvement of quality of services. The predominant approach to quality management in hospitals is through setting standards for the services e.g. inclusion of health promotion in the packages.
of services provided by hospitals etc. This health promotion orientation seeks to add value to the mere curative services usually associated with the hospitals. Health promotion is a core quality issue for improving health and sustaining quality of life, however, a review of existing standards for quality in health care for references to health promotion activities yielded little results. Standards for health promotion in hospitals are necessary to ensure the quality of services provided in the area.

A hospital is more than the sum of its parts. The major components of a hospital system are depicted in Figures 2.3 and Table 2.1.

**Figure. 2.3**

**Component of a Hospital System**

- Hospital System
  - Cure Subsystem
     - Diagnostic Subsystem
  - Care Subsystem
     - Therapeutic Subsystem
     - Nursing Subsystem
     - Supportive Subsystem

- Minor Subsystems
  - Administrative
  - Circulation
  - Environment
  - Technical
  - Social, etc.
### Table 2.1

**Hospital as a System**

<table>
<thead>
<tr>
<th>Input</th>
<th>Process – Transformation</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>People</strong></td>
<td><strong>Communication between</strong></td>
<td><strong>E</strong></td>
</tr>
<tr>
<td>A. Staff</td>
<td>• Physicians and patients</td>
<td><strong>F</strong></td>
</tr>
<tr>
<td>• Physicians and nurses</td>
<td><strong>F</strong></td>
<td></td>
</tr>
<tr>
<td>• Physicians/nurses and paramedical staff</td>
<td><strong>I</strong></td>
<td></td>
</tr>
<tr>
<td>• Physicians and administrators</td>
<td><strong>C</strong></td>
<td></td>
</tr>
<tr>
<td>• Administrators and community</td>
<td><strong>I</strong></td>
<td></td>
</tr>
<tr>
<td>• Administrators and nursing/paramedical staff</td>
<td><strong>N</strong></td>
<td></td>
</tr>
<tr>
<td>• Nursing/paramedical staff and patients</td>
<td><strong>T</strong></td>
<td></td>
</tr>
<tr>
<td>B. Patients, their attendants and relatives</td>
<td><strong>Decision Making</strong></td>
<td><strong>K</strong></td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td>For</td>
<td><strong>Patient</strong></td>
</tr>
<tr>
<td>• Drugs and chemicals</td>
<td>• Cure: Diagnosis, treatment</td>
<td><strong>T</strong></td>
</tr>
<tr>
<td>• Equipment</td>
<td>• Care: Creature comforts of patients, diet</td>
<td><strong>E</strong></td>
</tr>
<tr>
<td>• Diet</td>
<td>• Procurement of materials in right place at the right time</td>
<td><strong>C</strong></td>
</tr>
<tr>
<td><strong>Money</strong></td>
<td><strong>Action</strong></td>
<td><strong>Care</strong></td>
</tr>
<tr>
<td>• To maintain staff, facilities and procure materials.</td>
<td>• Putting decisions into practice</td>
<td><strong>E</strong></td>
</tr>
<tr>
<td></td>
<td>• Balanced mix of communication, decision-making and action</td>
<td><strong>T</strong></td>
</tr>
</tbody>
</table>
The growing realisation of the thin line of distinction between health and disease, the important relationship between social and material environment, its effects on the individual’s physical and mental well-being, the increasing demands for a better standard of living and health awareness of the people have all had a significant effect on hospital system and the trend of services provided by hospitals.

2.5 HEALTH CARE IN INDIA - THE CURRENT SCENARIO

The UNFPA’s state of the world Population Report 2004 highlighted the need for India to spend more on health and education. The country’s current health spending remains at a low 0.9 percent of the GDP as against the mandate of 7 percent, as laid down in the National Health policy.

The Prime Minister, S. Manmohan Singh, while launching the ambitious National Rural Health Mission on April 12, 2006 said, “We have created a delivery model that fragments resources and dissipates energies. Most importantly we have paid inadequate attention to the public health issues and the possibilities of social and preventive medicine in rural India.” It was reassuring to note the commitment to raise the annual spending on healthcare to more than 2% of the GDP, which had fallen to 0.9% in the past few years.

No doubt, hospitals are the largest and most costly units of health care systems and account for a large portion of the health sectors financial, human and capital resources. Hospitals utilize nearly half of the total national expenditure for the health sector and account for 50-80% of the government recurrent health sector expenditure.

Healthcare resources in India though not adequate are ample. There has been a definite growth in the overall healthcare resources and health related manpower in the last two decades. The number of hospitals grew from 11,174 hospitals in 1991 (57% private) to 18,218 (75% private) in 2000. A report of the PHD chamber of commerce and Industry (PHDCCI) on the sector has claimed that at present the healthcare industry in India is worth Rs. 1,00,000 crore and employs over four million persons. The sector is growing at a rate of 15% for the past five years. No wonder, large companies like
Apollo, Wockhardt, Max, Fortis, Tata and Duncans are setting up state-of-the-art hospitals and clinics across the country for providing multi-specialty healthcare services. In fact, hospitals have now become the money-spinners with the entry of these big business houses. The country has immense potential for promoting medical sector and the industry is expected to grow in size to Rs. 2,70,000 crore by 2012. The key advantage of India is medical tourism which stems from its low cost advantage, strong reputation in the advanced health care segment such as cardiovascular, organ transplant, eye surgery and diversity of tourist destinations available in the country. Spas, stress relief and centre for rejuvenation are different services which are growing in demand. A recent McKinsey study on health care says that medical tourism alone can contribute Rs.5000-10,000 crore additional revenue for up market tertiary hospitals by 2012 and will account 3-5% of the health delivery market. The Ministry of Health and Family Welfare and tourism are evolving strategies to give a strategic push to open the Indian healthcare sector to foreign tourists. The Ministry of Home Affairs has also introduced a new category of visa “Medical visa” which can be given for some specific purpose to foreign tourists coming to India for medical treatment. Thus, it is clear that hospital will occupy a major focus of attention (as well as a matter of concern) for authorities. In view of this, there has been a renewed emphasis on a planned approach in developing and running of hospitals in order to enhance the quality of care provided by them and to minimize the environmental hazards due to them. 24

2.6 HOSPITAL CLASSIFICATION

Hospital buildings can be classified in a variety of ways. In accordance with the nature of the health care provided, these buildings can be classified as primary, secondary and tertiary medical care facilities. This classification is in tune with the National Health Policy. A network of primary health care facilities supports upto 6 sub-centers or field units, catering to a population of about 100,000. Secondary health care facilities provide services to the patients referred from primary health care facilities. These are generally district level hospitals. Tertiary medical care provides superior level, super
specialties including cardiac care, neuro-science facilities, etc. with necessary high-end diagnostic and laboratory support facilities and medical colleges which are institutes of excellence. Depending upon the type of ownership, the hospitals include consultant clinics, polyclinics, nursing homes and hospice.  

**Figure 2.4**

**Classification of Hospital**

Private hospitals could be owned by individuals, trusts and corporate sectors. In certain cases, joint venture with government institutions/bodies is also resorted to. Indian standards provide functional planning norms for five categories of hospitals, A to E which range from 25-50 beds, 51-100 beds, 101-300 beds, 301-500 beds, and 501-700 beds respectively. All teaching hospitals are required to have a minimum of 200 bed hospitals as a part of medical college. Such teaching hospitals are governed by the mandatory requirements established by the Medical Council of India.
2.7 ISSUES IN PLANNING OF HOSPITALS

Hospital, by its very nature is a complex entity, and designing and building is an intricate job. The real test of any hospital is the quality of health care it provides. If the hospital has to pass this test - a rugged test - planning and designing must result in an efficient, functional and economical hospital. The economy of operation and maintenance over the life of the building as well as the quality of care given to patients depends in a large measure on the proper planning and designing of the hospital and is more important than the economy of construction.

The time spent in the hospital or in the doctor’s office can be traumatic to both the patient and his family. For the patient, fear of the unknown, fear of death, pain, separation from family, change of lifestyle, loss of dignity, etc. affect his adjustment and recovery. The patient experiences an increased awareness of his physical environment. Noise, colour, lighting, odours and air temperature are amplified, coupled with lack of privacy, interminable waiting at every stage, unconcerned attitude of staff or rude treatment at the hands of hospital personnel – these stimuli can seem traumatic to the patient. For the family too, which is deeply involved in the treatment and care of its member, the direct and indirect effects of illness can be overwhelming. Therefore, the atmosphere of the hospital is of utmost importance to the state of mind and emotional health of the family. The hospital engineers and architects should be sensitive to these anxieties and environmental factors and design and plan the hospital facilities in a way that will promote patient’s and his family’s health and emotional well being.28

Hospital building planning is directly related to the functional performance from the point of view of health care and the technological requirement to be fulfilled. The pace of technological advances has a tremendous impact on the future relevance of the facilities and high degree of obsolescence. Thus, while integrated planning of functional spaces in an issue, the future change is another aspect that has to be inherent in the planning though process. Structural systems of the buildings, architectural configuration, engineering services provisions (capacity and routing) and
budgeting can complicate managerial decision and, if not considered properly, can lead to definite adverse impact on the quality of health care delivered by the hospitals. It can, thus, be concluded at this stage that pre-construction is the most critical phase of hospital building project. Involvement of all stakeholders in the pre-construction phased as a multidisciplinary team is one way to ensure that the planning is relevant.24,28

2.7.1 Requirements for Proper Hospital Planning

Hospital requirements are worked out primarily through functional planning. Functional planning is the basis for incorporating other elements of building project, namely engineering services and equipment planning. For the purpose of hospital planning, various components/ departments have to be taken into consideration. Each department is an independent entity and specific peculiarities. However, there are many interrelated aspects that are to be considered from the point of view of compatibility and supportive role. The broad categorization of various departments is depicted in figure 2.5.

**Patient Care Division**
- a. Outpatient department (OPD).
- b. Inpatient department (IPD).
- c. Emergency department (ED).

**Diagnostic and Treatment**
- a. Radiology
- b. Pathology
- c. Operation suites
- d. Delivery suites

**Administrative Service**
- b. Admitting
- c. Medical records
- d. General administration
- e. Accounts
- f. Library/conference

**Ancillary Services**
- a. Mortuary
b. Housing
c. Cafeteria
d. Shops
e. Relatives inn

Inter-departmental and intra-departmental zoning is developed to ensure proper movement of hospital staff, doctors, patients and the services (especially clean and dirty services).

Figure 2.5
A Proper Hospital
2.7.2 Services Planning

In the hospital building, the services as depicted in Figure 2.6, contribute to about 53 percent of the initial capital cost. Operating and maintenance costs of the building are far more significant in case of services. The hospital planning should give equal importance to engineering services planning. Location and type of services are important since they are directly related to the functions of the buildings as per I.S. code, the engineering service requirement can be divided into the following sections:

**Civil**
1. Water supply and plumbing
2. Drainage and sanitation
3. Environmental hygiene

**Mechanical Engineering Department**
1. Heating, ventilation and air-conditioning
2. Laundry

**Electrical Engineering Department**
1. Illumination
2. Electric supply

**Miscellaneous**
1. Gas supply
2. Communication
3. Fire protection
4. Waste disposal
5. Acoustics
2.8 STANDARDS AND QUALITY ASSURANCE IN HOSPITALS

Standards are conspicuously absent in most of our hospitals. Acceptance and application of certain values, norms and principles that conform to professional standards by some hospitals and comparing them with those of other institutions seeking similar goals, have led to the development of definition of principles, responsibilities and standards in hospitals. Standards are used to describe the broad bases and fundamental policies as well as specific details for levels of patient care. They encompass almost every aspect of the hospital including hospital’s design, construction,
operation, maintenance and environmental safety. Standards relate to performance and/or results that are desired to be achieved.

Quality assurance (QA) aspects have always been a top priority in Indian hospitals. In recent years, we know that economic aspects have increasingly resulted in restructuring measures, especially in the health care sector. India’s health policy attaches great importance to quality assurance schemes, which are increasingly being introduced in order to ensure the internationally recognized high standard of Indian hospitals.29

Quality is defined as the sum total of all properties or characteristics of a product, process or service that render it suitable for satisfying specific, pre-defined requirements. From this definition, two central concepts of quality can be derived for hospital practice:

Performance-Related Concept of Quality

Quality is the sum or the level of properties that characterize services or products. Quality can be measured by applying objective criteria, once these have been laid down.

The Concept of Quality from the Patient’s Point of View

Here, the quality of the properties characterizing a product or service is determined by the patient's perceptions. Quality is measured according to subjective criteria, since every patient determines for him- or herself an individual level of quality, i.e. he/she expects and demands a specific level of performance.

For a patient, the quality of medical performance, both in subjective and in objective terms, depends on the qualifications of the doctors, nurses, therapists, etc. (structural dimension), on the course of the diagnostic process and the treatment given (sequential or process dimension) and on the healing of or improvement to his/her condition of health after release from hospital (result dimension).
Quality Components

The overall quality of a hospital is the result of the quality of every individual performance; so far, this cannot be measured. It is therefore recommended that the overall quality be divided into quality components, which helps determine the quality of individual areas or individual processes in a hospital as well as to compare it with previous periods or other hospitals. 30-31

The QA approach to improving health services and individual performance incorporates three core quality assurance activities:

- Measuring quality
- Defining quality
- Improving quality

The Quality Assurance Triangle effectively illustrates the synergy between these three core QA functions or activities. Although the QA Triangle highlights the three core quality assurance activities in its vertices, there is actually a range of sub-activities related to each core QA activity. The greatest impact on quality of care can be achieved only when all three activities are implemented in a coordinated fashion.

There is no "correct" or even optimal sequence to initiate QA activities. The order will depend on the capacity of the healthcare system or facility and the interest of the providers. In practice, QA is a cyclical, iterative process that must be applied flexibly to meet the needs of a specific program. The process may begin with a comprehensive effort to define standards or it may start with a small-scale quality improvement activity. Alternatively, the process may begin with monitoring. Some teams may even choose to simultaneously begin in two places. The time and effort required for each step will depend on the details of the project and whether any QA activities have taken place in the past. 30
2.8.1 The Emergence of EMS (Environment Management Systems) Standards

Numerous factors have contributed to the emergence of EMS standards. The following is a brief overview of some of the major contributing factors.

ISO 9000

The ISO 9000 series of international quality management standards was published in 1987. The standards were created to promote consistent quality practices and to facilitate international trade. The ISO 9000 series of standards has been adopted by more than 80 countries and is used as a benchmark for quality management by industry and government bodies worldwide. In some cases, ISO 9000 registration has become a prerequisite for doing business domestically and internationally. In North America, over 13,000 companies are registered to ISO 9000.

The quality management system framework can serve as a foundation for environmental management systems. In essence, an EMS is the application of quality management system principles to the management of environmental affairs. While the ISO 9000 and ISO 14001 standards have different focuses, they share similar requirements. (Annexure B). The three specification documents for ISO 9000 series are ISO 9001, ISO 9002, and ISO 9003. The key difference between ISO 9000 and ISO 14001 is that ISO 14001 requires planning steps to identify environmental aspects and significant environmental impacts which become the basis of continual improvement, whereas ISO 9000 focuses on consistency of process.

Sustainable Development

In 1987, the World Commission on Environment and Development (Brundtland Commission) coined the term sustainable development in its report entitled ‘Our Common Future’. This report emphasized the need to balance environmental protection and economic growth.
In 1991, the International Chamber of Commerce (ICC) created the Business Charter for Sustainable Development. The ICC Charter is comprised of sixteen Principles for environmental management that foster sustainable development. The Principles in this document include some of the basic elements of environmental management systems.

In 1992, the United Nations Conference on Environment and Development (UNCED) was held in Rio de Janeiro. The conference, also called the Earth Summit (or Rio Summit), resulted in two noteworthy documents Agenda 21 and the Rio Declaration. Agenda 21 is a comprehensive guidance document for sustainable development, while the Rio Declaration is a set of 27 principles for achieving sustainable development.

The international initiatives on sustainable development marked the dawning of a new age in environmental protection. The business community worldwide was asked to consider its impact on the environment and to take steps to mitigate that impact.

Private Sector Programs & Public Concern for the Environment

Private sector programs, such as the Chemical Manufacturers Association’s Responsible Care program, the Global Environmental Management Initiative (GEMI), and the Coalition for Environmentally Responsible Economies (CERES) Principles (formerly the Valdez Principles), resulted in model codes of conduct that encourage environmental stewardship. In addition, public concern for the environment has provided strong motivation for the development of EMS standards.

National EMS Standards & Regional EMS Legislation

In 1992, the British Standards Institute published BS 7750, the first national standard for environmental management systems. The British Standards Institute had previously published BS 5750 (a national quality management system standard), which was a significant contribution to the development of ISO 9000. ISO 14001 was largely based on BS 7750, and the
two standards share many similar requirements. The BS 7750 Standard, however, is viewed by many to be more stringent than ISO 14001. For example, BS 7750 requires that an organization compiles a register of its significant environmental effects, and a register of all legislative, regulatory, and other policy requirements. In addition, BS 7750 requires an organization to make its environmental objectives publicly available.

In addition to the national EMS standards, regional EMS legislation was developed. The Eco-Management and Audit Scheme (EMAS) was adopted by the European Union (EU) in 1993. EMAS is a regulation that enables industries to voluntarily implement formal environmental management systems in order to improve their environmental performance. While ISO 14001 and BS 7750 apply to organizations (or parts thereof), EMAS is restricted to site-specific industrial activities. EMAS participants must prepare an environmental statement specific to each site concerned, and provide information to the public about their environmental aspects. Third-party verification of the EMS is an essential component of EMAS. Participating organizations are included on the EU list of participating sites.

After the rapid acceptance of the ISO 9000 standards and the development of environment standards in different countries, the ISO felt the need to develop an international environmental management standard. They formed the Strategic Advisory Group on the Environment (SAGE) in 1991, to consider whether such standards could serve to:

- Promote a common approach to environmental standards common to quality standards.
- Enhance organisations ability to attain and measure improvements in environmental performance.
- Facilitate trade and help remove trade barriers.

2.8.2 The Development of ISO 14000

The International Organization for Standardization (ISO) is responsible for the development of the ISO 14000 series of international environmental management standards. ISO was founded in 1946 and its
headquarters is located in Geneva, Switzerland. ISO has developed international voluntary consensus standards for manufacturing, communication, trade, and management systems. Its mission is to promote international trade by harmonizing standards. Over 100 countries have national standards bodies that are members of ISO. The American National Standards Institute (ANSI) is the U.S. representative to ISO.

In June 1991, ISO created the Strategic Advisory Group on the Environment (SAGE). SAGE assessed the need for international environmental management standards and recommended that ISO move forward with their development. In January 1993, ISO created Technical Committee 207 (TC 207), which is charged with the development of the ISO 14000 series of standards. TC 207 is comprised of various subcommittees and working groups. Representatives from the ISO member countries contribute their input to TC 207 through national delegations.

In the United States, the U.S. Technical Advisory Group (U.S. TAG) develops the U.S. position on the various ISO 14000 standards. The U.S. TAG is comprised of approximately 500 members representing industry, government, not-for-profit organizations, standards organizations, environmental groups, and other interested stakeholders. The U.S. TAG has the largest number of members of any ISO member delegation. There are several organizations involved in the administration of the U.S. TAG’s input to TC 207, including: ANSI; the American Society for Testing and Materials (ASTM); the American Society for Quality Control (ASQC); and NSF International.

The ISO 14000 series is meant to cover

- Environmental Management Systems
- Environmental Auditing
- Environmental Performance Evaluation
- Environmental Labelling
- Life Cycle Assessment
- Environmental aspects in standard products
The ISO 14000 can be applied to any area of an organisation like production, services, operations, facilities, and transportation. The ISO 14000 series of standards is comprised of many guideline standards. Nevertheless, it has only one compliance standard -- ISO 14001 Environmental Management Systems. The list of ISO 14000 series of standard is given in Annexure A. A comparison and linkages between ISO 9000 and ISO 14001 are given in Annexure B.

2.8.3 Definition of an EMS:

A continual cycle of planning, implementing, reviewing and improving the actions that an organization takes to meet its environmental obligations as depicted in figure 2.7 below. An effective EMS doesn’t just happen, it needs ongoing management support.

Figure 2.7
Steps of an Effective EMS

Environmental management systems (“EMS”) are becoming the coin of the environmental compliance realm. An EMS is essentially a formal system of processes and procedures for analyzing, controlling, and reducing the environmental impact of an organization’s activities. Certain EMS components make it a particularly helpful tool for the complex hospital management structure. For example, an EMS should identify a specific management position that has the overall responsibility for ensuring that the EMS is developed, implemented, annually reviewed, and maintained. An EMS also
typically involves the development of organizational charts that identify departments, contractors, and individuals whose activities implicate environmental compliance, and that clarify responsibilities for managing those particular activities.

The EMS includes internal communications protocols so necessary in an organization in which disparate staff can have random impacts on environmental compliance, and external communications protocols that should prevent miscommunications and poor relationships between the hospital and regulatory authorities. An EMS will also assist a hospital in considering the costs of its present compliance efforts and alternatives to hazardous materials and work practices that are consistent with the hospital’s core mission, but may be less costly to implement. Finally, the EMS expressly considers, at the front end, the resources necessary to make the EMS work. As with environmental compliance audits, EMS’s have been formally recognized by the Environmental Protection Agency (EPA).

The EMS to be audited periodically and comprehensively to ensure that the legislations and regulations are being adhered to and make sure that the goals set are being achieved. In addition there should also be a management audit to check if the objectives set are suitable to the organisation and effective in operation periodically. The ISO 14000 EMS should be integrated with the other activities of the organization for efficiency and continuous improvement.

**Key EMS Benefits**

- Improved environmental performance
- Reduced liability
- Competitive advantage
- Improved compliance
- Reduced costs
- Fewer accidents
- Employee involvement
- Improved public image
• Enhanced customer trust
• Better access to capital
• Improved environmental performance

Costs and Benefits of Developing and Implementing an EMS

Costs
• Staff / employee time
• Possible consulting assistance
• Training of personnel

Benefits
• Improved environmental performance
• Improved compliance
• New customers / markets
• Increased efficiency / reduced costs
• Enhanced employee morale
• Enhanced image with public
• Reduced training effort for new employees
• Enhanced image with regulators

"We view the establishment of an EMS as a process that forces us to better organize our priorities and projects and to identify problems and exposures before they occur."

- K.J. Quinn & Co.

Some Common Aspects of Quality and Environmental Management Systems

• Quality Policy
• Adequate Resources
• Responsibilities and Authorities
• Training
• System Documentation
• Process Controls
• Document Control
• System Audits
2.8.4 Key Steps To Create EMS

1. Obtain Management Commitment
   The first step in the EMS-building process is gaining top management’s commitment to supporting the EMS. Management must understand the benefits of an EMS and what it will take to put an EMS in place. Management commitment and vision should be clear and communicated across the organization.

2. Choose a Champion
   Not all small or medium-size organizations have the luxury of choosing among multiple candidates, but choice of project champion is critical. The champion should have the necessary authority, an understanding of the organization, and project management skills. The champion should be a “systems thinker” (some ISO 9000 experience would be a plus, but is not necessary) and must have the time to commit to the EMS-building process.

3. Prepare Budget and Schedule
   The project champion should prepare a preliminary budget and schedule for developing the EMS. Costs will likely include staff and employee time, training, some consulting assistance, materials, and possibly some equipment (such as a computer or word processor). The schedule should consider the various tasks described below, among others.

4. Build Project Team
   A team with representation from key management functions and production or service areas can identify and assess issues, opportunities, and existing processes. It may include contractors, suppliers, and other external parties to be part of the project team where appropriate. This team will need to meet frequently, especially in the early stages of the project. The cross-functional team can help to ensure that procedures are reasonable and will build commitment to the EMS.

5. Involve Employees
   Employees are a great source of knowledge on environmental and health & safety issues related to their areas as well as on the effectiveness of current processes and procedures. They can help the project team in drafting
procedures. **Employee ownership** of the EMS will be greatly enhanced by meaningful employee involvement in the EMS development process.

6. **Conduct Preliminary Review**

The next step is to conduct a **preliminary review** of your current environmental programs and system and compare these against the criteria for EMS (such as ISO 14001). Organization’s structure and its procedures, policies, environmental impacts, training programs, and other factors should be evaluated and elements of current system should be determined.

7. **Modify Plan**

The **project plan** might need to be **modified** based on the results of the preliminary review. The modified plan should describe in detail the key actions needed, which will be responsible, what resources are needed, and when the work will be completed.

8. **Prepare Procedure & Documents**

In some cases, this might involve modifying existing environmental procedures or adapting other business procedures (such as quality or health & safety management procedures) for EMS purposes. In some cases, need to develop new procedures might arise and help from employees and the cross-functional team might be sought.

9. **Plan for Change**

The system should be sufficiently **flexible** so that changes can be incorporated, when needed.

10. **Train Employees**

Before implementing EMS, employees should be trained on the EMS, especially with regard to the environmental impacts of their activities, any new / modified procedures, and any new responsibilities.

11. **Assess EMS Performances**

After the EMS is up and running, **system performance should be assessed**. This will be accomplished through periodic EMS audits and ongoing monitoring and measurement. Assessment of EMS performance provides the opportunity to **improve the system and environmental performance** over time.
2.8.5 Elements of an ISO 14001 EMS: A Snapshot

• **Environmental policy** — To develop a statement of organization’s commitment to the environment and use of this policy as a framework for planning and action.

• **Environmental aspects** — To identify environmental attributes of products, activities and services and to determine those that could have significant impacts on the environment.

• **Legal and other requirements** — To identify and ensure access to relevant laws and regulations (and other requirements to which the organization adheres).

• **Objectives and targets** — To establish environmental goals for their organization, in line with its policy, environmental impacts, views of interested parties and other factors.

• **Environmental management program** — To plan actions to achieve objectives and targets.

• **Structure and responsibility** — To establish roles and responsibilities and provide resources.

• **Training, awareness and competence** — To ensure that the employees are trained and capable of carrying out their environmental responsibilities.

• **Communication** — To establish processes for internal and external communications on environmental management issues.

• **EMS documentation** — To maintain information on EMS and related documents.

• **Document control** — To ensure effective management of procedures and other system documents.

• **Operational control** — To identify, plan and manage operations and activities in line with policy, objectives and targets.

• **Emergency preparedness and response** — To identify potential emergencies and develop procedures for preventing and responding to them.

• **Monitoring and measurement** — To monitor key activities and track performance.

• **Nonconformance and corrective and preventive action** — To identify and correct problems and prevent recurrences.
• **Records** — To keep adequate records of EMS performance.
• **EMS audit** — To periodically verify that EMS is operating as intended.
• **Management review** — To periodically review EMS with an eye to continual improvement.

Figure 2.8
Key Elements of an EMS

- **Management Review**
  - Checking/Corrective Action
    - Monitoring and Measurement
    - Nonconformance and Corrective and Preventive Action
    - Records
    - EMS Audits
- **Environmental Policy**
- **Planning**
  - Environmental Aspects
  - Legal/Other Requirements
  - Objectives and Targets
  - Environmental Management Program
- **Implementation**
  - Structure and Responsibility
  - Training, Awareness, Competence
  - Communication
  - EMS Documentation
  - Document Control
  - Operational Control
  - Emergency Preparedness/Response
- **Continual Improvement**
- **Start**
In order to support Environmental compliance, ISO 14001 requires an organization to:

- Develop an environmental policy with a commitment to compliance;
- Have a procedure for identifying and having access to environmental laws and regulations;
- Set objectives and targets that are in line with its environmental policy (which includes a commitment to compliance);
- Establish operational control procedures;
- Establish procedures for emergency preparedness and response;
- Establish a procedure for periodically evaluating compliance.

While these requirements relate directly to an organization’s compliance management, each of the seventeen elements of the ISO 14001 Standard can contribute to enhanced compliance (e.g., communication, training, documentation, records, nonconformance and corrective/preventive action, EMS audits, management review, etc.). An EMS based on the ISO 14001 Standard can complement and improve the organization’s compliance management and help it to meet objectives and targets that go “beyond compliance.” An EMS based on the ISO 14001 Standard can also help the organization to meet objectives and targets that address issues that are not subject to regulation.

2.8.6 Environmental Policy

An environmental policy is ‘management’s declaration of commitment to the environment’. The policy should serve as the foundation for EMS and provide a unifying vision of environmental concern by the entire organization.

Everyone in the organization should understand the environmental policy and what is expected of them in order to achieve the organization’s objectives and targets. The policy should be built on three pillars i.e. compliance, improvement, and prevention and should be related to organizations products and services, as well as supporting activities. The
policy can be a stand-alone document or it can be integrated with the health & safety, quality, or other organizational policies.

Identifying Environmental Aspects

To plan for and control its significant environmental impacts, an organization must first know what these impacts are. But knowing what the impacts are is only part of the challenge; it should also know where these impacts come from.

If the organization has undertaken pollution prevention projects, then it should know how a waste is generated in order to minimize or eliminate it. As with pollution prevention, the identification and management of environmental aspects can (1) have positive impacts on the bottom line and (2) provide significant environmental improvements.

EMS should include a procedure to identify the environmental aspects that the organization:
• can control, and
• over which it can have an influence.

The Link Between Aspects and Impacts - Some Examples from a Real Company

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Potential Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions of volatile organic compounds</td>
<td>Increase in ground level ozone</td>
</tr>
<tr>
<td>Discharges to stream</td>
<td>Degradation of aquatic habitat and drinking water supply</td>
</tr>
<tr>
<td>Spills and leakages</td>
<td>Soil and groundwater contamination</td>
</tr>
<tr>
<td>Electricity use</td>
<td>Air pollution, global warming</td>
</tr>
<tr>
<td>Use of recycled paper</td>
<td>Conservation of natural resources</td>
</tr>
</tbody>
</table>
Things to Consider in Evaluating Environmental Aspects:

- Air Pollution
- Solid and Hazardous Wastes
- Contamination of Land
- Local Issues (e.g. concerns raised by the community such as: noise, odor, dust, traffic, appearance, etc.)
- Water Effluents
- Land Use
- Raw Material and Resource Use
- Normal and Abnormal Conditions (e.g., start-up, shutdown, emergencies)

2.8.7 EMS Auditing

Once the organization has established its EMS, verifying the implementation of the system becomes critical. To identify and resolve EMS deficiencies the organisation must actively seek them out. In a small organization, audits are particularly relevant since managers are often so close to the work that they may not see problems or bad habits that have developed. Periodic EMS audits will establish whether or not all of the requirements of the EMS are being carried out in the specified manner.

For EMS audit program to be effective, the organisation should:
- Develop audit procedures and protocols;
- Establish an appropriate audit frequency;
- Train auditors; and,
- Maintain audit records.

The results of the EMS audits should be linked to the corrective action system. While they can be time-consuming, EMS audits are critical to EMS effectiveness. Systematic identification and reporting of EMS deficiencies to management provides a great opportunity to:
- maintain management focus on the environment,
- improve the EMS, and
- ensure its cost-effectiveness.
As a rule of thumb, all parts of the EMS should be audited at least annually. The entire EMS can be audited at one time or can be broken down into discrete elements for more frequent audits.

Trained EMS auditors should carry out the task of auditing. Auditor training should be both initial and ongoing. EMS auditors should be trained in auditing techniques and management system concepts. Familiarity with environmental regulations, facility operations, and environmental science is a big plus, and in some cases may be essential to adequately assess the EMS. Some auditor training can be obtained on-the-job.

Management can use EMS audit results to identify trends or patterns in EMS deficiencies. The organization must also make sure that any identified system gaps/deficiencies are corrected in a timely fashion and that the corrective actions are documented.

2.8.8 Case Study

1. Healthy Hospitals: A Journey to ISO 14001 Certification

Inspired by Cambridge Memorial Hospital’s (CMH) vision of being "an excellent community hospital that contributes to making community as healthy as possible," Helen A.I. Wright, Mary Jane Hanley and Tammy L. Quigley, all working with CME conducted a study on a non-traditional area of healthcare - the environment. They started with the development of a comprehensive Environmental Management System (EMS), and, as a byproduct, CME became the first hospital in North America to be certified as ISO 14001 compliant.

Approximately 100 km west of Toronto, CMH is the only hospital in Cambridge and has a reputation for delivering high-quality, patient focused care to the residents of Cambridge and North Dumfries. The 277-bed hospital serves a community of approximately 120,000 people, with services including acute, ambulatory and long-term care. The hospital underwent a significant re-engineering process in 1995/96, resulting in an exceptionally flat organizational structure based on a program management model. Over recent
years the Board of Directors led an important shift for the hospital in its vision, moving from a model of "curing the sick" to one focused on improving the health of the community. This vision embraced improving health and wellness of the local environment.

Environmentally, the hospital was not a proud icon of waste management and recycling in the early 1990s. With an active biomedical waste incinerator and very limited recycling of materials, its environmental footprint was big, smelly and expensive. By 1997, they had begun their new journey in environmental awareness. The first step was approval of an environmental stewardship policy by the Board of Directors. After approving the environmental policy in June 1998 the hospital hired an experienced Environmental Coordinator to work part-time on the development of its Environmental Management System. The board and senior management recognized that not only was the EMS consistent with its new vision, it also made sense from a business perspective. By reducing the total amount of waste generated, significant savings were achieved. For example, by shutting down the on-site biomedical waste incinerator in 1998, and subsequently reducing the amount of biomedical waste, the hospital was able to save $5,000 per year in disposal costs and reduce annual total energy use by 5%.

Drastic reductions in waste generation did not happen overnight, and they did not happen with the support of only a few individuals. In order to develop its environmental plans, communicate them and implement them, the hospital created a team of primarily front-line staff, the "Green Team." This group of energetic, environmentally conscious individuals met on a regular basis to discuss trends in environmental issues, made recommendations to improve environmental performance and provided environmental leadership to the hospital. The team was instrumental in achieving the ISO 14001 designation and continues to support staff in achieving the environmental goals for the hospital.

Lot of battles had to be fought and challenges faced but was only possible with the commitment and hard work on the part of many people in the organization. One of the key success factors for Cambridge
Memorial was having a Board of Directors and Senior Management Team that were absolutely committed to achieving and maintaining the designation. While most people want to do the best they can for the environment, it was important to make the business case for the Board of Directors, to actually show them what the end result would be, the savings that would be achieved, and the positive public relations aspects of going forward.

The following areas were represented on the Green Team:
- Infection Control
- Housekeeping
- Environmental Coordinator
- Management Team
- Occupational Health and Safety
- Surgical Services
- Purchasing
- Laboratory
- Linen Service

The formation of the Green Team was another key factor in the success of this project; by choosing membership that included front-line staff from areas that were the greatest waste generators, and by having senior management representation at the table, this group was able to get the message out and keep up the enthusiasm for all environmental projects.

By using as many forums as possible, including electronic documentation, hard-copy documentation, hospital-wide in-services and orientation training, this group made sure that when the auditors asked any front-line employee what ISO 14001 was, they knew the answer. The communication tools needed to be varied and innovative in order to maintain a sustainable system that remained vibrant once the auditors left.

The next most important step in successful certification was follow-up. This meant checking back with each area in the hospital to ensure that all staff was following protocols and continued to be knowledgeable about the
Environmental Management System. Again, maintaining the message to staff was extremely important in keeping the project front and centre.

It was also important that all documentation was kept centrally, yet distributed widely. Not only was the central control and broad distribution important, but what was actually documented also counted. They were also careful to select measurable deliverables and kept accurate records of their accomplishments that clearly demonstrated how far they had come and where they needed to go in the future.

Achieving ISO 14001 certification was a great accomplishment for the hospital, and they still continue to receive recognition for their environmental achievements. The hospital was complimented in 2000 with the prestigious Chairman's Award from Recycling Council of Ontario. Recognition from the Regional Municipality of Waterloo and the Ministry of the Environment had also added to CMH's environmental portfolio. While these awards are symbols of the accomplishments achieved, there are real data that show how far they have come; in 2000, 60 tonnes of white paper and 40 tonnes of corrugated cardboard were diverted from disposal, there was a 284% increase in recycling from the year before, and a 20% reduction in the amount of biomedical waste compared to 1998. There were also many spin-off projects, such as intravenous bags recycled into automotive mudguards, nickel cadmium battery and fluorescent lamp recycling and a pledge to create a mercury-free workplace. Not only has the hospital itself made changes to the way it operates environmentally, it has inspired other organizations in the community to also make changes; for example, after the hospital stopped using pesticides on its grounds, it negotiated with the City of Cambridge to put an end to pesticide use on the adjoining property and to make plans for further reductions in pesticide use throughout the municipality.

2.9 ENVIRONMENT AND HOSPITAL

The key to man’s health lies largely in his environment. In fact, much of man’s ill-health can be traced to adverse environmental factors such as water pollution, soil pollution, air pollution, poor housing conditions, presence of
animal reservoirs and insect vectors of diseases which pose a constant threat to man’s health. Often man is responsible for the pollution of his environment through urbanization, industrialization and other human activities.

Industrial growth has given rise to the problem of environmental pollution by industrial wastes leading to profound social and environmental changes. Therefore, the attainment of a healthy environment is becoming more and more complex. Proper environmental health now requires services of the public health qualified doctor, the epidemiologist, the economist, and the health inspector. A purely medical or engineering approach by itself is no longer sufficient; a combined multi-disciplinary programme of action is needed to achieve a healthy environment. Hospitals as a part of environment get affected by environment and in turn also affect it as depicted in the figure 2.9.

Figure 2.9
Hospital- Environment Interaction

(Model Developed by Dr. A.J. Singh and Er. Parampreet Kaur)

However, lack of proper management & planning and failure to implement standardization has turned hospitals into risky ventures. In fact it seems almost ironical that these hospitals which provide relief to the ailing masses can also create health hazards. Hospitals and other health care institutions generate ‘waste’ day in and day out which may be a potential health hazard to the health care workers, the general public and, the flora and fauna of that area. Many diseases have been reported to be caused by biomedical waste mismanagement.
Although waste generation and disposal has always been a concern of the medical professional, these were being carried out by the practices of burning, land filling and burial; which conformed to the then existing knowledge of public health acts. So far, the problem was not discussed in public and the general public and social activities were not much concerned with hospital wastes because early hospitals were situated away from human inhabitation.

The present day hospitals and health care institutions including research centres use a wide variety of drugs including antibiotics, cytotoxics, and corrosive chemicals, radioactive substances, which ultimately become part of hospital waste. The advent of “disposable” in the hospitals has brought in its wake, attendant ills i.e. inappropriate recycling, unauthorized and illegal re-use and increase in the quantum of waste. All round technological progress has lead to increased availability of health related consumer goods, which have the propensity for production of increased wastes.

During the last couple of decades, the public has also become increasingly aware of one of the major consequences of development i.e. the quantity and diversity of hazardous waste that is generated. While some countries have made great efforts to develop effective technologies and standard protocol for administrative procedures; in most, it is in its infancy and clear cut answers to several questions are still unanswered national solutions to the problem differ according to the constitution and legislative system of the country concerned and are a reflection of the level of industrialisation, population density, geological and climatological conditions within individual countries. Moreover, because of overcrowding and increasing population density of cities, hospitals are now located in the (or near) residential areas, further increasing the chances of hazards linked with biomedical waste.

The WHO Regional Office for Europe convened a “Working Group” on Hospital Waste Management in collaboration with Norwegian Government; at Bergen from 28th June to 1st July 1983, which was the first time when medical specialists, hospital engineers, and hospital administrators from nineteen European Countries participated. The purpose of the meeting was to review
recent development in the handling, transport, treatment and disposal of waste from health care establishments and to prepare guidelines for a code of practice to be used by administrators, engineers and others in industrialized countries. The group’s deliberations concentrated on three principal aspects of the subject namely:

1. The health of personnel and patients in health care establishments;
2. The risks to public health arising from the transport and disposal of infectious and hazardous waste; and
3. The environmental and economic implications of waste disposal methods.\(^{35}\)

After deliberations and visits to some hospitals, the group concluded that Health Care Waste Management requires a “systems” approach involving all aspects; increasing awareness of all categories of personnel in health care organizations, emphasis on proper segregation at source with colour coding; source reduction as far as possible, special precautions regarding radioactive wastes, ensuring comprehensive waste disposal plans, collection of data on wastes generated and passage of legislation regarding the same.

In a workshop on ‘Management of Hospital Waste’ held in Jaipur in May 1997, most of the representatives of various hospitals failed to appreciate their responsibility to implement the steps of waste management. It was noted that in most of the health facilities, waste management is a non existent problem, with no one responsible for the same, and “buck passing” was the commonest excuse advanced by them.\(^{36}\)

The last decade witnessed a significant increase in the public concern regarding medical waste disposal, fuelled by reports of “beach washing” of medical wastes on the coasts of Florida and Gulf Coast; and “recycling” of disposables in developing countries. The first such instance that gained notoriety was the ‘beach wash-up’ of the summer of 1988, which was investigated by the Environmental Protection Agency (EPA) of USA.\(^{37}\) It was found to be ‘syringe related’ with its origins from household health care facilities and illegal intravenous drug abusers. This significant event culminated in the passing of Medical Waste Tracking Act (MWTA) on 1st
November 1988, thus making USA the pioneer in scientific Hospital Waste Management. The federal structure of USA prompted most member states to pass laws regarding transportation, storage and final disposal of medical wastes, as per the guidelines suggested by EPA, resulting in making waste management a very costly affair.

In South-East Asian region, Hospital Waste Management has now become a serious concern, largely due to reports in the print and audiovisual media which brought into limelight the plight of the rag pickers who rummage through the waste and segregate materials which are sent for recycling. Even then, few governments in the region have adequate programmes to properly manage the collection and disposal of waste from hospitals; and few people on the staff of hospital administration are familiar with the various aspects of scientific Waste Management. In most of the hospitals, waste handling is left to poorly educated lower category staff operating without, adequate knowledge, guidance, or supervision.

To bring the issue of Hospital Waste Management to the attention of the decision makers, the Environment Health Unit of South East Asia Regional Office (SEARO) carried out a questionnaire survey during June to September 1994 to assess the status of Hospital Waste Management in the countries and to identify the area needing improvement. This focused only on the wastes from hospitals and the aim was to identify issues, which require intervention rather than undertaking a detailed review of Hospital Waste Management practices.

The issue of improper Hospital Waste Management in India was first highlighted in a writ petition filed by Dr. B.L. Wadhera against the Union of India in the Hon'ble Supreme Court. The writ petition related to the dumping of hospital waste and garbage of Safdarjung Hospital at Bhalswa Dump by the civic authorities; as the incinerator installed there had not been working for more than a week and the repairs were likely to continue for several more days. Further more, the incinerator had been suffering from breakdowns and there was no stand-by arrangement for disposal of hospital waste. The dumping of hospital waste was stated to be extremely harmful, as the same
could contaminate the waters of river Yamuna during the rainy season. The contention was that this dumping of hospital waste at Bhalswa should be stopped henceforth and measures be initiated for stand-by incinerator facility, for proper disposal of hospital waste.40

The Supreme Court of India, after hearing the afore mentioned case in connection with safe disposal of hospital wastes ordered that:

1. All hospitals with 50 beds and above should install incinerators or any other effective alternate method under their own administrative control before 30th Nov. 1996.

2. The incinerators or alternative methods should be fitted with necessary pollution control mechanism, approved by and conforming to the standards laid down by Central Pollution Control Board (CPCB).

3. The CPCB and Delhi Pollution Committee should regularly send its inspection teams in different areas of Delhi/New Delhi to ascertain that the collection, transportation and disposal of garbage/waste is carried out satisfactorily, and file reports accordingly.41

During the same period, a High Power Committee was constituted to look into various aspects of Solid Waste Management in India and suggest suitable models for the development of cost-effective and environment friendly approaches to promote sanitary methods of collection, transportation and disposal of solid wastes in cities and towns including hospital wastes and the associated risks.42

Pursuant to the directives of the Hon’ble Supreme Court, the Ministry of Environment and Forests, Government of India issued certain draft rules called Biomedical Waste (management and handling). Rules 1995 vide extraordinary gazette notification on 25th April 199543 to invite suggestions, comments or objections from parties/persons concerned; and had also incorporated some suggestions on 30th August 1995. Subsequently, a round table discussion on the topic was organized by several NGOs, which are actively involved in this area on 13th December 1997, and they came up with certain recommendations, which were forwarded to appropriate authorities.
After duly considering suggestions/objections; and making some modifications the final notification was issued on 20th July 1998 and gazetted on 27th July '98. These rules have been framed in exercise of the powers conferred by sections 6, 8 and 25 of Environment (Protection) Act 1986 (29 of 1986); and shall apply to every hospital, nursing home, veterinary institutions, animal houses or slaughter houses, which generate bio-medical waste in a time bound manner. These rules have been further amended in 2002 and 2003. It shall also, be applicable to clinics, dispensaries, laboratories providing treatment or diagnostic facility-to not less than 1000 patients per month.

The situation of waste disposal in Rohtak and Jhajjar districts was reported in 'Tribune' of May 19, 2000. The Drug Control Department, Haryana had reportedly taken strict measures to check the sale and storage of medical waste in the state in view of the reports regarding the development of a “nexus” leading to the supply of used disposable syringes and intravenous (IV) sets for recycling and resale in market.

Thus, hospital waste poses a great hazard as it can spread infection. But most hospitals don’t follow any standard waste disposal method. Government hospitals as well as the private nursing homes dump their waste just like ordinary garbage. Needles, syringes, dressings, swabs immersed with blood, pus or other body fluids, culture stocks, infected or unused blood are all disposed of in the same way. Only placenta and body parts are buried or burnt. Advent of new technologies has revolutionized the diagnosis and treatment methods, but at the same time it has also added to the quantum of hazardous waste.

The Ministry of Environment and Forests formulated certain rules called the Biomedical Waste (Management and Handling) Rules, 1998, to be followed throughout the country, but these are being flouted-everywhere.

For evolving national guidelines on hospital waste management, the All India Institute of Medical Sciences (AIIMS) organized a two-day expert committee meeting in November 1998, where medical officers and health
administrators evolved guidelines, which were published and circulated to all states. But they are hardly being followed.

The Ministry of Environment and Forest has categorized and notified medical wastes in the Bio-medical Waste Handling and Management rules. Each category needs a separate disposal treatment. But this is not done in most hospitals. The whole lot is dumped with waste from other sources infecting the latter also. Scavengers are the potential carriers of infections.

Rajan Kashyap in his article, “Dangers from Medical Wastes-Need for Multi-disciplinary Approach” in the Tribune dated July 13, 2000 stated that even as hospitals provide solace and relief from disease, the dangerous wastes generated by them has become a serious hazard, which threatens public health. Indiscriminate disposal of hospital wastes is indeed a major source of pollution and infection. Bio-medical wastes from hospitals, nursing homes and clinics include hypodermic needles, scalpel blades, surgical gloves, cotton, bandages, clothes, medicines, blood and body fluid, human tissues and organ, body parts, radioactive substances and chemicals. Some of these contain harmful organisms. Reuse of discarded syringes/needles can transmit lethal disease like AIDS and hepatitis. Similarly, indiscriminate recycling of used cotton, clothes and medicines poses a host of health hazards.

There is particular concern about infection with human immunodeficiency virus (HIV) and hepatitis viruses B and C, for which there is strong evidence of transmission via health-care waste. These viruses are generally transmitted through injuries from syringe needles contaminated by human blood. Sharps may not only cause cuts and punctures but also infect these wounds if they are contaminated with pathogens. Because of this double risk-of injury and disease transmission, sharps are considered as a very hazardous waste class. The principal concerns are infections that may be transmitted by subcutaneous introduction of the causative agent, e.g. viral blood infections. Hypodermic needles constitute an important part of the sharps waste category and are particularly hazardous because they are often contaminated with patients’ blood. For serious virus infections such as
HIV/AIDS and hepatitis B and C, health-care workers particularly nurses-are at greatest risk of infection through injuries from contaminated sharps (largely hypodermic needles). Other hospital workers and waste-management operators outside health-care establishments are also at significant risk, as are individuals who scavenge on waste disposal sites (although these risks are not well documented). The risk of this type of infection among patients and the public is much lower. Certain infections, however, spread through other media or caused by more resilient agents, may pose a significant risk to the general public and to hospital patients. For instance, uncontrolled discharges of sewage from field hospitals treating cholera patients have been strongly implicated in cholera epidemics in some Latin American countries.59

A hospital housekeeper in the USA developed staphylococcal bacteraemia and endocarditis after a needle injury. Table 2.2 summarizes data on occupational transmission of HIV, and Table 2.3 shows the estimated risk of infection with HIV or viral hepatitis after hypodermic needle puncture based on data from France, Japan, and USA. Outside health-care establishments, the risk to the general public of HIV infection by this means is negligible: it has been estimated that no more than 1-4 HIV infections are caused annually by health-care waste in the USA, compared with an overall total of about 68000 infections for the whole country during 1995. The risk of viral hepatitis B and C infection from contact with health-care waste may be more significant, as this virus is viable for longer than HIV.59
Table 2.2
**Occupational transmission of HIV in France and USA**

**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.

**USA**
In June 1996, 51 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 each 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.

Table 2.3
**Risk of infection after hypodermic needle puncture**

<table>
<thead>
<tr>
<th>Infection</th>
<th>Risk of infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV</td>
<td>0.3%</td>
</tr>
<tr>
<td>Viral hepatitis B</td>
<td>3%</td>
</tr>
<tr>
<td>Viral hepatitis C</td>
<td>3–5%</td>
</tr>
</tbody>
</table>

(Data from Japan)

There were insufficient data on other infections linked to health-care waste to allow any conclusions to be reached. On the basis of the figures for
HIV, however, it is recommended that all personnel handling healthcare waste should be immunized against the disease. Unfortunately, no vaccine is yet available against viral hepatitis C.

If these data are to be extrapolated to developing countries, it should be borne in mind that supervision and training of personnel exposed to waste in those countries may be less rigorous, with the result that more people are likely to be exposed to health-care wastes, both within and outside healthcare establishments.

In any health-care establishment, nurses and housekeeping 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 the USA is 180 per 1000. Although most work-related injuries among health-care workers and refuse collectors are sprains and strains caused by overexertion, a significant percentage are cuts and punctures from discarded sharps. Infection with blood-borne pathogens particularly HIV and hepatitis B and C virus is considered an occupational risk for health care workers. Clinical laboratory technicians and nurses are the most vulnerable group and have 3-5 times higher risk of hepatitis B than the general population. Similarly waste handlers are also at the higher risk and needle pricks and exposure to infected material.

In another study, dealing with a health care setting, the federal Centers for Disease Control has estimated that 12,000 health care workers whose jobs entail exposure to blood become infected with hepatitis B each year, that 500-600 of them are hospitalized as a result of that infection, and that 700-1,200 of those infected become carriers. Of the health care workers infected with hepatitis, about 250 can be expected to die of hepatitis, cirrhosis of the liver, or liver cancer.

Many of the chemicals and pharmaceuticals used in health-care establishments are hazardous (e.g. toxic, genotoxic, corrosive, flammable, reactive, explosive, shock-sensitive). These substances are commonly
present in small quantities in health-care waste; larger quantities may be found when unwanted or outdated chemicals and pharmaceuticals are disposed of. They may cause intoxication, either by acute or by chronic exposure, and injuries, including burns. Intoxication can result from absorption of a chemical or pharmaceutical through the skin or the mucous membranes, or from inhalation or ingestion. Injuries to the skin, the eyes, or the mucous membranes of the airways can be caused by contact with flammable, corrosive, or reactive chemicals (e.g. formaldehyde and other volatile substances). The most common injuries are burns. Disinfectants are particularly important members of this group: they are used in large quantities and are often corrosive. Chemical residues discharged into the sewerage system may have adverse effects on the operation of biological sewage treatment plants or toxic effects on the natural ecosystems of receiving waters.

Exposure to radioactive waste may lead headache, dizziness, and vomiting to much more serious problems. Because radioactive waste, like certain pharmaceutical waste, is genotoxic, it may also affect genetic material. Handling of highly active sources, e.g. certain sealed sources from diagnostic instruments, may cause much more severe injuries (such as destruction of tissue, necessitating amputation of body parts).

Medical-related waste is disposed off illegally into the garbage and into the sewers. Even in developed countries, infectious and hazardous wastes are dumped in the municipal bin, where used syringes with or without blood and needles, used intravenous bottles, tubes, soiled cotton, medicine vials, urine bags, mattresses are picked up by rag pickers and junk dealer (kabari). The used cotton is further sold to people after washing with water. The blood is drained out of syringes at the time of sorting and emptied into the drain outside of the residential premises. Bags, syringes and other wastes materials are reused and recycled in large quantity after picking up from the incinerator and autoclave sites. These all activities are associated with risk of transmission of HIV, hepatitis B & C infections. Rubbish collectors and scavengers are aware of this activity and some had needle-stick injuries.
many places, authorities are failing to install appropriate systems due to non-availability of technologies, inadequate financial resources and absence of professional training on waste management. In addition, the awareness is poor among various categories of health workers about environment health including biomedical waste management.\textsuperscript{45}

2.9.1 Health-Care Waste

Definitions

No single standard and universally accepted definition for such terms as “hospital waste”, “medical waste”, “regulated medical waste” exists, may be because of the variety of waste generated in the hospital itself. A diverse group of people from doctors to scientists to environmental groups are increasingly getting involved in hospital waste management scenario.

Medical Waste

Medical waste is a term used to describe, “any waste that is generated in the diagnosis, treatment or immunization of human beings or animals, in research pertaining there to, or in the production or testing of biologicals.

Bio-medical Waste

Bio-medical waste is defined as “any solid, fluid or liquid waste, including its container any intermediate product, which is generated during the diagnosis, treatment or immunisation of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals and the animal waste from slaughter houses or any other like establishments.

Clinical Waste

Clinical waste is defined as “any waste coming out of medical care provided in hospitals or other medical care establishments, but does not include waste generated at home.

Hospital Waste

Hospital waste refers to all waste, biological or nonbiological that is discarded, and is not intended for further use in a hospital.
Pathological Waste
Pathological waste is defined as “waste removed during surgery/ autopsy or other medical procedures including human tissues, organ, body parts, body fluids and specimens along with their containers.

Infectious Waste
Infectious waste refers to that portion of Bio-medical waste, which may transmit viral, bacterial or parasitic diseases, if concentration and virulence of pathogenic organisms is sufficiently high.

A) Classification Of Waste

There are various classifications of Bio Medical Wastes of which following are important and relevant.

1. WHO classification

According to WHO, healthcare waste can be classified into eight categories, each of which represents varying degree of risk, of transmission of infectious disease or adverse effect on health, due to human exposure to this waste.35

1. General waste
2. Pathological Waste
3. Radioactive Waste
4. Chemical Waste
5. Infectious Waste
7. Pharmaceutical Wastes
8. Pressurised Containers

2. U.S. Classification (Centre for Disease Control, Atlanta)

The USA used a separate classification laid down by Centre for disease control, Atlanta: which is enunciated below46:

1. Microbiological waste—which includes cultures and stocks of infectious agents.
2. Sharps—which include needles, syringes, scalpels, blades, etc.
3. Human blood, blood products and body fluids.
5. Pathological wastes—tissues, sections, organs, supply specimens.
6. Cytotoxic wastes— are those which are toxic to the living cells, and can cause death of the cells, e.g. anticancerous agents etc.
7. Radioactive wastes
8. Communicable disease isolation wastes—which includes certain highly communicable waste such as Marburg, Lassa and Ebola viruses.

3. WHO Classification for Developing Countries

WHO has recommended a five category classification of hospital waste, for practical purposes. These include:
1. General Non-hazardous Wastes
2. Sharps
3. Infected Wastes (Not Containing Sharps)
4. Chemical and Pharmaceutical Wastes
5. Other Hazardous Waste-This has been sub divided into two categories namely: (a) Radioactive waste, and (b) Cytotoxic waste

4. Classification and categorization of bio medical wastes (Ministry of Environment and Forests)

The Ministry of Environment and Forests has drafted certain rules in exercise of powers conferred by sections 6, 8, and 25 of the Environment (Protection) Act, 1986. The classification and categorization of Bio medical wastes as per schedule 1 is given in Annexure C.

All biomedical waste is hazardous. In hospital, it comprises of 15% of total hospital waste. In nutshell, health-care waste includes all the waste generated by health-care establishments, research facilities, and laboratories. In addition, it includes the waste originating from “negligible” or “scattered” sources-such as that produced in the course of health care undertaken in the home (dialysis, insulin injections, etc.).

Between 75% and 90% of the waste produced by health-care providers is non-risk or “general” health-care waste, comparable to domestic waste. It
comes mostly from the administrative and housekeeping functions of health-care establishments and may also include waste generated during maintenance of health-care premises. The remaining 10-25% of healthcare waste is regarded as hazardous and may create a variety of health risks.

BMW, generally consists of:

- Soiled bandages, linen and other infectious waste (30-35%)
- Plastics (7-10%)
- Disposable syringes (0.3-0.5%)
- Glass (3-5%)
- General uninfected waste including left over food (40-45%)

It has been found that in India the generation rate varies between 0.5 to 2.0 kg per bed per day and total generation is more than 0.33 million tonnes per year.48

It has been found from studies that the amount and composition of hospital waste normally generated in a hospital is as follows:

(a) Hazardous/non-hazardous

<table>
<thead>
<tr>
<th>Hazardous</th>
<th>15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Hazardous but non-infective</td>
<td>5%</td>
</tr>
<tr>
<td>b) Hazardous and infective</td>
<td>10%</td>
</tr>
<tr>
<td>Non-hazardous</td>
<td>85%</td>
</tr>
</tbody>
</table>

(b) Composition

By weight

<table>
<thead>
<tr>
<th>Plastic</th>
<th>14%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry cellublastic solid</td>
<td>45%</td>
</tr>
<tr>
<td>Wet cellublastic solid</td>
<td>18%</td>
</tr>
<tr>
<td>Non-combustible</td>
<td>20%</td>
</tr>
</tbody>
</table>
2.9.1.1 Generation and Segregation of Waste

A) Definition

Generation of Waste

It refers to those activities or procedures, which result in the production of waste. In the hospital scenario, generation of biomedical waste is done at almost all areas, and at all levels from highly trained specialists to the Group 'D'-sanitation staff. It is the first step in the system of Hospital Waste Management.

B) Source of Waste

It refers to those areas or sites where wastes are generated or produced. Although source of waste generation are a legion in any hospital or healthcare institution; there are some sources, which are more important from the view of scientific hospital waste management.

Indian Scenario-Source and Generation of Wastes

In India, taking the classification (based on source or origin of waste) into consideration, non-hazardous or general waste in any hospital or healthcare institution is generated at the following places.

Non-hazardous (General) Wastes

- Offices
- Kitchen
- Cafeteria
- Administration
- Billing
- Cashier
- Rest rooms
- Dharmshala/guest room
- Hostels
- Residential areas.
- Pantries in wards
- Stores

Hazardous Wastes (Both Categories infectious and Toxic Wastes)

- Wards- treatment room, nursing station
- Isolation room (entire waste)
- Sluice rooms
- Operation theatres
- Intensive Care units and Recovery room
- Labour rooms and clinics
- Dental suites, minor OTs
- Blood Banks
- Pharmacy and Medical stores
- All laboratories
- Animal House
- Experimental Centres
- OPD treatment rooms
- Injection rooms and procedure rooms
- Dialysis and Endoscopy centres
- CT Scans and MRI
- Day care centres; various clinics

C) Quantum Of Waste Generated In Hospitals

The quantum of waste generated will vary depending upon the type of health problems, hospital policies and practices and type of care being provided. The reports and figures available from developed countries indicate a range from 1-5kg/bed/day, with substantial inter country and inter speciality differences. Meagre data from developing countries indicates that the range is essentially similar but the figures are lower i.e. 1-2kg/bed/day/patient.49

According to a WHO report, around 85% of the hospital wastes are actually non-hazardous, 10% are infective (hence, hazardous) and the remaining 5% are non-infectious but hazardous (chemical, pharmaceutical and radioactive). The quantities of the hospital waste generated in some developed countries of the world are given below in Table 2.4 50-51
Table 2.4  
Quantum of Waste Generated in Hospitals of Developed Countries

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Country</th>
<th>Type of Health Care Institution</th>
<th>Quantity of Hospital Waste (in kg/bed/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>United Kingdom</td>
<td>General</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teaching</td>
<td>3.3</td>
</tr>
<tr>
<td>2.</td>
<td>France</td>
<td>-</td>
<td>2.5</td>
</tr>
<tr>
<td>3.</td>
<td>Norway</td>
<td>Teaching</td>
<td>3.9</td>
</tr>
<tr>
<td>4.</td>
<td>Spain</td>
<td>General</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teaching</td>
<td>4.4</td>
</tr>
<tr>
<td>5.</td>
<td>Netherlands</td>
<td>General</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teaching</td>
<td>4.2</td>
</tr>
<tr>
<td>6.</td>
<td>U.S.A.</td>
<td>-</td>
<td>4.5 (Mean)</td>
</tr>
<tr>
<td>7.</td>
<td>Latin American Countries</td>
<td>-</td>
<td>2.63-3.8</td>
</tr>
</tbody>
</table>

In India, there are no national level studies on quantum of hospital waste generated per bed per day; but studies have been carried out at local or regional levels in various hospitals. From whatever data is available from these studies, it can safely be presumed that in most hospitals roughly about 1-2 kg of waste is generated per bed per day. Some of the notable studies are given in the Table 2.5. It is evident from some of these studies, that wastes generated in developing countries like India, contain much less disposable articles and plastics than waste generated in developed countries. This can be explained by differences in lifestyle and less use of disposables.
Table 2.5
Quantum of Waste Generated in hospitals of major Indian cities

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>City/Place</th>
<th>Type of hospitals</th>
<th>Quantum of waste generated in kg/pt/day</th>
<th>Composition %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Calcutta AIIHP&lt;sup&gt;51&lt;/sup&gt;</td>
<td>Govt., Private Nursing Homes</td>
<td>1.044 to 1.368 (large hospitals)</td>
<td>20-30% infectious 50-75% general</td>
</tr>
<tr>
<td>2.</td>
<td>New Delhi • Vatavaran • NIHFW&lt;sup&gt;52&lt;/sup&gt; • AIIMS&lt;sup&gt;53&lt;/sup&gt;</td>
<td>Govt. and Pvt. Hospitals Govt. teaching hospitals Tertiary care (research hospitals)</td>
<td>1.500 kg 1.4 to 1.6 kg 2.2 kg</td>
<td>45% Infectious waste</td>
</tr>
<tr>
<td>3.</td>
<td>Mumbai • THM</td>
<td>Tertiary care Cancer Hospital</td>
<td>1.13 kg</td>
<td>46% infectious</td>
</tr>
<tr>
<td>4.</td>
<td>Jaipur&lt;sup&gt;54&lt;/sup&gt;</td>
<td>Large tertiary hospital Small hospitals</td>
<td>1.5 kg 0.25-0.5kg</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Manipal&lt;sup&gt;55&lt;/sup&gt; KMC-Manipal</td>
<td>Large tertiary hospital</td>
<td>0.775 kg</td>
<td>16.26% infectious</td>
</tr>
<tr>
<td>6.</td>
<td>Punjab&lt;sup&gt;56&lt;/sup&gt; Amritsar</td>
<td>Large tertiary hospital</td>
<td>1.051-1.30 kg</td>
<td></td>
</tr>
</tbody>
</table>

More studies along these lines are required at national level to bring out facts and figures and also to create awareness amongst medical fraternity.

Several surveys have provided an indication of typical health-care waste generation. Data from some of these surveys are summarized in Tables 2.6 to 2.9 and show that generation of health-care wastes differs not only from country to country but also within a country. Waste generation depends on numerous factors such as established waste management methods, type of health-care establishment, hospital specializations,
proportion of reusable items employed in health care, and proportion of patients treated on a day-care basis.

Developing countries that have not performed their own surveys of health-care waste may find the following estimates for average distribution of health-care wastes useful for preliminary planning of waste management:

- 80% general health-care waste, which may be dealt with by the normal domestic and urban waste management system;
- 15% pathological and infectious waste;
- 1% sharps' waste;
- 3% chemical or pharmaceutical waste;
- less than 1% special waste, such as radioactive or cytotoxic waste, pressurized containers, or broken thermometers and used batteries.

**Table 2.6**

Health-care waste generation according to national income level\(^57\).

<table>
<thead>
<tr>
<th>National income level</th>
<th>Annual waste generation (kg/head of population)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-income countries:</td>
<td></td>
</tr>
<tr>
<td>— all health-care waste</td>
<td>1.1–12.0</td>
</tr>
<tr>
<td>— hazardous health-care waste</td>
<td>0.4–5.5</td>
</tr>
<tr>
<td>Middle-income countries:</td>
<td></td>
</tr>
<tr>
<td>— all health-care waste</td>
<td>0.8–6.0</td>
</tr>
<tr>
<td>— hazardous health-care waste</td>
<td>0.3–0.4</td>
</tr>
<tr>
<td>Low-income countries:</td>
<td></td>
</tr>
<tr>
<td>— all health-care waste</td>
<td>0.5–3.0</td>
</tr>
</tbody>
</table>

**Table 2.7**

Health-care waste generation according to source size\(^58\).

<table>
<thead>
<tr>
<th>Source</th>
<th>Daily waste generation (kg/bed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>University hospital</td>
<td>4.1–8.7</td>
</tr>
<tr>
<td>General hospital</td>
<td>2.1–4.2</td>
</tr>
<tr>
<td>District hospital</td>
<td>0.5–1.8</td>
</tr>
<tr>
<td>Primary health-care centre</td>
<td>0.05–0.2</td>
</tr>
</tbody>
</table>
Table 2.8
Total health-care waste generation by region\textsuperscript{59}

<table>
<thead>
<tr>
<th>Region</th>
<th>Daily waste generation (kg/bed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>7–10</td>
</tr>
<tr>
<td>Western Europe</td>
<td>3–6</td>
</tr>
<tr>
<td>Latin America</td>
<td>3</td>
</tr>
<tr>
<td>Eastern Asia:</td>
<td></td>
</tr>
<tr>
<td>— high-income countries</td>
<td>2.5–4</td>
</tr>
<tr>
<td>— middle-income countries</td>
<td>1.8–2.2</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>1.4–2</td>
</tr>
<tr>
<td>Eastern Mediterranean</td>
<td>1.3–3</td>
</tr>
</tbody>
</table>

Table 2.9
Hospital waste generation by waste type (Western Europe)\textsuperscript{59}

<table>
<thead>
<tr>
<th>Waste class</th>
<th>Daily waste generation (kg/bed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical and pharmaceutical waste</td>
<td>0.5</td>
</tr>
<tr>
<td>Sharps</td>
<td>0.04</td>
</tr>
<tr>
<td>Combustible packaging</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The composition of waste also varies greatly not only from country to country but also among facilities within any given country as depicted in Table 2.10. The approximate chemical composition of general health-care waste is usually as follows:

- 50% carbon
- 20% oxygen
- 6% hydrogen
- Numerous other elements.
Table 2.10
Composition of waste from three hospitals in Taiwan, China vis a vis Indian data

<table>
<thead>
<tr>
<th>Material</th>
<th>University hospital</th>
<th>Hospital A</th>
<th>Hospital B</th>
<th>Indian Hospital*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>16</td>
<td>34</td>
<td>51</td>
<td>15</td>
</tr>
<tr>
<td>Plastics</td>
<td>50</td>
<td>21</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Textiles</td>
<td>10</td>
<td>14</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Metals (sharps etc.)</td>
<td>0.5</td>
<td>1</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Glass</td>
<td>21</td>
<td>17</td>
<td>7</td>
<td>53.5</td>
</tr>
<tr>
<td>General waste</td>
<td>1.5</td>
<td>2</td>
<td>5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

*The data comprises average values obtained from 10 large hospitals in Bombay, Calcutta, Delhi, and Nagpur during the period 1993–1996.

2.9.1.2 SEGREGATION OF HOSPITAL WASTE

A) Definition

As per the Biomedical Waste (Management and handling) Rules, 1998, segregation is defined as “separation of different types of waste by sorting” and is the most important pre-requisite in the entire process of waste management as it allows special attention to be given to the relatively small quantities of infectious and hazardous waste, thereby reducing the risks as well as the cost of handling and disposal. Proper segregation of hazardous (infectious and toxic) wastes from general wastes is important because, it allows general waste to be disposed of with municipal garbage. It can rightly be said to be the ‘Key’ to the entire process scientific waste management, as proper sorting or separation into different categories will entail the right treatment and disposal. Conversely, incorrect or improper segregation will either cause enhanced risks to personnel and public, or will cost more money and become uneconomical. To cite one example, if non-infectious waste gets
mixed with infectious waste, the whole lot has to be incinerated which will require more money.

Unfortunately, this stage of segregation which is and should be the responsibility of the “generator” of waste i.e. those persons in hospitals and health care institutions who generate or produce wastes, namely doctors, nurses and paramedics, is more often than not relegated below to the sanitation department. It is indeed surprising and sad that most of the doctors, nurses and paramedics who are educated and trained, do not know the basics of hospital waste management. These are the people who are most closely associated with patient care activities, quite often in conditions of urgency and under pressure, and they are least concerned with the amount, quality and type of waste they generate and the way it is disposed. As this aspect is not included in the discussion, the people concerned have little or no idea of what happens to the waste once it is taken out from the wards, ICUs, OTs etc. They rarely think about the consequences of improper waste management, and the hazards it can cause, not only to the other staff working in the hospital, but also to general public, Smug in their complacence, it is they who question the sanitation staff and pull them up for improper segregation, forgetting all the while that the best course of action is segregation into various categories at the point of generation of waste, which can only be achieved if every doctor, nurse, or paramedic conscientiously, practices segregation whenever he/she is generating waste, rather than blaming the sanitation staff who is generally illiterate and is likely to make mistakes. Till the time doctors do not “wake” up to this problem and perform it rather than paying lip service, the ground reality will not improve in any way. Thus it can very rightly be said that “sensitizing” the generators of waste to properly segregate the waste at source is the “Key” to the successful implementation of scientific hospital waste management.

Operational Aspects
Segregation of hospital wastes in a proper manner will depend upon the following factors:
a) Type of hospital/health care institution- superspeciality, with teaching or research facilities available or not.
b) The motivation and training level of the generators of waste viz doctors, nurses and paramedics.
c) Sound hospital waste policies and procedures in consonance with health legislation.
d) The final treatment options available for hospital waste.

Segregation of waste into various categories as decided in hospital policy, needs to be done at all points/areas where waste is generated, so that the subsequent steps follow smoothly. All personnel working in health care institutions including patients and their attendants should be made aware of, and given training on practical aspects of waste management. The minimum categorization that can be done by any hospital is two, i.e.

a) Non-hazardous/general waste, which can be disposed off in the same manner as domestic waste.
b) Infectious and hazardous waste which have to be treated with some method before disposal. However, depending upon the factors mentioned above, the various classifications can be implemented.

Times of India, Bombay dated 17th August 2004 reported the following news highlighting the poor scenario of management of medical waste in Maharashtra-

"The thick nose masks do nothing to block the putrid smell but the workers seem oblivious to it. Bags stuffed with medical waste are being shoved into an autoclave where the waste is sterilised and then shredded. Gloves coated with muck are discarded on the floor after every round of loading and slipped on again for the next round. Welcome to the centralised bio-medical waste treatment facility at Sewree, the only BMC-run facility in the city that treats the infectious waste of around 1,500 hospitals and nursing homes in Mumbai. The numerous problems dogging the issue of bio-medical waste (BMW) in Mumbai and in other cities in the state show up all the players in poor light-hospitals, treatment facilities, the BMC and the Maharashtra
Pollution Control Board (MPCB). The problem starts at source-in the way the waste is segregated. Infectious waste is of two types: anatomical tissues which should be packed in yellow bags and sent for incineration and other waste (plastics, needles, etc) which should be packed in red bags and autoclaved. But at Sewree, several yellow bags go in for autoclaving along with the red ones. The attendant explains, "Since many hospitals don't observe the colour coding, we assume the heavier bags contain anatomical parts and send them to an incinerator at Taloja while the lighter ones go into the autoclave."

(The Taloja incinerator is used because the one at Sewree has been shut since last November after local residents complained of air pollution.) Not only do many hospitals fail to segregate correctly, their waste often remains uncollected by the BMC contractor for up to four days.

As MPCB member-secretary Dr D B Boralkar notes, "Collection should be done every 24 hours, but this is not being done." Even the six hospitals which have their own treatment facilities do not meet the norms laid down in Bio-Medical Waste (Management & Handling) Rules, 1998, officials say. Many hospitals and nursing homes which do not want to pay the Rs 18 per kg which the BMC charges to treat waste at its Sewree facility simply don't send their waste in. "Where is that waste going?" demands Deepika D'Souza of Mumbai Medwaste Action Group. Mixing bio-medical waste with other types of waste amounts to contaminating 7,000 tonnes of waste generated every day by the city, observes Dr Rohini Kelkar, head of microbiology department of Tata Memorial Hospital. Sharp-edged waste such as needles and blood-stained glass pieces alone can transmit 22 types of blood-borne diseases of which Hepatitis-B being the commonest. "Hepatitis-B is 150 times more transmissible than HIV or Hepatitis-C, and doesn't get killed by drying," she says.

A recent report of the MPCB highlights gaping holes in the way bio-medical waste in 15 cities of the state is treated. The report revealed non-compliance in terms of "proper segregation, collection, treatment and disposal".
At the Sewree facility, it yellow waste notes, "The transport agency does not have adequate infrastructure like vehicles, manpower, etc resulting in non-collection of waste from all generators." In all 15 cities, biomedical waste is not properly segregated at source while autoclavable waste is sold in the scrap market. Medical units in other cities too prefer to dump their waste rather than pay the treatment facilities which charges them on the basis of weight. If charged on bed-occupancy basis, the facility receives all sorts of waste without segregation, the report says. Some incineration facilities like the ones at Pune and Nagpur do not have a proper arrangement for ash disposal. The MPCB report stresses that a treatment facility should be responsible for "total BMW management" including "collection, transport, storage and treatment and disposal". In other cases, the required temperatures for incineration and autoclaving were not maintained. "The incineration of BMWat temperatures lower than the specified range is likely to emit toxic/carcinogenic air pollutants like dioxins and furans. Hence, improper BMW incineration at lower temperatures and lower residence time is more dangerous than not treating the waste," it says. D'Souza says the MPCB should put systems in place for compliance monitoring and regulation. Boralkar concedes the need for greater vigilance and intervention and says that the MPCB will now crack down on units that don't send their waste to an authorised treatment facility. "We have issued notices to hospitals recently. Beginning August 17, we will prosecute violators," he says.

A survey conducted by the CPCB in 66 major hospitals of Delhi in 1998 stated that proper segregation of waste was not being practiced except in a few hospitals. Rag pickers were playing a key role in segregation of waste for materials, which have some resale values.

**2.9.1.3 COLLECTION OF HOSPITAL WASTE**

Collection of hospital waste is the process, which is done after segregation, and in a way both can be considered by as being complementary to each other. In the pre-antibiotic era, the hygienic disposal of hospital waste received due attention of the doctors and other staff. Right at the point of origin or generation of waste, proper collection was being done, e.g. collection
of sputum in utensils which do not overflow and spill over; decontamination of linen prior to washing. With the advent of antibiotics the fear of getting infected through contact with infectious waste declined and personnel started getting bolder. So much so that, in the present scenario we have staff transporting waste (potentially infectious) in open boxes or bins without cover. Dressings, linen soaked with blood/body fluids, excreta are dumped in any corner and the sanitary attendant has to collect and take it for final disposal. When the sharps get mixed up with non-hazardous waste, the chances of needle stick injuries becomes high and the handlers of waste become susceptible for injuries.

**Pre-requisites**

General hospital hygiene is a pre-requisite for good biomedical waste management and it is imperative to ensure that the following facilities are available before implementation of scientific waste management programme.

i. Reliable supply of safe water

ii. Basic sanitation facilities in terms of toilet and urinals.

iii. Basic level of cleanliness especially in the patient care areas.

iv. “Zoning” concept in vital and critical areas, which need sterility.

In fact, it is vital to keep the whole hospital clean and in satisfactory level of sanitation to prevent the spread of infection from patients to patient, patient to health care worker and vice-versa. Similarly, it is of vital importance to ensure safe disposal of hospital waste so that handlers of waste and outsiders do not get infected from the same.

**Criteria for Categorisation of Collected Waste**

The criteria for categorization of collected waste in any hospital or health care institutions will depend upon the following factors:

(a) The type of facilities being provided, the degree of superspecialisation and research activities being carried out in the institution.

(b) The technological options available with hospital management for treatment of biomedical wastes.

(c) Hospital policies and procedures for waste management.
There are several guidelines suggested for categorization of hospital wastes, enunciated by various authorities, some of which are given below;

(a) Colour coded classification for developing countries (WHO) (Table 2.11)

(b) Containers and colour coding for disposal for Bio-medical wastes (as per Ministry of Environment and Forest guidelines).

(c) Recommended colour coding by Sulabh International Institute of Health and Hygiene (Table 2.12).

Table 2.11

Colour coded classification for developing countries

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Category of waste</th>
<th>Recommended Colour code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>General non-hazardous waste</td>
<td>Black</td>
</tr>
<tr>
<td>2.</td>
<td>Sharps (whether infected or not)</td>
<td>Yellow</td>
</tr>
<tr>
<td>3.</td>
<td>Infected wastes (not containing sharps)</td>
<td>Yellow</td>
</tr>
<tr>
<td>4.</td>
<td>Chemical and pharmaceutical (other than cytotoxic drugs, radioactive wastes, high pressure containers)</td>
<td>Red</td>
</tr>
<tr>
<td>5.</td>
<td>Clinical waste that requires autoclaving</td>
<td>Blue</td>
</tr>
</tbody>
</table>

Table 2.12

Colour coded classification followed by Sulabh International Institute of Health and Hygiene

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Colour of container</th>
<th>Type</th>
<th>Category of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Green</td>
<td>Covered</td>
<td>General waste (Food waste, Kitchen waste, i.e. putrescible part)</td>
</tr>
<tr>
<td>B.</td>
<td>Red</td>
<td>Covered</td>
<td>Microbiological; Surgical, Human anatomical organs, tissues, blood and body fluids, etc. pathological, infectious waste contaminated with blood, secretion, etc. soiled cotton, dressing, beddings, animal waste, research laboratory waste, etc. (incinerable)</td>
</tr>
<tr>
<td>C.</td>
<td>Yellow</td>
<td>Covered</td>
<td>Disposables, plastics, PVC, Polyethylene, sharps e.g. needles, blades, scalps, etc. cardboards, thermacols, discarded glasswares, etc.</td>
</tr>
</tbody>
</table>
This uses the minimum number of colours and is favoured by a number of authorities. Keeping in view the educational status, knowledge base and training of the sanitation staff, the colour should be supplemented by writing the category of waste on a label. This has been recommended as it has been seen that at present the segregation and collection of wastes in various hospitals is negligible and there is no way the 10-12 category containers can be implemented soon. The three colour coding system is more down to earth, practical and with proper training and motivation can be implemented easily. However colour coding should be in consonance with national level policies.61

2.9.1.4 STORAGE OF HOSPITAL WASTE

A) Definition

According to the Biomedical Waste (Management and Handling) Rules, 1998 storage means “the holding of biomedical waste for such period of time, at the end of which waste is treated and disposed of”. In other words it means the duration of time the wastes are kept in the areas of generation, transit, till the point of disposal. It is important to be very careful about storage of biomedical wastes because, unless they are securely stored, there are chances of rag pickers and other unscrupulous elements gaining access to them and causing problems.

Current Scenario

Presently, in most of Indian hospitals/health care institutions, no scientific principles of storage are being followed. According to various studies and reports storage of the waste is presently being done in the wards or near “dalaos” or municipal garbage dumps. In some places the contractors have taken up the responsibility for waste disposal and hence storage is considered as his problem. In a number of small Government hospitals, rag pickers have free access to these garbage dumps, and they pick up plastics, disposables and other “recyclable” materials, thus increasing not only their risk for infection, but also that of general public who buy such recycled stuff. Only in some hospitals where waste management is considered seriously; efforts have been made to cover bins in the waste generation areas; and the storage
site is guarded to prevent entry of rag pickers and other unscrupulous elements.

A storage location for health-care waste is preferably designated inside the health-care establishment or research facility. The waste, in bags or containers, is stored in a separate area, room, or building of a size appropriate to the quantities of waste produced and the frequency of collection.

Unless a refrigerated storage room is available, storage times for healthcare waste (i.e. the delay between production and treatment) are not expected to exceed the following:

- temperate climate: 72 hours in winter
  48 hours in summer
- warm climate: 48 hours during the cool season
  24 hours during the hot season

Cytotoxic waste is to be stored separately from other health-care waste in a designated secure location.

Radioactive waste is to be stored in containers that prevent dispersion, behind lead shielding. Waste that is to be stored during radioactive decay should be labelled with the type of radionuclide, the date, and details of required storage conditions.

**Legal Perspective**

Under the provisions of Biomedical Wastes (Management and Handling) Rules, 1998, the following sections pertain to storage and waste:

- Authorised person handling biomedical wastes shall ensure that:
  a) No untreated bio-medical waste shall be stored beyond a period of 48 hours.
  b) If for any reason, it becomes necessary to store the waste beyond such period, the authorized person must take permission of the prescribed authority and take measures to ensure that the waste does not adversely affect human health and environment.
B) Characteristics of Waste Storage Containers

Containers for interim storage of waste should have the following characteristics:

a) Made up of hard plastic/metal, which can be sturdy and leakproof.

b) The size of the containers (bins) will depend upon the quantum of waste generated per day and the collection frequency, i.e. once or twice/day.

c) To have a secure lid, which can be shut down, after the waste is collected. It should not allow insects and other animals to go inside.

d) To be puncture proof, colour coded, labeled and not easily destroyed by rodents and other animals.

e) The inner surfaces be smooth and rounded without any sharp edges which can tear the plastic kept inside the bags.

Plastic (Polythene) Bags used for Waste Storage and Transport.

a) To be large enough to accommodate all the waste of the particular category. (It should completely line the bin and some portion of it should be outside).

b) To be sturdy enough to withstand the weight of the required load of waste without tearing or giving away (especially in the longitudinal direction)

c) To be leak proof (water proof) with no weak areas or tears.

d) To be made up of low density polythene of 55 microns (minimum gauge 225) or high density polythene of 25 microns (minimum gauge 100)

e) To be colour-coded, labeled and marked clearly with “Biohazard” and other labels as mentioned in Schedule III.

Containers for Sharps to have following characteristics

a) Sturdy, puncture proof container made up of plastic/metal.

b) To have a secure lid, which closes tightly, making the container leak proof.

c) The containers to contain appropriate disinfectants like polar bleach, sodium hypochlorite etc.
d) The containers to have a handle so that it can be transported easily.
e) To have a mechanism to show (e.g. vision panel) when it is three fourths full, so that it can be replaced.

Waste Collection Area/Centre to have the following characteristics
a) An area to be specifically earmarked for collection and storage of waste, pending treatment and final disposal.
b) To be covered and protected from all sides, against humans or animals.
c) Facility for proper locking of the area so that there is no tampering.
   The key should be kept with a responsible person, round the clock.
d) A clear warning sign with proper symbols.
e) Accessible only to authorized persons and to be guarded.
f) Location to be away from public places and food preparation areas.
g) The size of the facility to be adequate for storage of hospital waste for a period of at least two days.
h) Construction to be robust, with drainage system, proper lighting and ventilation.

Radioactive Waste Storage Container/Area
a) To be made up to hard plastic/metal, of size large enough to keep the waste for up to one month.
b) To be puncture proof and leak proof, labelled with appropriate symbols.
c) To be kept in an area meant for storage of radioactive materials.
d) The name of radioactive substance and activity on a given day, period of storage to be mentioned on the label clearly and the words “Radioactive hazard” to be in bold.

Operational Aspects
Containers to be made available in all areas of generation of waste and each container to be clearly labelled to show ward and room number, in consonance with the WHO policy of “cradle to grave” system of tracking wastes.
2.9.1.5 TRANSPORTATION OF HOSPITAL WASTE

Waste disposal is a multiphase activity, in which the different stages (i.e. generation, segregation, collection, interim storage, transportation, treatment and final disposal) are highly interdependent, both technically and organizationally. In this entire spectrum of activities, collection and transport form the vital link between the point of generation and final disposal. In the case of non-hazardous or general waste, number of precautions need not be taken; but in case of transport of hazardous waste, neither the public nor the operators (personnel) need to be exposed to unnecessary risks. Some additional problems which arise are:

a) Lack of knowledge about the chemical and physical properties of waste, as it is very frequently a mixture from which all economically useful components have been extracted.

b) At times there occurs mixing of incompatible wastes, done because of convenience of transit, which can create an acute hazard, either immediately or on treatment or disposal, e.g. explosion.

c) At times there occurs a perception of economic value in the waste, which can be dangerous and lead to “recirculation” of the same.

A) Types of Transport

The movement and transport of waste internally and externally is essentially a part of a comprehensive waste management system in all health care institutions. There are two types of transport of wastes.

a) Intramural (internal) Transport

It refers to the transport of waste from the point of generation, collection and storage in the wards to the point outside the building premises, where it is kept, pending the transport to the actual side of disposal.

b) Extramural (external) Transport

It refers to the transport of wastes from a central collection point outside building premises to the site of final disposal.
Vehicle for Transport

The vehicle for transport can be studied under both the types of transport, i.e internal and external. All vehicles should be carefully designed so that they are stable; quiet in operation, and transportation achieved with minimum effort. The waste should also be distributed minimally during transport, so that chances of spillage are less.

Internal Transport

a) Pushcart—An open pushcart made of stainless steel, which is designed in such a way, that one or two bins/containers of waste can be moved from the sluice room or treatment room to the garbage trolley, which may ideally be parked outside the ward.

b) Waste trolley—It is a large trolley made up of iron/stainless steel with four revolving castors and a handle on one side. It should be leak proof and of sturdy construction. The size should be such that it can be moved up and down through the lifts, and will also depend upon the quantum of waste generated. It should be covered so that insects, flies, etc. do not have access inside, and large enough so that waste is not piled on top of each other in an unsafe way.

c) Wheelbarrow—This can be used for small amount of general non-hazardous garbage collected from hospital premises and transport to the municipal dumping grounds (dalaos). These are made up of iron and have two castors and two stays, along with handle on one side.

External Transport

a) Cycle rickshaw—This is similar to the rickshaw trolleys except for the fact that the receptacle is covered on all sides and has a secure lid on top. This is of use in those institutions where the site of final disposal is close enough for the rickshaw to be effective. It can also be divided into two compartments one for infectious and other for non-infectious waste.

b) Waste van/Lorry—The specific lorry should be earmarked for waste transport, property identifiable with the labeling “Biomedical waste” both at the sides and rear. It should be fully covered, lined internally
with aluminum, or metal to give smooth impervious finish, and rounded corners without edges and angles for effective cleaning and disinfection. The drivers cabin should be fully separated by a bulk head, and the load compartment should be securely locked during transit. If the journey to final waste disposal centre is long the compartment should be refrigerated, otherwise it should have roof vents for ventilation.

B) Legal Aspects

As per the Biomedical Waste (Management and Handling) Rules, 1998, the following relate to transportation of waste:

“An authorized person handling biomedical waste shall segregate it prior to its storage, transport, treatment and disposal”.

Notwithstanding anything contained in the Motor Vehicles Act, 1998 or rules framed there under, untreated biomedical waste shall be transported only in such vehicle, which may be authorized by competent authority.

C) Labelling

All waste bags or containers should be labelled with basic information on their content and on the waste producer. This information may be written directly on the bag or container or on preprinted labels, securely attached. Table 2.13 denotes United Nations substance classes that characterize health-care waste. According to the United Nations recommendations for Class 6.2 substances i.e. infectious waste, the following indications should appear on the label:

- The United Nations packaging symbol, e.g. the international symbol for infectious substances
- The proper shipping name and the UN number
- The total quantity (mass or volume) of waste covered by the description;
- The country authorizing the allocation of the label (identified by international code system used on motor vehicles).
Table 2.13

United Nations substance classes that may characterize health-care waste

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Oxidizing substances</td>
</tr>
<tr>
<td>6.1</td>
<td>Toxic substances</td>
</tr>
<tr>
<td>6.2</td>
<td>Infectious substances (containers of sharps should in addition be marked with “Danger, contaminated sharps”)</td>
</tr>
<tr>
<td>7</td>
<td>Radioactive material</td>
</tr>
<tr>
<td>8</td>
<td>Corrosive substances</td>
</tr>
<tr>
<td>5.1, 6.1, 8</td>
<td>Would usually characterize chemical or pharmaceutical waste.</td>
</tr>
</tbody>
</table>

The classification should represent the most hazardous property of the transported waste.

It is also recommended that the last two digits of the year of manufacture of the packaging specified by the competent authority are marked on the package, as well as a special code designating the type of packaging.

For health-care waste, the following additional information should be marked on the label:
- Waste category
- Date of collection
- Place in hospital where produced (e.g. ward)
- Waste destination.

In case of problems involving questions of liability, full and correct labelling allows the origin of the waste to be traced. Labelling also warns operative staff and the general public of the hazardous nature of the waste. The hazards posed by container contents can be quickly identified in case of accident, enabling emergency services to take appropriate action.

Cytotoxic waste should be marked with the label “CYTOTOXIC WASTE”.

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Labelling for radioactive waste

Three labels have been designed by the UN/IAEA (International Atomic Energy Agency) for radioactive material, providing information on the levels of activity of a given package. Unless the package is large (and it is assumed here that all packages containing radioactive waste do not exceed 1m² in cross-sectional area), the labels should be chosen according to Table 2.14. If the two types of conditions of Table 2.14 differ, the package shall be assigned to the higher category. This categorization is as recommended in Regulations for the safe transport of radioactive material (IAEA, 1996).

Table 2.14

Categories of packages for radioactive waste

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum radiation level at a distance of 1m from the external surface of the package</td>
<td>Maximum radiation level at any point on the external surface</td>
</tr>
<tr>
<td>Not more than 0.0005mSv/h</td>
<td>Not more than 0.005mSv/h</td>
</tr>
<tr>
<td>More than 0.0005mSv/h but not more than 0.01mSv/h</td>
<td>More than 0.005mSv/h but not more than 0.5mSv/h</td>
</tr>
<tr>
<td>More than 0.01 mSv/h but not more than 0.1mSv/h</td>
<td>More than 0.5 mSv/h but not more than 2mSv/h</td>
</tr>
</tbody>
</table>
Routing

Health-care waste should be transported by the quickest possible route, which should be planned before the journey begins. After departure from the waste production point, every effort should be made to avoid further handling. If handling cannot be avoided, it should be pre-arranged and take place in adequately designed and authorized premises. Handling requirements can be specified in the contract established between the waste producer and the carrier.

2.9.1.6 Waste Treatment Technologies

Definition

“Treatment” is a term used for those processes that modify the waste in some way before it is finally disposed of, with the main objective of disinfecting or decontaminating it by some means, so that the following objectives are achieved:

a) Making it free from pathogenic microorganism
b) To reduce the volume of the waste and
c) To make it unrecognizable and hence more acceptable for final disposal.

According to the draft Biomedical Waste (Management and Handling) Rules, 1997, treatment means “a method, technique or process designed to change the physical, chemical or biological characteristics or composition of any biomedical waste so as to render such waste non-hazardous to health and environment. After such treatment the residues can be handled safely, transported, stored and disposed off. In considering the most suitable treatment and disposal methods for health care/hospital waste account should always be taken of all existing local options. The consideration of plans should also provide for emergencies. There are five broad categories of Biomedical waste treatment technology viz. chemical, thermal, mechanical, irradiation and biological.
A) Chemical Technology

I) Disinfection

Disinfection is defined as the "process by which most of the pathogenic microorganisms are destroyed from any inanimate body surface or material". When this is done by chemical means it is known as chemical disinfection.

Hospital wastes in the category of "infectious wastes" have to be disinfected prior to final disposal.

Indications
- Instruments and equipments that come in contact with skin, mucus membrane, before use of skin piercing instrument.
- Infected sharps like needles, tubings, and syringes etc.
- Contaminated floors, surfaces like trolley tops, table tops, trays, clothes, beddings, beds, crockery, enamel, stainless steel, bed pan etc.
- Contaminated instruments and equipments.
- Wards, OTs, ICUs from time to time

Common Chemicals used for Disinfection with contact period of 30 minutes. 47

- Bleach 1% solution for materials contaminated with blood/body fluids.
- Bleaching powder – for toilets, urinals, bathroom, etc.
- Methylated spirits (70%) – Methyl alcohol to which 1% glycerine is added, available in all clinical settings.
- Glutaraldehyde (2%) – Cidex for disinfection of surfaces and instruments that are destroyed by bleach, changed after 14 days.
- Detergent with enzyme – for cleaning endoscopes, theatre instruments and obstetric instruments before disinfection.
- Savlon 1% - for cheatle forceps, solution to be changed every day.

Guidelines have been prepared by Department of Health, Govt. of India on Hospital Acquired Infection for concentration/dilutions of different disinfectants to be used in cleaning contaminated and grossly contaminated conditions. The choice of disinfectants depends on number of factors such as effectiveness, stability, availability and price.
B) Thermal Technology

These processes use heat to decontaminate or destroy medical wastes. Most microbes are destroyed at temperatures ranging from 49°C to 91°C, and most living organisms are killed at 100°C. For the treatment of biomedical wastes, there are two categories of thermal technologies, i.e.

Low heat system, which use steam, hot water or electromagnetic radiation to heat and decontaminate the waste, by operating at temperatures less than 150°C.

High heat systems employ the processes of combustion pyrolysis and high temperature plasma to decontaminate and destroy the waste by operating at temperatures ranging from 600°C to > 5500°C.

I) Autoclave

This is low heat thermal process, which is designed to bring steam into direct contact with the waste in a controlled manner for a sufficient duration to disinfect the waste. This was originally introduced outside the arena of biomedical waste, and has been used since a long time for the sterilization of reusable medical instruments and microbiological laboratory cultures and stock solutions. The first instance when autoclave was put to use for sterilization of medical waste was in 1978 in California, USA. Tata Memorial Hospital in Bombay was the first hospital in India to install an autoclave machine to handle its infectious waste in September 1999 as was reported in Indian Express dated 19th October 1999. This new facility at the hospital sterilised and disposed around 50 kilograms of infectious waste everyday. The “dump” that existed within the premises had been replaced by this spotless facility, complete with a little garden patch. The biggest plus point of the entire process was that it reduced the volume and weight of the collected waste by 80 percent.

Types

All autoclaves can be classified physically into three basic types viz.

Gravity Type Autoclaves

In which pressure alone is used to evacuate air from the treatment chamber. It operates with steam temperatures of about 212°C and has a cycle
time of approximately 60-90 minutes, in order to achieve full steam penetration into densely packed waste wads.

**Prevacuum Type Autoclaves**

In which vacuum pumps are used to evacuate air from the treatment chamber, which helps in the reduction of cycle time to about 30-60 minutes at 132°C in order to achieve full steam penetration and quicker heating.

**Retort Type Autoclaves**

Comprise of large volume treatment chambers designed for much higher steam temperatures and pressures. Hence, their cycle times are substantially less than other systems.

Another classification of autoclaves can also be done based on physical characteristics and the temperature required for sterilization to occur, e.g.

a) **Above 100°C**
   i. Simple autoclave
   ii. Steam jacketed autoclave – considered to be the most suitable for hospital practice
   iii. Pressure cooker at 121°C for 30 minutes can be safely used (either the domestic type of pressure cooker or WHO/UNICEF modification of pressure cooker).

b) **At 100°C**: Boiling at 100°C for 20-30 minutes also sterilizes the instruments and equipments when autoclaving is not possible.

c) **Below 100°C**: Done by using a low temperature steam formaldehyde (I.TSF) sterilizer, at a temperature of about 75°C, at sub-atmospheric pressure, and a vapour holding time of one hour.
Operational Aspects

- The infectious wastes and bags are placed in sealed, pressurized chamber and exposed to open steam at required temperature (depending upon the type of autoclave) for a specific holding time (which is also fixed for different types of autoclave). The most important thing is that the proper temperature, pressure and holding time correlation is matched, in order to achieve desired level of sterilization.
- As a rule of thumb, all infectious waste is recommended to be treated at 121°C for a holding time of 30-60 minutes. After treatment it reduces the volume by minimal amount, with plastic materials melted and disfigured.
- To monitor the efficacy of the treatment process and see destruction of all microorganisms has taken place; spores of Bacillus stearothermophilus can be placed at the centre of waste load, and checked.

Advantages

i. Low capital and operating costs as compared to other treatment options.
ii. Low level of skills required for operators.
iii. Liquid emissions are minimal.
iv. Air emissions are not toxic /hazardous.

Disadvantages

i. Medium efficacy for sterilization, which implies some microorganisms, may still be thriving.
ii. There occurs partial reduction in waste volume and some plastic materials tend to melt and get disfigured. Non-plastic wastes are still recognizable hence landftilling, etc. is difficulty.
iii. Certain categories of waste viz pathological, cytotoxic and other toxic waste cannot be treated through this method.
iv. Survey of organizations indicates that extremely potent offensive and potentially toxic emissions may be release during processing.
v. Odorous fumes create problems that need to be controlled by putting odour control tablets.

vi. “Batch Operation” System involves manual loading and removal of waste from the autoclave; hence there is chance of infections.

**Problem Elimination/Control**

Addition of ancillary equipments in the form of a shredder, grinder and compactor will help in the shredding of waste so that at the end it is unrecognizable, thus eliminating one of the disadvantages. This will also help in volume reduction, thus increasing the ease of final disposal of waste. To control the malodorous air emissions, odour control tablets will be required.

Monitoring of the autoclaving process is done by putting test spores of Bacillus stearothermophilus, to ensure proper autoclaving. To avoid human element during operations, micro-processor control and monitoring system have to be incorporated. However, with the addition of such ancillary features and machines, there is bound to be a rise in costs, both capital and operational.

II) Hydroclave

This is a low heat thermal process, which is an innovation of the autoclave designed to apply steam as an indirect heating sources, allowing total dehydration of the waste. In addition, the waste is also internally agitated and fragmented to attain high degree of sterilization of all waste components and particles. In the process, the resultant waste is fragmented and dehydrated with reduction in volume and weight. The first prototype hydroclave invented by Richard Vanderwal was put into operation at Kingston General Hospital, a large teaching hospital in Ontario, Canada processing about 450 Kg of biomedical waste per day. Hydroclave is costlier than autoclave that limits its use. It is installed in one of the hospitals in Bangalore.
Description and Mechanism of Action

It is essentially a double walled cylindrical vessel, horizontally mounted, with one or more top loading doors, and a smaller unloading door at the bottom. The vessel is fitted with a motor driven shaft to which are attached powerful fragmenting mixing arms that slowly rotate inside the vessel.

When steam is introduced into the vessel jacket, it transmits heat rapidly to the wet fragmented waste, which, in turn produces steam of its own. This causes the waste to be fragmented and continuously tumbled against the hot walls by the fragmenting arms. The moisture content of the waste turns into steam and the vessel starts to pressurize. In the absence of adequate moisture in the waste to pressurize the vessel, a small amount of steam is added until the desired pressure is reached. The treatment/holding time is 15 minutes at 132°C or 30 minutes at 121°C to achieve sterilization. This dynamic interaction hydrolyses the organic components of waste and reduces volume (upto 85%) and weight (upto 60%), besides allowing self-unloading after the treatment cycle.

Operational Aspects

Loading

The waste is loaded simply by dropping bagged and/or boxed waste into the open loading door(s) on the upper side of the vessel. No special operator skill is required, since a heavy, light or very wet load is not an issue with this type of process.

Heat-up and Fragmentation

After loading, the vessel doors are closed, and the outer jacket of the vessel is filled with high temperature steam. The entire vessel starts to gain temperature. The drive mechanism is turned on, rotating the shaft and paddles, causing the waste to be fragmented and continuously tumbled against the hot vessel walls. All material heats up rapidly, being thoroughly exposed to the hot inner surfaces. The moisture content of the waste turns to steam, and the vessel starts to pressure. If there is not enough moisture in the waste to pressurize the vessel, a small amount of steam is added until the desired pressure is reached. Only when 132°C and 36 psi have been attained inside the vessel, will the sterilization period start.
**Sterilization Period**

The amount of steam fed to the outer jacket is regulated to maintain the desired temperature/pressure of the inner vessel, and the mixing paddles continue to rotate. The treatment time is 15 minutes at 132°C, or 30 minutes at 121°C. 64

**Depressurisation**

After the treatment time, the steam to the jacket will remain on, and the internal vessel will be vented through a condenser, and depressurised, whereby the waste loses its water content through a combination of heat input from the jacket, and flashing of water due to depressurization.

**Dehydration**

Further dehydration is achieved by maintaining the heat input and by mixing almost total dryness can be achieved.

**Unloading**

Finally, steam to the jacket is shut off, the unloading door is opened and shaft and paddles are reversed to a clockwise rotation to ensure that no waste remains stuck to the jacket walls. The paddles now act as an unloading mechanism, and scoop the waste fragments out of the unloading door, into a shredder, to be dumped into a waste container.

**Advantages**

i. No pretreatment of waste is required as the fragmenting and mixing mechanism is available inside the hydroclave.

ii. Complete waste dehydration during the sterilization process, which can help in the long run, as transportation and landfilling costs will be decreased.

iii. Volume and weight reduction is achieved to a great extent thus reducing the landfilling requirements.

iv. Operator maintenance skills are required to be of low level; as it is a simple electromechanical device with “push button” operation.
v. Both capital cost and operating cost are low, as it uses steam, which is practically the least expensive source of energy.

vi. Environmental aspect – Air emissions may be somewhat odorous but are generally non-toxic; and water emission are minimal, odorous but sterile. It can also hydrolyse segregated, organic waste to a homogenous substance ready for use as a soil supplement; and two hydroclaves (one for organic waste, other for hospital waste) could be put into use tandem at hospitals or municipal landfills.

Disadvantages
i. The air emissions are odorous which could cause problems during the operation of the machine.

ii. The sterilization efficacy is not as complete as it is during incineration.

iii. Certain types of waste i.e. pathological, cytotoxic and other toxic wastes cannot be treated with this.

iv. However, it seems that some of the problems that were evident in the autoclave have been removed by this treatment option, although shredder might be required to shred the output of hydroclave, before landfiling. This has not been approved by the Central Pollution Control Board in India.

IV) Microwave
This is low heat thermal process with a difference, in the sense that unlike other low heat processes, which heat the waste from outside, this heating occurs inside the waste material. Microwaves are electromagnetic waves that enter into or penetrate materials. It is that portion of electromagnetic and radiation spectrum, lying between 300 and 300,000 mega hertz. When exposed to microwave energy, all dipole molecules of a mass are put to vibration, which produces friction. This friction of vibrating molecules produces heat which result in disinfection. The microwave technology originated in Germany in the early 80’s and the first unit was installed at Forsyth Memorial Hospital in Winston-Salem, North Carolina in 1990. Subsequently, this has been gaining ground and has been approved for
a number of States of USA, Canada, Brazil and Europe. It has also been approved by the Central Pollution Control Board in India.

**Operational Aspects**

It is a very compact unit which is fully self contained and requires only appropriate electrical connections and a water line. The treatment process is fully automated, and the only manual work is placing the sealed bags of waste on a bucket hoist. This is automatically loaded into the sealed unit which contains the shredder. Here the bag and the waste are shredded into "confetti" like particles and it is moistened with steam to have effective heating by the non-ionising microwave.

The principle on which microwave operates is by energising the water (dipole) molecules, so that substance gets heated from inside the mass. The next step involves the movements of wastes in a screw auger which is heated to about 95°C to 100°C by a number of conventional microwave generators, arranged in series, to ensure continuous turning of waste material. Maintenance of this temperature for a holding time of 25 minutes ensures that all microorganisms (i.e. bacteria, spore, parasites, fungi and virus) are killed.

There is no decomposition of materials thereby; both liquid and gaseous emissions are eliminated. The inside air is treated with high-pressure steam and discharged through HEPA and Carbon filters which eliminate potentially hazardous airborne pathogens. A microprocessor control maintains the time temperature interaction for complete disinfection of the waste and alerts the operator when to feed more waste into the unit. Additional features include computer-aided reports attached to microwave device, which confirm total disinfection by providing temperature achieved in the chamber along with duration of heating.

Treatment of infectious waste like syringes, needles, tubings, dialysis etc. in a microwave device, makes it harmless and unusable. They are discharged as unrecognizable materials with a volume reduction of upto 80% without any reduction of weight. These can be discharged as household wastes. Once treated, the waste is dry and can be landfilled or recycled after
classification for recyclables such as plastic, metals, glass and organic constituents for composing. It can be tested by appropriate biological indicates, e.g. spores of Bacillus.

Advantages

i. Although disinfection technology is similar to autoclave (i.e. with heat) the process is not batch operated but continuous with automatic removal of product for disposal. It is a more mechanical and automated process, with less manual work.

ii. Characteristics of treated waste is acceptable for landfilling as it has been rendered unrecognizable, with volume reduction upto 80%, even though there is no weight reduction.

iii. Environmental aspect—Air emissions are somewhat odorous, but non-toxic, whereas water emission are negligible. No pollution hazards are associated with this.

Disadvantages

i. Microwave as a disinfection system requires a shredder prior to putting the waste, so that they are sterilized more evenly and quickly.

ii. It is not able to penetrate large and device object like—amputated limbs, tissues, specimens, etc. which are part of anatomical waste.

iii. High cost technology—both the capital cost and operational cost for microwave is quite high.

iv. Operator skills—since the process is largely automated, one requires a skilled operation for proper operation.

v. There is potential for release of volatile material from the process.

vi. According to Biomedical Waste (Management and Handling) Rules, 1998, microwave cannot be used for cytotoxic, hazardous or radioactive wastes, and large metal pieces.

IV) Incinerator

Incinerator is the process by which combustible materials are burned, producing combustion gases and non-combustible residues and ash. They use high temperature combustion under controlled condition to convert waste
containing infectious and pathological materials into inert mineral residues and gases. It deploys stage combustion concept, followed by cleaning of flue gases through a number of pollution control devices, and provides the advantages of greatly reducing the mass and volume of the waste, which subsequently reduces transportation and hospital costs. For infectious hospital wastes, the major objective of the incineration process is the destruction of infectious organism (pathogens) caused by their exposure to extremely high temperature. Besides, it is also attractive aesthetically because it destroys organic components of the waste, that the community often finds objectionable when wastes are disposed off in land fills.66 A simplified flow scheme is shown in figure 2.10.

The technology of incinerators has undergone many advances in the past decades from simple single stage type units, to the three or four stage systems available today. In the middle of 20th century (1930s to 60s), it was common place for incinerators to be of the single stage type where the waste was simply placed on a grate with underfire injected by natural draft, and the emissions were permitted to go directly to atmosphere. The next couple of decades saw the emergence of the two stage incineration plants which employed the use of an after burner and excess air injectors as methods of reducing the dense smoke. Thereafter, as a result of pressure from media, general public and environmental pressure groups, three stage systems have come into the market, mainly to reduce and control the emission of incineration plants.67
Figure 2.10

Simplified flow scheme of incinerator

- Air
- Waste
- Ashes
- Wastewater (optional)
- Flue gas ► Heat recovery
- Furnace
- Wastewater Water Discharge
- Sludges ► (require Treatment)
- Ashes (to disposal, and possibly stabilization)
Types

There are various classifications of incinerators, depending on type of fuel consumed, stages of incineration process and mechanism of action. Based on the type of fuel consumed, they can be divided into the following types.

a) Conventional incinerator—uses wood/charcoal of combustion.
b) Electrical incinerator—uses electricity for combustion.
c) Oil fired incinerator—uses some electricity and oil (diesel) for combustion.

The features of each of the above mentioned types is shown in the comparative Table 2.15

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Features</th>
<th>Conventional Incinerator</th>
<th>Electrical Incinerator</th>
<th>Oil Fired Incinerator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chamber</td>
<td>Single chambered</td>
<td>Single chambered</td>
<td>Multiple</td>
</tr>
<tr>
<td>2.</td>
<td>Fuel</td>
<td>75 Kg of Coal/Wood for 1000 bedded hosp./day</td>
<td>40 kg/hour burning requires 93kw/hr electricity</td>
<td>40 kg/hr burning requires 2 kw/hr of electricity and 2.4 kg of oil</td>
</tr>
<tr>
<td>3.</td>
<td>Pollution</td>
<td>Present, as no filtration of harmful smoke</td>
<td>Excessive smoke is present</td>
<td>Almost smoke free unburnt carbons are burnt</td>
</tr>
<tr>
<td>4.</td>
<td>Build up temp.</td>
<td>Very slow, almost never reaches desired temperature</td>
<td>Very slow 600°C in 6 hr.</td>
<td>Very fast 600°C in 30 minute</td>
</tr>
<tr>
<td>5.</td>
<td>Maintenance</td>
<td>Regular and cumbersome maintenance</td>
<td>Failure rates are very high, as heating element burns up</td>
<td>Almost maintenance free, having least failure rate</td>
</tr>
</tbody>
</table>

Based on stage of combustion, the incinerators can be divided into three stages i.e. Stages I, II, III. The brief description, mechanism of functioning and features are as following:
Stage I

This comprises of a refractory lined heated chamber where the waste is thermally decomposed by maintaining temperature above 800°C. Depending upon the entry of air into the primary chamber the incinerator could be either a pyrolytic (no air); starved air (less than 50% of combustion air) or excess air type. The advantages of “starved air” type is that, it prevents carrying over of solid wastes to secondary chamber after it is heated to ignition temperature, more so when waste contain excessive paper and plastic. In this stage, organic constituents of the waste decompose and produce a host of chemicals grouped as “volatiles” which are led into the secondary stage. The resulting ash is removed from this stage. There is one oil/gas burner in the stage to keep temperature at 800°C.

Stage II

The volatile chemicals along with combustion gases are heated in this chamber to around 1050°C to 1100°C with excess additional air. The volume of the chamber should be large enough, so that the combustion gases stay at temperature of 1050°C at least for one second. Residence time is calculated as “the effective volume of this stage divided by volumetric flow of these gases at the prevailing temperature and pressure. Since temperature is high in the range of 1050°C the volume should be sufficiently large. The stage is made up of special refractory material, which raises the cost and also has an oil gas burner. The main objective, of this stage is to destroy all the chemicals/volatiles produced during stage-I including some dioxins and furans.

Stage III

By having the two stages mentioned above, it is not possible to eliminate the polluting gases, which are emitted. These are particulate matter and carbon monoxide (CO) due to incomplete combustion and poor operating condition; HCl vapours when chlorinated plastics and substances are not segregated at source; oxides of nitrogen due to nitrogenous compounds in the waste, heavy metals like lead, Nickel, cadmium and mercury; dioxines and furans which tend to reform when gases are cooled below 400°C in presence
of particulates and chlorine. To effectively counter these problems, venturiscrubbers followed by packed bed towers are commonly used to remove acid gases HCL, HF and sulphur dioxide. Wet scrubbers are effective in removing the acid gases and dioxins, but are less effective than fabric filters in removing heavy metals. Recently it has been found that injection of lime and activated carbon can result in 95% removal of mercury and dioxines from gases when bag house are employed.69

Based on mechanism of action there are three types of incinerators, which are being used for incineration of hospital waste, namely multiple hearth, rotary kiln and controlled air. All these three types can have primary and secondary combustion chambers to ensure maximum combustion of waste.

Multiple hearth chamber: This type consists of two or more combustion chambers, of which the primary chamber is for solid phase combustion and secondary chamber is for gas phase combustion. These are also referred to as excess air incinerators because they operate with excess air levels in both primary and secondary chambers. These were in vogue before 1960’s and were designed specially for pathological wastes, as per Incinerator Institute of America specifications.

Rotary kiln: Consists of a cylindrical refractory lined large metal drum that is mounted at a slight incline from the horizontal plane to facilitate mixing of waste materials with circulating air. The kiln acts as the primary chamber (with excess air) to volatilize and oxidize combustibles in the waste. Some manufacturers have rotary kilns designed to operate with substoichiometric atmosphere in the kiln, using special seals and air injection schemes. The secondary chamber is present after the kiln to ensure complete combustion of the waste. Both the kiln and the secondary combustion chamber are usually equipped with an auxiliary fuel system to bring the units up to desired temperature.

Controlled air Incinerator: These burn waste in two or more chambers under conditions of both low and excess stoichiometric oxygen requirements. In the primary chamber waste is dried, heated and burnt at 40-80% of the
stoichiometric oxygen requirement. Combustible gas produced by this process is mixed with excess air and burnt in the secondary chamber between 100-150% of the stoichiometric requirement. A supplementary fuel burner is used to maintain elevated gas temperature and provide for complete combustion. The rational behind the use of low levels of air in primary chamber is that there is very little entrainment of particulate matter in the fuel gas.

This classification is of assistance in characterizing how hospital waste incinerators operate, but it is limited because it does not address the complete combustion system. The three important factors which help to characterize the hospital waste incinerator system and its operation are:

i. The air distribution to combustion chambers, which can be starved/excess air.

ii. The mode of operation and method of moving waste through the system can be single batch intermittent duty or continuous duty.

iii. The method of ash removal can be single batch or continuous duty.

**Process Outline**

The hospital waste incineration process can be divided into the following steps:

a) Waste preparation

b) Waste charging

c) Waste combustion

d) Treatment of combustion gases (i.e. add on pollution control).

e) Residue ash handling.

Besides these five steps, waste heat recovery may also be included as a part of the incinerator system in which all the steps mentioned above are interrelated, e.g. charging of waste will effect, how well the waste are incinerated and consequently ash quality.

An understanding of how an incinerator operates as a system requires familiarity with some basic scientific and engineering principles. The two principles are pathogen destruction and combustion chemistry/physics. The
primary objective of incineration is pathogen destruction in infectious wastes, which is achieved primarily by the high temperature. Emissions of microorganisms from incinerator could be due to insufficient retention time and temperature due to following reasons.

- Initial charging before it has achieved operating temperature.
- Failure to preheat the refractory lining.
- Temperature fluctuations.
- Charging beyond capacity
- Exceeding airflow design, thus reducing retention times.

In principle, the combustion of hospital waste is a chemical process that is equivalent to combustion of fossil fuels for energy recovery. It is a chemical reaction that involves rapid oxidation of the organic substances in the waste (notably carbon, hydrogen and oxygen) and auxiliary fuels. The reaction chemistry in the combustion zone is quite complex, involving a wide variety of organic compounds and free radical species. The maximum combustion temperatures are attained at stoichiometric conditions. As the amount of excess air is increased beyond this point, the combustion temperature is lowered because energy is used to heat the combustion chamber temperature. Below the stoichiometric point, the temperature decreases because complete combustion (exothermic reaction) has not occurred. In the design and operation of incinerator, the gas flows are of major concern. Complete destruction of pathogens and complete combustion of organic constituents require exposure of the materials to high temperatures for minimum specified residence times.

Hospital waste fed into incinerator varies considerably in their composition, heat and moisture content, and bulk density. The following categories of hospital waste can be incinerated.

a) Surgical, autopsy and obstetrical waste like placenta.

b) Human and animal tissue containing pathogens, which are infectious.

c) Dialysis and ward waste which have had contact with blood/ body fluid.

d) Isolation room wastes which are in contact with body fluids of infectious and communicable disease patients.
e) Blood and blood products.

f) Microbiological and biotechnological wastes from laboratories and research institutions.

The chemical composition of waste materials may also affect pollutant emissions, and in this category wastes containing metal and plastics are of particular concern. Metal which vaporize at primary combustion chamber temperature (800°C) e.g. Mercury may become metal oxides with very less particle size (range of 1mm or less). Halogenated plastics, such as polyvinyl chlorides (PVCs) will produce acid gases such as HCl. The presence of chlorinated wastes may also contribute to the formation of toxic polycyclic organic materials like dioxines and furans under poor operating conditions. However, some plastics such as polyethylene and polystyrene do not contain significant amount of halogens and can be incinerated without major concern for acid gas or toxic pollutant formation.

**Advantages**

a) Incinerators can potentially destroy any material containing organic carbon, including infectious pathogens found in medical wastes, thus ensuring total sterilisation. Transport bins made up of cardboard boxes can also be incinerated.

b) By combustion, they typically reduce the volume and mass of hospital waste up to 80 to 95%, which has to be disposed off by landfilling.

c) Recognisability of medical waste is not at all present, hence anatomical tissues, specimen, etc can be easily incinerated.

d) No ethical problems for the persons handling medical wastes.

e) No pretreatment of waste like shredding etc. is required before it is incinerated.

f) Heat from incineration can be recovered and used to generate steam, thus reducing the net operating costs.

**Disadvantages**

a) Air emissions from incinerators is of primary concern as it may contain a number of pollutant and toxic materials viz. particulate matter, acid gases, oxides of nitrogen, dioxins and furans.
b) Capital costs and operating costs are very high, hence it may be out of reach of most hospitals. Rotary kiln incinerators have more moving parts; hence maintenance costs will be more.

c) High levels of operator maintenance skills are required. The trends towards more stringent emission by laws will complicate the procedure still further. Incineration also represents a moderate risk to operators and maintenance personnel due to high operating temperature and potential for fires.

d) Inability to deal with radioactive wastes and pressurized containers.

e) Disposal of incinerator ash can cause problems at times.

Health Care Without Harm, a coalition of 433 organizations in 52 countries is working to reduce the environmental impact of health care. They strongly propagate that incineration is an outdated,polluting, and an expensive technology and appeal to all to phase out the use of incineration as a waste treatment method. Hospitals are not supposed to undermine public health. Medical waste incinerators harm people. They pollute the air we breathe and the environment in which we live, posing serious health risks. Incinerators release dioxin, mercury, and other toxic pollutants, and expose workers and communities to these poisonous chemicals. Making it even less popular, incineration also costs significantly more than cleaner, less dangerous waste treatment technologies. Because incineration is an obsolete, dirty, and costly technology, its continued use is a liability that harms Stericycle’s reputation and its profits. Medical waste incinerators pose serious health and financial risks, and cost more than cleaner, readily available alternative technologies. Incineration is, in short, a dying trend. Non-burn technologies are the future of waste treatment. In USA and UK, there has been a ban on the use of incinerators.

In most of the countries including India, the standard of incinerator is not very high and never maintained all the time. It is found that the desired temperature never reached in most of the incinerator in Delhi. In 1999 the CPCB surveyed 40 such hospitals incinerators and majority of them were not
adhering to standards. There are various technical and administrative
difficulties in attaining higher standards.⁴⁵

Many pollutants are released during combustion of waste, which
contained various hazardous materials. Even bags in red color should not be
incinerated because they contain cadmium. Following emission from
incinerators are known for various adverse health impacts ranging from minor
illness to severe illness and cancers⁷²:
  • Particulate Matter
  • Toxic metals: arsenic, cadmium, lead, mercury, etc.
  • Toxic Organics: PVC generate Dioxins and Furans
  • Carbon monoxide
  • Acid gases: Hydrogen chloride, sulphur dioxide, nitrous oxides.

Causes of excessive emission from incinerators are:
  • Excessive infiltration air
  • Excessive negative draft in primary chamber
  • Excessive primary air
  • Excessive secondary combustion air
  • Adverse waste characteristics
  • Untrained incinerator operator

C) Mechanical Technology

These are used to change the physical form or characteristics of waste,
either to facilitate waste handling, or to process waste in conjunction with
other treatment steps. These were put to use in mid 1980’s and comprise
primarily of compaction and shredding. These are not considered as
acceptable medical waste treatment solutions by themselves and are
complementary to some other treatment options: Compaction involves
compressing the waste into containers to reduce its volume; whereas
shredding includes granulation, grinding, pulping, etc. which are used to break
the waste into smaller pieces. Typically these processes are carried out either
before or after the waste has been decontaminated in order to reduce the
volume and to make it unrecognizable.
I) Compaction

Compaction techniques are used to reduce the waste volume; and affect waste recognisability. Generally, a hydraulic ram is used to compress the waste against a rigid surface, so that it gets compressed or compacted. This in way affects the infectious nature of the waste. One of the disadvantages of compaction is that it destroys the integrity of containers, causing dispersion of materials. There is potential for aerosols to be formed and released; and liquids can drain out of devices. Since mechanical operation of the equipment is the most significant factor affecting compaction effectiveness the operators have to be trained to operate and maintain machines. The quality of compaction can be observed for monitoring.

II) Grinding and Shredding

These are used to convert medical wastes into a more homogenous form so that they are easily handled. In this, the wastes are physically broken down by primary and secondary shredding in one pass into smaller particles and the equipments are maintained at negative pressure to ensure that no material escapes outside Additional cutting process occurs when the material is recycled by the side cutting teeth into final uniformly defined material. Needle clipping devices are used to remove needles from syringes. This reduces the volume of waste material and renders it particularly unrecognizable. The only disadvantage is that pathogen can form aerosols, hence there is potential for transmission of infection to the workers. The quality of shredding and grinding will depend upon the quantity of metal and glass present in the waste stream, and the presence of fibrous, rubber of soft plastic materials. The former can wear out the grinding edges, while the latter may get caught on the equipment and cause it to malfunction. The waste coming out of the shredder can be inspected to keep tract of quality and the size of shredded waste will determine if it is functioning effectively. Due to the wear and tear of the grinding equipment frequent, preventive maintenance of the equipment is required. Some operator training is also required in the aspect.
III) Pulverisation

This is a process by which waste is reduced by one tenth in volume so that the resultant granular debris, treated with a chemical decontaminant is safe for final disposal by sanitary landfiling. The system consists of wastes and the container being placed on a large enclosed incline conveyor and carried to a feed hopper where a large volume of water and sodium hypochlorite (bleach solution) are introduced. The waste is torn into an ultra high speed hammer mill consisting of a closed chamber in which large steel blades spin at approximately 3600 revolutions per minute. By this action, cloth items are reduced to fibrous pulp; glass is reduced to sand, needles, sharps and other metal objects are reduced to small safe particles, soft tubings and dialyser filters are completely powdered and plastic bags are reduced to small flakes. All waste materials are pulverized into very small particles, and get intimately and thoroughly mixed with strong chlorine solution. The synergistic action of the hammermill and chemical solution produces a homogeneous mixture of waste and chemical in matter of seconds. This resulting slurry flows to an automatic solid-liquid separator from where majority of liquids go to the sewer lines, solids are placed in an enclosed covered tilt cart. The cart has an overnight drainage system, which completely dewater the waste for final disposal. The entire process is under negative pressure provided by the dual air fans, which exhaust air through HEPA filters, which remove microbes from the aerosol. Noise levels are within acceptable limits and the machine can process wastes in about 30 minutes. The primary advantage of such a system is that it eliminates the need for waste segregation at source, as all waste is put in the machine.74

D) Irradiation (Electron Beam Gun) Technology

Irradiation with ultraviolet or ionizing radiation is a potentially available method for treating medical wastes. This involves exposing the medical wastes to ultraviolet or ionizing radiation in an enclosed chamber. A process utilizing Cobalt 60, and electron beam accelerator unit or electron beam gun for irradiating and sterilization the medical waste have been developed. These radiations help in sterilization of wastes by destruction of pathogenic organisms and inducing chemical and biological changes in the waste.
material. Decontamination occurs when nucleic acids in living cells are irradiated. Methods are similar to those being currently used for sterilization of food articles, medical supplies and disposables. The time of exposure of irradiation, the directness of exposure and relative humidity level play an important factor in determining efficacy of the process. Periodic testing of the test microorganism can be conducted to monitor the effectiveness. Costs are increased due to radioactive fields, which need shielding. Volume of waste is reduced by 20% and disinfected remains are shredded and land filled.

**Advantages**

i. Very little energy input is required, because the equipment requires very less amount of electricity and no heat.

ii. It is useful in treatment of items/materials, which cannot be thermally heated.

iii. If it is for adequate duration, cent percent sterility is assured.

iv. No toxic air or water emissions are present.

**Disadvantages**

i. Technology is complex and requires highly trained operators and support personnel who can utilize the machines.

ii. Radiation itself does not make the waste unrecognizable; hence it has to be complemented by some of other mechanical means, e.g. shredder.

iii. Radiation source will eventually decay and hence will require replacement. Its disposal is a significant problem.

iv. The ability of the source to activate trace metals in the waste has not been characterized.

v. Human exposure to ultraviolet and other ionizing radiation can cause adverse health effects.

**E) Biological Technology**

A system is being developed using biological enzymes for treating medical wastes. It is claimed that biological reactions will not only decontaminate the waste, but also, cause the destruction of all the organic
constituents so that only plastics, glass and other inert substances remain in residues.

F) **Emerging Technologies for Treatment of Waste**

Several emerging technologies are being thought of as alternatives to those, which have been mentioned earlier. These are now in experimental stage and may be available in future for commercial use. These are being tried out with the objective for complete recycling hospital wastes.\(^75\)

I) **Molten Salt Technology**

Although this has been in existence for many years, it is now being tried out for treatment of hazardous hospital wastes. In this process, combustible wastes and air are introduced continuously beneath the surface of a bath of molten salt. The hazardous material is thus combusted at temperatures below its ignition point, salts like sodium carbonate, alkali salts are used as the melt, but others can also be used. The process can be batch fed or continuous feed, but the capacity is generally small. The temperature range is 1500-1850\(^\circ\) C and residence time is around 5 seconds for the gas phase of combustion, and hours for solid phase of combustion. The containers are made up of ceramics, aluminium, stainless steel or iron.\(^76\)

II) **Electric Reactors**

These are designed to pyrolyse waste contaminants on particles through the use of an electrically heated fluid wall reactor. These units have been used successfully in other chemical processes and are being tried out for waste treatment. The portable version of this, appears to offer a very different and potentially valuable thermal option for hospital waste management.

III) **Plasma System/Plasma Torch Technology**

In these systems, the extremely high temperature of plasma is employed to destroy waste materials, and it offers an innovative approach to destroying highly toxic chemicals. A plasma is defined as “a material in which the temperature is so high that some of its electrons are separated from its
atoms. These systems basically utilize a plasma torch or burner for heating (pyrolysing) the wastes to super high temperatures beyond 1150\(^0\) C (at times furnace temperatures go as high as 10000\(^0\) C for periods up to 1 second to produce combustible gases and “vitrions” or glass like rock substances. The plasma temperature incinerator burns toxic wastes including PCBs in a pressurized stream of preheated oxygen. The system consists of a preheater, combustion chamber, residence chamber, quench chamber, scrubbed tower and exhaust stack. The preheater is a refractory lined, water-cooled chamber in which a clean fuel is burnt to preheat oxygen to about 1800\(^0\)F. This oxygen enters combustion chamber through dispenser plate, which contains a number of fuel nozzles and oxygen ports, and is designed to achieve optimal mixing of both. This arrangement minimizes the risk of flame out and subsequent contamination of the area with partially burnt waste.\(^{77}\) The final product of this type of incinerator is a glass like substance, rather than particulate ash, which is suitable for concrete and asphalt construction. The gases may serve as a source of energy. One of the disadvantages is that the capital and operating costs are very high, even when compared with incinerators.

IV) Molten Glass Technology

Molten glass technology uses a pool of molten glass as the heat transfer mechanism to destroy waste material. The attractiveness of this is based upon the extremely good quality of residue from the process, which is essentially non-leachable glass. The combustion condition for organics appears to be at least as good as those present in hazardous waste incineration, and the inorganic residue and ash is incorporated into the glass. This could be extremely beneficial especially for highly toxic organic stream containing toxic metal if it could be verified that it is non-leachable. In this method, a pool of molten glass is charged into an electric furnace. The waste is burnt to ashes (or dried to solids) that are immediately melted into glass; all in the same chamber. Excess glass is drained off into canisters from time to time for final disposal. The composition of glass used is very stable. Solid waste in fibreboard containers are put into the glass furnace, which is heated by immersion heaters. Dirt and non-combustible elements drop into the glass...
and melt in. The gases go up through the filter to spray chambers where hydrogen chloride is converted into common salt.\textsuperscript{78}

V) Infrared System

These offer considerable potential for mobile use. The unit has infrared lamps (powered by electricity) strung in a row that can be expanded as desired. Wastes are conveyed into the radiation zone by a steel belt, and are carried along until fired with propane at about 2400\textdegree F. The advantage here is that solids are not volatilized thus needing less energy and less particulate carry over into secondary chamber. Most units run at 50-100\% excess air and may discharge some of the waste out of the stack. It can run even below atmospheric pressures and has a retention time measured in minutes. The cost of this method have been found to be at par with landfilling and below the cost of rotary kiln type operations.\textsuperscript{78}

VI) Detoxification Technology (Superheated steam Sterilisation)

This system consists of a heated shredder where the waste is heated to 480-700\textdegree C and simultaneously shredded. The gases that are evolved are treated with steam for reformation and solid organic matters (compounds) are destroyed by heating with superheated steam to 1540\textdegree C at increased atmospheric pressures. This causes medical equipments to melt into a sterilized mass in an hour; the remaining residues are cooled and dropped into a collection bin. The process employs a continuous batch system and has been shown to reduce medical waste by 50-80\% of its original volume. It is claimed that this technology can handle all waste including chlorinated plastic products and low level radioactive wastes. Operational costs are however, quite high.

VII) Wet Oxidation Technology (Advanced)

This is similar to mechanical/chemical type of technology with use of proprietary catalyst for rapid disinfection of shredded waste. Weighed plastic drums filled with medical waste are placed on top of a shredder. The shredded waste drops into a spinning basket in an oxidation chamber. Once the chamber is full, it is closed and a water based solution containing 10\%
sulphuric acid, an iron ion catalyst and co-catalyst is introduced. The sulphuric acid maintains a highly acidic pH, and the agitation ensures that entire mass is saturated with the solution. Then the remaining waste is doused with a finishing rinse of deionised water. It is claimed that this can oxidize most of the organic matter at a quick rate of 225kg/hr. The treated waste from this method can be landfilled or recycled.

VIII) Thermal Dry Heat Technology (TAPS)

Thermal Activated Plastic Sanitiser, these are small desk top units which sterilize, encapsulate and compact the waste, with a volume reduction of 10:1. The waste is kept in a special type of plastic bag in a chamber which can be heated upto 190° C for three hours either by electricity, recirculation of convectional heat, infrared rays or any combination of these components. The methodology causes the plastic to melt around and through the waste, sterilizing it and making it plastic block on cooling. Waste becomes rigid and loses its recognisability. It is very suitable for small dentists office for dry type wastes. Large units, a bit costly, are also available in the market.

IX) Electrikinetic Gasification Technology

In this technology, gases comprising of hydrogen, carbon monoxide and carbon dioxide are produced in an electric furnace. Carbon dioxide is then converted into carbon monoxide in a coke bed electric are furnace, to produce mixture of carbon monoxide and hydrogen. This gas can be used for power generation through gas turbine.

X) Encapsulation

Disposal of health-care waste in municipal landfills is less advisable if it is untreated than if it is pretreated. One option for pretreatment is encapsulation, which involves filling containers with waste, adding an immobilizing material, and sealing the containers. The process uses either cubic boxes made of high-density polyethylene or metallic drums, which are three-quarters filled with sharps and chemical or pharmaceutical residues. The containers or boxes are then filled up with a medium such as plastic
foam, bituminous sand, cement mortar, or clay material. After the medium has dried, the containers are sealed and disposed of in landfill sites.

This process is relatively cheap, safe, and particularly appropriate for establishments that practise **minimal programmes** for the disposal of sharps and chemical or pharmaceutical residues. Encapsulation alone is not recommended for non-sharp infectious waste, but may be used in combination with burning of such waste. The main advantage of the process is that it is very effective in reducing the risk of scavengers gaining access to the hazardous health-care waste.

**XI) Inertization**

The process of “inertization” involves mixing waste with cement and other substances before disposal in order to minimize the risk of toxic substances contained in the waste migrating into surface water or groundwater. It is especially suitable, for pharmaceuticals and for incineration ashes with a high metal content (in this case the process is also called “stabilization”).

For the inertization of pharmaceutical waste, the packaging should be removed, the pharmaceuticals grounded, and a mixture of water, lime, and cement added. A homogeneous mass is formed and cubes (e.g. of 1m^3^) or pellets are produced on site and then can be transported to a suitable storage site. Alternatively, the homogeneous mixture can be transported in liquid state to a landfill and poured into municipal waste.

The following are typical proportions for the mixture:

- 65% pharmaceutical waste
- 15% lime
- 15% cement
- 5% water

**2.9.1.7 Selection of Treatment Technology**

The selection of the right type of treatment technology for a particular hospital/health care institution is indeed the proverbial Hobson's choice for the hospital administrators. The hospital management is really at the cross roads,
where one of the roads leads to technological development leading to the use of more and more disposables and expansion of “technology intensive” health care services, whereas the other road leads to a firm commitment for public health facilities, a commitment to preserve the environment and eco system. The social activists and the environmentalists keep on clamoring against any true or perceived assault on the environment. The bureaucratic and political dictum of resource crunch for investments in invisible return oriented services like hospital waste disposal has also strained the medical administrator. In the background of this scenario the hospital administrator should consider the various functional aspects, and assess the process of waste generation and its disposal from a holistic angle. He/she should have to address the issue of hospital waste management from the point of view of technological feasibility, operational practicability, economic adaptability and socio-cultural acceptability. All the technological options should be evaluated critically on the basis of a number of factors namely:

i. The types and quantities of various categories of waste generated in the health care institution per day.

ii. The types ad applicability of equipments available for treatment on site, i.e. within the hospital.

iii. The type and applicability of equipments/technologies available for treatment “off side”, i.e. away from the hospital.

iv. The appropriateness of each selected method/technology for that particular category of waste. More emphasis is to be given to that category of waste, which is most infectious, and its treatment method.

If one treatment option is not suitable for all types of infectious wastes; then one principal treatment technique should be selected, with other additional/back up technologies.

Selection of type of equipment for treatment should be based on consideration of the following factors –

a) Technical capability to treat waste effectively

b) Applicability to various types of infectious waste produced (i.e. suitability)

c) In treating more than one category of waste

d) Capacity of the equipment vis-a -vis waste generation
e) Reliability of the equipment/technology
f) Ease of operation and training of operators

Since the primary objective of infectious waste treatment is to render it non-infectious, two treatment technologies are generally used viz. (i) incineration for pathological wastes, tissues, anatomical organs parts, etc. and (ii) autoclaving (steam sterilization) for other infectious wastes, which are not incinerable.

While selecting the right technology all the following should be evaluated and the best option chosen:

i. Factors that should be maximum
   - Disinfection efficiency
   - Automation and continuous process system
   - Quantum of volume and weight reduction
   - Potential for recovery of energy or recyclable products

ii. Factors that should be minimum
   - Environmental pollution
   - Liquid discharges
   - Air emissions
   - Occupational hazards
   - Exposed manual handling of waste
   - Power consumption
   - Capital and operational costs
   - Consumables and fuel consumption

It is felt that an integrated or holistic approach will give the best solution for finding the appropriate technology in any health care organization.

2.9.1.8 FINAL DISPOSAL OF HOSPITAL WASTE

Waste generation in hospitals and their final disposal has always been a concern of the medical professionals, ever since hospitals came into being. Even during the earlier times, waste disposal systems in the form of burning, burial and land filling did exist, as these were conforming to the then existing knowledge of public health, epidemiology and sanitation practices. These were regulated to some extent by the local municipal (civic) acts or other public health legislation enacted from time to time. The primary aim of hospital
waste management is the scientific collection, segregation, transportation, treatment and final disposal of hospital waste without creating problems. Once the infectious and hazardous wastes are treated by various modalities and are rendered harmless, the question of final disposal comes up. According to the draft Biomedical Waste (Management and Handling) Rule, 1997, Disposal means "burial, discharge, deposit, dumping, land filling or placing on land of any biomedical waste."

**Disposal of Various Wastes**

Once the various categories of waste have been treated by some methodology like incineration/autoclaving etc they are non-infectious or non-hazardous. Their disposal can be discussed under the following heads:

1. Disposal of general/non-hazardous solid wastes
2. Disposal of waste water/liquid waste
3. Disposal of human anatomical, blood and body fluids
4. Disposal of sharps
5. Disposal of microbiological and biotechnical wastes
6. Disposal of pharmaceuticals.
7. Disposal of infectious solid wastes
8. Disposal of chemical wastes
9. Disposal of radioactive wastes and
10. Disposal of pressurized containers

**1) Disposal of General/Non-Hazardous Solid Wastes**

Depending upon the quantity of general, non-hazardous solid wastes generated in a hospital. The following disposal options are available:

For Small Quantity of Wastes

i. Landfill
ii. Use of pits and
iii. Composting

For Large Quantities of Wastes (in commercial scale)

i. NADEP composting
ii. Pelletisation technology
iii. Biopress and manure and
iv. Pyrolysis/gasification technology
As far as general hospital wastes are concerned, these are non-hazardous in nature and are the same as household or domestic waste. Hence, these wastes if properly segregated from infectious wastes can be handed over to the municipal (civic) authorities for disposal by them.

2) Disposal of General Waste in Small Scale

Landfilling (Controlled tipping) is the most satisfactory method of garbage/refuse disposal where suitable land is available. However, the site of landfill has to be chosen with utmost care and the following factors regarding construction should be kept in mind:

- It should be avoided, in sites located on sensitive aquifers and sources of water.
- Site should be securely fenced and have a gate situated away from dwelling units, far away from public view. Signboards should be put at these sites with letters – “Landfill site”.
- Covered with at least 0.5 meter of suitable cover material, especially when autoclaved/microwaved clinical materials are being used for landfilling.

Landfilling is done by any of the following three methods:

a) **Trench method**- Long trench 2-3 meters deep and 3-10 meters wide depending upon local condition, is made. The treated waste is ideally compacted and filled upto 2 meters, covered with excavated earth.

b) **Ramp method**—this is well suited where the terrain is moderately sloping; and some excavation is done to secure the covering material.

c) **Area method**—This method is used for terrain land depressions, disused quarries and clay pits. The treated waste is deposited, packed and consolidated in uniform layers upto 2-2.5 meters deep. Each layer is sealed on its exposed surface with a mud cover at least 12” thick to prevent infestation of flies, rodents etc.

With the advent of mechanized equipment, sanitary landfill has been revolutionized, as the bulldozer, achieves the task of spreading, trimming and spreading top soil. After the waste is buried, chemical, bacteriological and physical changes occur and the temperature goes above 60° C within 7 days,
hastening the decomposition process. Within 4-6 months, complete decomposition of organic matter occurs into an innocuous mass. The term “modified sanitary landfill” has been applied to those operations where compaction and covering are accomplished once or twice each week. The potential use of filled land includes improvement of eroded areas; marshes and other marginal lands, which have been used for golf courses, parks, recreational uses etc.

**Pit burial:** This is suitable for small camps or institutions, where in a small pit of size 2 mts. by 2 mts, is dug and the wastes are put there with 10 cm soil between each layer of waste. When the level is almost full, it is closed with thick layer of soil, it is also fenced with secure gate for entry and exit. Contents get decomposed by 4-6 months time.

**Composting:** Composting is a method of combined disposal of refuse and night soil or sludge. It is a process of nature whereby organic matter breaks down under bacterial action resulting in the formation of a relatively stable humus like material called ‘compost’ which has considerable manurial value for soil as it contains nitrates and phosphates. The temperatures achieved (upto 60°C) over a period of several days, destroys the egg and larvae of flies and other insects. This is generally done by two methods viz. anaerobic method (Bangalore method or hot fomentation process) and aerobic method (mechanical composting).

**Vermiculture:** In this process biodegradable garbage especially from the kitchen, houses and cafeteria are converted into manure with the help of earthworms. Organic waste is kept in a wooden box or earthen ditch with small amount of waste in the bottom. Bunch of earthworms are placed in each part and covered with organic matter. This is sprinkled with water, and in due course of time it gets converted into manure.

**Disposal of General Wastes in Large Scale**

**NADEP composting:** This is an ideal technology to take care of both, the organic household refuse as well as agricultural refuse of villages. In
large health care institution the general refuse /waste can also be utilized, to be converted into rich soft, good smelling compost, by using this simple, economical and non-polluting technology.

Pelletisation technology: This process converts biodegradable waste into “fuel pellets” by treatment with heat, humidity and pressure by machine designed for this purpose. The fuel thus developed is cheaper, has less smoke emission, but lasts longer.

Biopress methods: This turns garbage into incinerable matter and produces methane gas. Methane is produced naturally in any landfill through decomposition of organic matter, for a period of 20-30 years. It contains roughly 50% of carbon dioxide. The recoverable gas is around 50-80% of total gas, which can be used for

i. Generation of electricity in an internal combustion engine or gas turbine;

ii. Used directly as boiler fuel

iii. Compressed for vehicle fuel or upgraded to pipeline gas.

Environmental effect of methane (landfill gas) is about 10 times more potent than carbon dioxide, and it can be reduced to methane which is recovered for energy production. The experience of “wastes to energy technologies” (WET) such as this has been encouraging in developed countries, but not in developing countries.

Gasification technology (Biogas from organic wastes): Energy derived from anaerobic digestion of organic waste involves the production of biogas from organic waste. The technology requires separation of wastes at source or mechanically prior to digestion and comprises of the following three steps (i) pre-treatment, (ii) digestion and (iii) post-treatment of waste. This process is ecofriendly and recovers 100% methane; reduces odour, produces energy and also forms a suitable by product viz compost which is an excellent manure.

3) Disposal Of Waste Water And Liquid Waste

Wastewaters and liquid wastes from the kitchens, cafeteria and laundry should be drained into the municipal/civic drains. In case no sewer connections are available in the hospital, they should develop their own
sewerage treatment plants. Generally, cytotoxic and hazardous wastes are not discharged into the sewers without treatment.

**Effluent Limits**

The following limits have been prescribed for effluents in hospital waste.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Permissible limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.5-9.0</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>100 mg/L</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>10 mg/L</td>
</tr>
<tr>
<td>Biological Oxygen demand</td>
<td>30 mg/L</td>
</tr>
<tr>
<td>Chemical Oxygen demand</td>
<td>250 mg/L</td>
</tr>
<tr>
<td>Bio-assay test</td>
<td>90% survival of fish after 96 hrs in 100% effluent</td>
</tr>
</tbody>
</table>

**Methods of Disposal**

Depending upon the size and location of the hospital, the following can be done:

**Discharge into Sewers**

Liquid waste along with associated colloidal and crystalloid solids should be drained. Chemical wastes should be treated first before being discharged into sewers.

**Soak Pits**

It can be a very useful method for final disposal of liquid wastes in rural or small healthcare institutions, as they are cheap, simple to build and require only tools for digging. The drawback is that they are not effective in rainy season.

**Waste stabilizing Pond**

It is a very useful and economical method provided space is available. It consists of anaerobic filters with activated sludge technology (USAB-up flow anaerobic sludge technology), which is new and effective.
4) Disposal of Human Anatomical, Blood and Fluids

The preferred for this category of waste is by incineration. This category also includes experimental animals, tissues, and specimen from animals, slaughterhouse wastes. After incineration, the ash can be sent for specialized landfills, as it is sterile. Sanitary landfill has been described in disposal general wastes.

5) Disposal of Sharps

Although sharps comprise of a relatively small proportion of the total hazardous waste generated in any hospital, they have maximum propensity and potential for causing needle “stick” injuries and hence can cause infection. A number of studies all over the world have proved it beyond doubt that if there is any one category of waste that needs maximum precaution and care, it is the sharps. Sharps are stored in the areas/points of generation in puncture proof containers. Before storing them, the needles which comprise of the majority of “sharps” can be destroyed by needle destroyers (manual or electrical) or by using syringe melting and disposal system. The manual needle destroyers use a stainless steel blade and the electrical ones use a platinum plate, which is heated to 800°C, and melts the needle. These could be disinfected in 1% bleach solution for about 30 minutes in the wards itself, and then sent for shredding and disposal in specialized landfills. The used syringe disposal system is also an innovative technology which causes simultaneous melting and sterilization of disposable plastic syringes at over 250°C, wherein they are converted into harmless plastic block encasing the needles which is one-fifth of pretreatment volume; after which they can be disposed off as ordinary industrial waste.

6) Disposal of Microbiological and Bio-Technological Waste

This is done after treating the waste by any of the technological options including autoclaving, hydroclaving, microwave or incineration.

7) Disposal of Pharmaceutical and Infectious Solid Waste

This can be done by incineration and the ash can be finally disposed off in specialized landfills.
8) Disposal of Infectious Solid Waste

Infectious solid waste should be first “treated” and converted into non-hazardous general waste, which can be disposed off as general waste.

9) Disposal of Chemical Wastes

Non-hazardous chemical wastes can be disposed off by the same method as general wastes, while those which can be recycled, should be packed, labelled properly and stored for recycling. Hazardous chemical wastes should be recycled if possible, otherwise chemically treated and discharged in sewers after dilution (for liquids) and incineration (for solids). The ash is then disposed off in specialized landfills.

10) Disposal of Radioactive Wastes

This should be done in accordance with the guidelines laid down by Bhabha Atomic Research Commission (BARC), India. These wastes can be disposed off in the normal channels under strict supervision, if they are stored till their radioactivity is almost finished. There are two main principles of disposal viz.,

i. concentration and storage-used principally for solid wastes and
ii. dilution and dispersal usually applied to liquid and gaseous radioactive wastes.

Solids should be stored in appropriate containers like plastic bags or large caps under strict security, as most of the materials have ‘half life’ of hours-to-days and thereafter disposed of in the same manner as ordinary waste after removal of all radioactive labels and warning signs. Liquid and gases which are generally low-level radioactive wastes can be diluted properly and disposed off in the sewers or released into the open atmosphere.

11) Disposal Of Pressurized Containers

These should be disposed off along with general waste, in specialized landfills. Table 2.16 provides the summary of main advantages and disadvantages of treatment and disposal options and Table 2.17 gives the overview of disposal and treatment methods suitable for different categories of health-care waste.
Table 2.16

Summary of main advantages and disadvantages of treatment and disposal options

<table>
<thead>
<tr>
<th>Treatment/Disposal method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotary kiln</td>
<td>Adequate for all infectious waste, most chemical waste, and pharmaceutical waste.</td>
<td>High investment and operating costs.</td>
</tr>
<tr>
<td>Pyrolytic incineration</td>
<td>May have high disinfection efficiency. Adequate for all infectious waste and most pharmaceutical and chemical waste.</td>
<td>Incomplete destruction of cytoxins. Relatively high investment and operating costs.</td>
</tr>
<tr>
<td>Single-chamber incineration</td>
<td>Good disinfection efficiency. Drastic reduction of weight and volume of waste. No need for highly trained operators. Relatively low investment and operating costs.</td>
<td>Significant emissions of atmospheric pollutants. Need for periodic removal of slag and soot. Inefficiency in destroying thermally resistant chemicals and drugs such as cytoxins.</td>
</tr>
<tr>
<td>Drum or brick incinerator</td>
<td>Drastic reduction of weight and volume of the waste. Very low investment and operating costs.</td>
<td>Destroys only 99% of microorganisms. No destruction of many chemicals and pharmaceuticals. Massive emission of black smoke, fly ash, toxic flue gas, and odours.</td>
</tr>
<tr>
<td>Chemical Disinfection</td>
<td>Highly efficient disinfection under good operating conditions. Some chemical disinfectants are relatively inexpensive. Drastic reduction in waste volume.</td>
<td>Requires highly qualified technicians for operation of the process. Uses hazardous substances that require comprehensive safety measures. Inadequate for pharmaceutical, chemical, and some types of infectious waste.</td>
</tr>
<tr>
<td>Wet thermal treatment</td>
<td>Environmentally sound. Drastic reduction in waste volume. Relatively low investment and operating costs.</td>
<td>Shredders are subject to frequent breakdowns and poor functioning. Operation requires qualified technicians. Inadequate for anatomical, pharmaceutical, and chemical waste and waste that is not readily steam-permeable.</td>
</tr>
<tr>
<td>Microwave irradiation</td>
<td>Good disinfection efficiency under appropriate operating conditions. Drastic reduction in waste volume. Environmentally sound.</td>
<td>Relatively high investment and operating costs. Potential operation and maintenance problems.</td>
</tr>
<tr>
<td>Encapsulation</td>
<td>Simple, low-cost, and safe. May also be applied to pharmaceuticals.</td>
<td>Not recommended for non-sharp infectious waste.</td>
</tr>
<tr>
<td>Safe burying</td>
<td>Low costs. Relatively safe if access to site is restricted and where natural infiltration is limited.</td>
<td>Safe only if access to site is limited and certain precautions are taken.</td>
</tr>
<tr>
<td>Inertization</td>
<td>Relatively inexpensive.</td>
<td>Not applicable to infectious waste.</td>
</tr>
</tbody>
</table>

May not apply to more sophisticated, self-contained, commercial methods.
Table 2.17
Overview of disposal and treatment methods suitable for different categories of health-care waste

<table>
<thead>
<tr>
<th>Technology or method</th>
<th>Infectious waste</th>
<th>Anatomical waste</th>
<th>Sharps waste</th>
<th>Pharmaceutical waste</th>
<th>Cytotoxic waste</th>
<th>Chemical waste</th>
<th>Radioactive Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotary kiln</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Low-level infectious waste</td>
</tr>
<tr>
<td>Pyrolytic incinerator</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Small quantities</td>
<td>No</td>
<td>Small quantities</td>
<td>Low-level infectious waste</td>
</tr>
<tr>
<td>Single-chamber incinerator</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Low-level infectious waste</td>
</tr>
<tr>
<td>Drum or brick incinerator</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Chemical disinfection</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Wet thermal treatment</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Microwave irradiation</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Encapsulation</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Small quantities</td>
<td>Small quantities</td>
<td>No</td>
</tr>
<tr>
<td>Safe burial on hospital premises</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Small quantities</td>
<td>No</td>
<td>Small quantities</td>
<td>No</td>
</tr>
<tr>
<td>Sanitary landfill</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Small quantities</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Discharge to sewer</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Small quantities</td>
<td>No</td>
<td>No</td>
<td>Low-level liquid waste</td>
</tr>
<tr>
<td>Inertization</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Other methods</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Return expired drugs to supplier</td>
<td>Return expired drugs to supplier</td>
<td>Return unused chemicals to supplier</td>
<td>Decay by storage</td>
</tr>
</tbody>
</table>
2.9.1.9 Case Studies - Hospital Waste Management Practices in India and Abroad

1. Standards of Clinical Waste Management in UK Hospitals

The safe disposal and subsequent destruction of clinical waste is a key step in the reduction of illness or injury through contact with this potentially hazardous material, and in the prevention of environmental contamination. The transmission of blood borne virus infection is a major risk; respiratory, enteric and soft tissue infections are also recorded infrequently. Other risks include physical injury and adverse local or systemic effects through contact with potentially hazardous pharmaceuticals. In the ward or clinic, clinical waste is disposed into suitably labelled colour-coded plastic sacks or rigid bins. Unless treated using an onsite facility, waste requires secure transfer to a suitably licensed disposal facility. The cost of disposal, which can exceed £450/tonne in the UK, reflects the complexity of control imposed on the transfer, storage and destruction of waste, and the disposal of the resultant treatment residues. Several decades of advances in the standards of clinical waste disposal in hospitals have enabled substantial risk reduction, although this has not been subject to formal audit.

The study examined the aspects of clinical waste management in hospitals, focusing on issues of security and safety. Visits were made to 26 hospitals in London and elsewhere across south and south-east England, each on one occasion only, to observe the arrangements for bulk clinical waste handling and to obtain a snapshot of overall standards of performance. Visits were unannounced and conducted on weekdays between 9 am and 5 pm. Hospitals included in the study were selected other than by reason of location. Observations were restricted to public areas including hospital grounds, access roads, car parks, corridors and freely accessible service areas. The use of bulk clinical waste carts and arrangements for their storage was observed. In particular, the availability and use of lid locks on individual carts, and the location of cart storage, was noted. The use of a central cart storage area and the security arrangements preventing unauthorized access to waste was recorded, as was the use and location of satellite cart storage.
areas. An assessment of the total number of carts in use was based on direct observation of the number of carts in accessible public areas, together with an estimate of the number of carts in inaccessible or restricted areas. Lastly, an assessment was made of the general standards of waste handling evidenced by the proper containment of waste, any spillage of waste, the presence of clinical waste sacks or bins on the floor or placed in inappropriate and insecure locations, and the arrangements for segregation of clinical waste from other waste streams. Twenty-six hospitals providing almost 7000 beds were included in the study. Sixteen acute hospitals provided general medical, surgical, maternity, pediatric and a range of specialist services. The remainders were smaller community hospitals providing limited general medical.

Estimated total cart numbers include an allowance for those not directly observed, including those in inaccessible locations such as wards and departments.

It was found that all 26 hospitals used 1100- or 800-L capacity wheeled and lidded carts (Eurocarts) for the storage of clinical waste. Four hospitals had additional smaller capacity carts in use, although these numbered less than 20 in total. There was approximately one clinical waste cart for every 10 beds, with little variation between acute and community hospitals.

All hospitals had a central cart storage area, with additional satellite storage areas in all acute hospitals. Satellite cart stores were sited both outside and inside hospital buildings, often close to stairwells or lifts, in corridors or on external walkways. Not all waste carts appeared to comply with the provisions of UN3291, which requires containers intended for the transport of clinical waste (regulated medical waste) to be rigid, puncture and break resistant, leak resistant and impervious to moisture, tightly lidded, and marked with a biohazard symbol. Waste carts at 21 of 26 hospitals were manufactured from yellow, heavy duty, high-density polyethylene (HDPE). In two thirds of waste carts, colour coding was reinforced by overprinted and embossed wording ‘clinical waste only’, and these carts also generally carried
a biohazard symbol with additional ‘biohazard’ wording. Approximately 5% of carts had no visible hazard warnings. At the remaining five locations, overpainted galvanized metal carts were in use. Although in generally sound mechanical condition, the majority (75%) of metal waste carts were badly scuffed, and weathered. On at least 10% of these metal carts, printed safety warnings were virtually obliterated. Approximately 15 hybrid carts were noted during the survey, comprising yellow HDPE or galvanized metal carts with lids of different and inappropriate colour (black, blue, green), suggesting that improvised repair of these carts had taken place. In nine hospitals, carts without lockable lids were in use although these were few in number and accounted for less than 30% of the cart stock. In a further four hospitals, a high proportion of waste carts had clearly defective locks or locks that had been removed. The integral lid locks of clinical waste carts were engaged in five of 26 hospitals (one acute hospital, four community hospitals), but at only one of these sites were the lids of all filled waste carts locked at the time of inspection. In 19 of 26 hospitals, the main storage areas for clinical waste carts were accessible to the general public on an internal roadway used for visitor access, close to an unsupervised site entrance, or situated against an external boundary wall or fence that provided an ineffective barrier against unauthorized access. Storage of waste carts in a staff/visitor car park was common. In many hospitals, there was little clear separation of clinical waste storage from areas intended for more general refuse. Five hospitals did not demarcate storage areas, and mixing of clinical and non-clinical waste was noted in two of these hospitals.

The overall security arrangements for waste carts were largely inadequate (as shown in Table I). Almost all hospitals provided a dedicated storage area for clinical waste carts, many with a high security fence or grille, or a dedicated indoor storage area. However, in 12 of 19 hospitals providing dedicated storage, the storage area was open and freely accessible; in two of 11 hospitals providing gated storage, the gates were broken, and the gates had been removed in one hospital. In other locations, waste carts, although padlocked to an adjacent rail, were fully accessible and left with lids unlocked allowing unrestricted access to their contents. Satellite storage areas were
insecure in every case, with cart lids unlocked and carts placed in locations that were freely accessible to visitors. Waste storage areas were generally clean and tidy with little evidence of spilled clinical waste.

Table I
Clinical waste carts and cart storage areas at 26 hospitals

<table>
<thead>
<tr>
<th></th>
<th>Acute hospitals (N=16)</th>
<th>Community hospitals (N=10)</th>
<th>Total (N=26)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed capacity</td>
<td>89–692 (mean 390)</td>
<td>14–79 (mean 45)</td>
<td>14–692 (mean 267)</td>
</tr>
<tr>
<td>Total beds</td>
<td>6518</td>
<td>447</td>
<td>6965</td>
</tr>
<tr>
<td>Clinical waste carts observed</td>
<td>400</td>
<td>64</td>
<td>464</td>
</tr>
<tr>
<td>Total carts in use (estimateda)</td>
<td>626</td>
<td>70</td>
<td>696</td>
</tr>
<tr>
<td>Dedicated storage area available for carts</td>
<td>16</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>Storage area can be effectively secured</td>
<td>14</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td>Main storage area is secured</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Satellite storage</td>
<td>16</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Satellite storage area is secured</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>All carts have lockable lids</td>
<td>11</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>Carts locked when in use</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

At two city centre locations, several filled clinical waste sacks and sharps bins were lying on the ground in unsecured outdoor areas on public walkways, fully accessible to passers by. It was also common to observe clinical waste sacks piled in corridors, often close to ward entrances. Overfilled waste carts with gaping lids and protruding sacks were common, both at the main cart stores and at satellite locations within hospital buildings. It was concluded that the safe disposal of clinical waste has received much attention over many years. Emphasis was placed on the correct segregation and disposal of waste from clinical areas, and on technical developments in the destruction of waste.
With the implementation (in 2005) of the Hazardous Waste Regulations 2004, there existed a wide array of legislation, Codes of Practice, and licensing conditions that dictate the standard for operation for both waste producers and those providing merchant clinical waste disposal services. This covered all issues of waste transport, storage and disposal, including aspects of site hygiene and security. Failure in proper containment of clinical waste in hospitals breached several Codes of Practice and operational ‘good practice’ guidelines. Environmental law required clear and robust procedures to ensure correct containment of clinical waste and effective segregation from other waste streams. Health & Safety legislation has also been used for successful prosecution of National Health Service Trusts in breach of Section 3, Subsection 1 of the Health and Safety at Work Act, 1974. This Act places on employers ‘a duty to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not exposed to risks to their health or safety’. Trusts must exercise an appropriate Duty of Care to ensure that waste is properly managed to ensure the safety of its employees and of others. Prosecution has followed storage of clinical waste in hospital areas accessible to the public.

The results indicated that deficiencies in waste management and the secure handling and storage of clinical waste in hospitals were both common and widespread. The infection risk and other risks arising from contact with clinical waste could not be dismissed. Few clinical waste carts were locked; in 21 of 26 hospitals, the total absence of locked clinical waste carts suggested that failure to properly secure hazardous waste was a common, regular (almost universal) practice. The location of storage areas for filled waste carts was inadequate in most cases, with carts freely accessible to the public. Furthermore, the location of waste carts in satellite locations may contravene fire regulations by creating an unacceptable obstruction. Overfilled carts with lids that were not and cannot be closed properly created a further fire risk, and increased the probability of waste spillage. Further difficulties arose from the depth of public and political concern, and adverse press attention directed towards shortcomings in hospital hygiene.
Safe handling and secure storage of clinical waste in hospitals was an important part of good housekeeping and risk reduction. Clinical waste must be handled with care at all times. Waste carts should be well maintained and kept in locations that do not compromise safety, while security arrangements must ensure that unauthorized access was prevented at all times. A site waste manager should carry overall responsibility for the management of clinical and other waste. To be effective, the post holder must liaise with and receive support from the site safety manager, risk manager, infection control personnel, nursing and laboratory managers, housekeeping and Estates staff, and security services. Where portering, housekeeping and waste management services were outsourced, waste managers needed to work closely with and supervise the work of contractors. Investment directed to waste stores and satellite storage areas would greatly assist improvement in waste handling in hospitals. Based on the observations, much remained to be done to improve the standards of clinical waste management in hospitals.

2. Biomedical waste management practices at Balrampur Hospital, Lucknow, India

Biomedical waste has become a serious health hazard in many countries, including India. Careless and indiscriminate disposal of this waste by healthcare establishments and research institutions can contribute to the spread of serious diseases such as hepatitis and AIDS (HIV) among those who handle it and also among the general public. The present study pertains to the biomedical waste management practices at Balrampur, a premier healthcare establishment in Lucknow, in North India. The study shows that infectious and non-infectious wastes are dumped together within the hospital premises, resulting in a mixing of the two, which are then disposed of with municipal waste at the dumping sites in the city. All types of wastes are collected in common bins placed outside the patients wards. For disposal of this waste the hospital depends on the generosity of the Lucknow Municipal Corporation, whose employees generally collect it every 2 or 3 days. The hospital does not have any treatment facility for infectious waste. The laboratory waste materials, which are disposed of directly into the municipal
sewer without proper disinfection of pathogens, ultimately reach the Gomti River. All disposable plastic items are segregated by the rag pickers from the hospital as well as municipal bins and dumps. The waste is deposited either inside the hospital grounds, or outside in the community bin for further transportation and disposal along with municipal solid waste. The open dumping of the waste makes it freely accessible to rag pickers who become exposed to serious health hazards due to injuries from sharps, needles and other types of material used when giving injections. The results of the study demonstrate the need for strict enforcement of legal provisions and a better environmental management system for the disposal of biomedical waste in the Balrampur Hospital, as well as other healthcare establishments in Lucknow in 2003.

3. Biomedical Waste Management Scenario in Delhi

In Delhi there are about 72 hospitals under government sector, 550 registered nursing homes and 936 dispensaries. In addition to these, there are about 1560 unregistered establishments with different names like Nursing Homes, Medical Centres, Dental Hospitals, MTP Centres etc. About 40000 hospital beds are available in the public and private sector in Delhi. With increasing number of hospitals and nursing homes in Delhi, this number may go up even higher.

There is a big network of Health Care Institutions in Delhi. Although, these are not under one banner but these can be utilized by better coordination among different organizations. The organization-wise Institutions are as shown in Table I.
Table I
The Agency wise Distribution of Institutions:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Organization</th>
<th>Hospitals</th>
<th>No. Of Beds</th>
<th>Dispensaries</th>
<th>Allopathic</th>
<th>Homeo</th>
<th>Ayur</th>
<th>Unani</th>
<th>SHS</th>
<th>MHS</th>
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</tr>
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<td><strong>Total</strong></td>
<td><strong>2229</strong></td>
<td><strong>41629</strong></td>
<td><strong>939</strong></td>
<td><strong>454</strong></td>
<td><strong>88</strong></td>
<td><strong>125</strong></td>
<td><strong>16</strong></td>
<td><strong>63</strong></td>
<td><strong>72</strong></td>
<td><strong>121</strong></td>
<td><strong>939</strong></td>
<td></td>
</tr>
</tbody>
</table>

These Health Care Institutions are inclusive of Allopathic, ISM and Homeopathic. The hospitals and dispensaries mainly under Delhi Government, Municipal Corporation of Delhi, New Delhi Municipal Council, Employees State Insurance Corporation and Central Government Health Scheme require special attention. Equally important is the private sector comprising of major hospitals, nursing homes, clinics, blood banks, diagnostic laboratories, and Yunani, homeopathy and Sidda Dava-khanas. At present there are 606 registered nursing homes under this directorate in Delhi.

Under Biomedical Waste (Management & Handling) Rules 1998, all health care institutions are required to handle biomedical waste in a specified manner. Delhi is generating approximately 7000 metric tons of waste out of which 70 tons are Biomedical Waste. The Government hospitals and major private hospitals have their own arrangement for treatment of biomedical waste. Total no of beds in Delhi government hospitals are 6278. The smaller Nursing Homes and Clinics, which cannot make their own arrangements due
to high cost involved in treatment facilities, require some alternative modalities. Keeping in view the difficulties faced by smaller nursing homes/clinics/blood banks/diagnostic laboratories etc., Government is taking initiatives to establish centralized waste treatment facilities. The Government of NCT of Delhi (GNCTD) had been allotted land by Delhi Development Authority (DDA) for establishment of Centralized Biomedical Waste treatment facilities 1000 sq. meter each at Okhla and Gazipur in Delhi.

There are 31 hospitals under Government of Delhi. Four hospitals are having incinerators and 9 hospitals are having Autoclaves and shredders for scientific management of bio-medical waste. Bio-medical waste from these hospitals, where such facilities are not available are segregated and transported in special van to hospitals where such facilities exist.

Figure 2.11

Biomedical Waste (BMW) generated in Delhi Government Hospitals in December 2006:
Authorization:

All Hospitals and 184 Dispensaries under this Directorate have obtained authorization from DPCC under Bio-medical Waste (Management & Handling) Rules 1998. Authorization for new hospitals and new dispensaries will be obtained soon.

Bio-Medical Waste - Plan of Activities: 2007-2008:

• Establishment of Occupational Safety & Health Cell in the DHS (HQ) & BMW management will be part of it.
• The authorization for the remaining/new Dispensaries will be taken from Delhi Pollution Control Committee (DPCC).
• Transportation of BMW from Hospital and dispensaries where treatment facilities are not available will be done by centralized treatment facility operator.
• Procurement of Segregation Bags, containers and other materials used in management of biomedical waste.
• Behaviour change communication/IEC activities will be carried out through newspaper advertisement and awareness generation among the community using posters, pamphlets booklets, hoardings, guidelines, TV, doordarshan, calendars, radio, metro trains & unipoles etc.
• Establishment of centralized bio-medical waste treatment facilities with the help of private entrepreneurs at Gaziapur.
• Inspection of hospitals and dispensaries under Delhi Govt. for BMW.
• Organization of workshop / seminars on bio-medical waste management

4. Hospital waste management in the teaching hospitals of Karachi.

A cross-sectional survey was conducted in eight teaching hospitals of Karachi in 2005, using convenient sampling technique to evaluate the current practices of segregation approaches, storage arrangements, collection and disposal systems. The instrument of research was a self-administered questionnaire, with four sections, relating to the general information of the institution, administrative information, information regarding Health Waste
Management personnel and a check-list of Hospital Waste Management activities.

Out of eight hospitals visited, two (25%) were segregating sharps, pathological waste, chemical, infectious, pharmaceutical and pressurized containers at source. For handling potentially dangerous waste, two (25%) hospitals provided essential protective gears to its waste handlers. Only one (12.5%) hospital arranged training sessions for its waste handling staff regularly. Five (62.5%) hospitals had storage areas but mostly it was not protected from access of scavengers. Five (62.5%) hospitals disposed off their hazardous waste by burning in incinerators, two (25%) disposed off by municipal landfills and one (12.5%) was burning waste in open air without any specific treatment. No record of waste was generally maintained. Only two (25%) hospitals had well documented guidelines for waste management and a proper waste management team.

It was concluded that there should be proper training and management regarding awareness and practices of waste disposal. Research must be undertaken to seal existing gaps in the knowledge about hospital waste management. The hospital waste management guidelines enacted on 7th June 2004 should be followed and regulated by law enforcement agencies rigorously.

5. Pattern of medical waste management: existing scenario in Dhaka City, Bangladesh.

The study was undertaken recently in 2008 to document the handling practice of waste (e.g. collection, storage, transportation and disposal) along with the types and amount of wastes generated by Health Care Establishments (HCE) in Dhaka City since the problem is growing with an ever-increasing number of hospitals, clinics, and diagnostic laboratories, Bangladesh. However, research on this critical issue has been very limited, and there is a serious dearth of information for planning.

A total of 60 out of the existing 68 HCE in the study areas provided relevant information. The methodology included empirical field observation
and field-level data collection through inventory, questionnaire survey and formal and informal interviews. A structured questionnaire was designed to collect information addressing the generation of different medical wastes according to amount and sources from different HCE. A number of in-depth interviews were arranged to enhance our understanding of previous and existing management practice of medical wastes. A number of specific questions were asked of nurses, hospital managers, doctors, and cleaners to elicit their knowledge.

The collected data with the questionnaire survey were analysed, mainly with simple descriptive statistics; while the qualitative mode of analysis was mainly in narrative form. The study showed that the surveyed HCE generate a total of 5,562 kg/day of wastes, of which about 77.4 per cent are non-hazardous and about 22.6 per cent are hazardous. The average waste generation rate for the surveyed HCE is 1.9 kg/bed/day or 0.5 kg/patient/day. The study revealed that there is no proper, systematic management of medical waste except in a few private HCE that segregate their infectious wastes. Some cleaners were found to salvage used sharps, saline bags, blood bags and test tubes for resale or reuse and lack of awareness, appropriate policy and laws, and willingness for the improper management of medical waste in Dhaka City. New facilities should be established for the complete management of medical waste in Dhaka City.


A cross-sectional study was conducted by Deptt. of Community Medicine, Pramukh Swami Medical College, Karamsad, Gujarat with the objective of assessing the level of awareness about the various aspects of biomedical waste and disposal practices by the medical practitioners. 30 hospitals with more than 30 beds minimum were randomly selected from Sabarkantha district, Gujarat. The doctors and auxiliary staff of those 30 hospitals were the study population. While all the doctors knew about the existence of the law related to biomedical waste but details were not known. Doctors were aware of risk of HIV and Hepatitis B and C, whereas auxiliary
staff (ward boys, ayabens, sweepers) had very poor knowledge about it. There was no effective waste segregation, collection, transportation and disposal system at any hospital in the district. It was concluded that there is an immediate and urgent need to train and educate all doctors and the staff to adopt an effective waste management practices.

7. Waste Management in the Hospitals of Mauritius

This study was initiated by Department of Chemical and Sugar Engineering, Faculty of Engineering, University of Mauritius, Reduit, Mauritius to characterize solid and liquid wastes generated in healthcare institutions and to provide a framework for the safe management of these wastes. The project was carried at three major medical institutions, namely, the Jeetoo Hospital, the Sir Seewoosagur Ramgoolam National (SSRN) Hospital and the Clinic Mauricienne. A waste audit carried out at these sites revealed that approximately 10% of solid wastes were hazardous in nature, consisting mainly of infectious, pathological and chemical wastes. The average amount of hazardous wastes per patient per day was found to be 0.072 kg at Jeetoo hospital, 0.091 kg at SSRN hospital and 0.179 kg at the clinic. The amount of hazardous wastes generated as a function of the number of occupied beds was found to follow a relationship of type $y=0.0006x-0.19$, where $y$ was the amount of hazardous wastes generated per bed per day and $x$ was the number of occupied beds. The waste quantifying process also revealed that at SSRN Hospital, 0.654 m$^3$ of water was being consumed per patient per day and the amount of wastewater produced was 500 m$^3$/day. Further analysis revealed that the wastewater was polluting with chemical oxygen demand (COD), biological oxygen demand (BOD), total suspended solids (TSS) and coliform content well above permissible limits.

8. Variations in hospital waste quantities and generation rates undertaken in Kuwait

A case study on the relationship between public health problems and improper collection, handling, and disposal of solid wastes in general, and hospital wastes in particular was taken up in Kuwait. Hazardous and
nonhazardous wastes generated from different divisions of two of the largest public hospitals (capacity of approximately 400 beds each) in Kuwait were quantified and generation rates were determined. The generation rates were related to some important factors such as the number of patients, number of beds, and the type of activity conducted in different sections of the hospitals. The relationship between the waste generation rate and the number of patients was more applicable than that expressed in terms of the number of beds. The rates observed were in the range of 4.89 to 5.4 kg/patient/day, which corresponds to 3.65 to 3.97 kg/bed/day, respectively. These generation rates were comparable with those reported in the literature for similar hospitals. Minimal waste quantities were collected in the weekends. The study indicated that the hospitals surveyed provide some segregation of hazardous and non-hazardous wastes. Hazardous wastes contributed about 53% of the total quantity of wastes generated at the hospitals.

9. Management of medical waste in Tanzanian hospitals

A survey was conducted to study the existing medical waste management (MWM) systems in Tanzanian hospitals during a nationwide health-care waste management-training programme conducted from 2003 to 2005. The aim of the programme was to enable health workers to establish MWM systems in their health facilities aimed at improving infection prevention and control and occupational health aspects. During the training sessions, a questionnaire was prepared and circulated to collect information on the MWM practices existing in hospitals in eight regions of the Tanzania. The analysis showed that increased population and poor MWM systems as well as expanded use of disposables were the main reasons for increased medical wastes in hospitals. The main disposal methods comprised of open pit burning (50%) and burying (30%) of the waste. A large proportion (71%) of the hospitals used dust bins for transporting waste from generation points to incinerator without plastic bags. Most hospitals had low incineration capacity, with few of them having fire brick incinerators. Most of the respondents preferred on-site versus off-site waste incineration. Some hospitals were using untrained casual labourers in medical waste management and general
cleanliness. The knowledge level in MWM issues was low among the health workers. It was concluded that hospital waste management in Tanzania is poor. There is need for proper training and management regarding awareness and practices of medical waste management to cover all cardres of health workers in the country.

10. Study of bacterial flora of different types in hospital waste: evaluation of waste treatment at AIIMS Hospital, New Delhi.95

A case study of bacterial flora of different types in hospital waste was undertaken at AIIMS Hospital, New Delhi. Bio-medical waste management rules were formulated in response to the worldwide public concern over medical waste. The practice of separation into different types of waste in health care institutes should be evaluated more scientifically. Due to a lack of data from the Indian sub-continent, this study was initiated at a tertiary care hospital. Samples were collected from different types of waste at the hospital, at different time intervals, for microbiological evaluation. The results reveal that the microbial flora isolated from infectious waste and general waste from the hospital are similar. The samples from general waste in this study reveal many types of pathogens. The bacteria present in the waste initially was low in quantity, but they replicated rapidly over time so that significant numbers were detected by 24 hours, due to environmental factors which were favorable for growth during this period. This study strongly suggested that waste should be removed from the hospital within 24 hours of its generation to prevent environmental contamination caused by any accidental spillage of waste. General waste generated in the hospital should be treated similar to infectious waste, as it could be equally hazardous.

11. Bio-medical waste management in the U.T., Chandigarh.96

Investigations were carried out by Department of Civil Engineering, Punjab Engineering College, Chandigarh to assess the generation and disposal of biomedical waste in the various medical establishments in the urban and rural areas of the U.T. Chandigarh. It was found that there were 474 medical establishments in the U.T., Chandigarh including Nursing
Homes, Clinics, Dispensaries, Pathological labs., Hospitals, Veterinary Institutions and Animal houses. The total quantity of bio-medical waste generated in Chandigarh is 811.35 kg/day and the rate of generation of bio-medical waste varies from 0.06 kg/day/bed to 0.25 kg/day/bed. Though the major hospitals are equipped with incinerators, proper bio-medical waste management system is yet to be implemented. The medical establishments in the rural area and smaller ones in the urban area dispose off their bio-medical waste along with municipal solid waste and no proper biomedical waste management system exists. It was recommended that an integrated waste management plan using the three incinerators installed at the major hospitals could safely dispose off the total bio-medical waste generated in the city.

12. Biomedical solid waste management in an Indian hospital in U.P.

A case study was undertaken by Institute of Pharmacy, Bundelkhand University, Jhansi to: (i) assess the waste handling and treatment system of hospital bio-medical solid waste and its mandatory compliance with Regulatory Notifications for Bio-medical Waste (Management and Handling) Rules, 1998, under the Environment (Protection) Act 1986, Ministry of Environment and Forestry, Govt. of India, at the chosen KLE Society’s J. N. Hospital and Medical Research Center, Belgaum, India and (ii) quantitatively estimate the amount of non-infectious and infectious waste generated in different wards/sections. During the study, it was observed that: (i) the personnel working under the occupier (who had control over the institution to take all steps to ensure biomedical waste is handled without any adverse effects to human health and the environment) were trained to take adequate precautionary measures in handling these bio-hazardous waste materials, (ii) the process of segregation, collection, transport, storage and final disposal of infectious waste was done in compliance with the standard procedures, (iii) the final disposal was by incineration in accordance to EPA Rules 1998, (iv) the non-infectious waste was collected separately in different containers and treated as general waste, and (v) on an average about 520 kg of non-infectious and 101 kg of infectious waste was generated per day (about 2.31 kg per day per bed, gross weight comprising both infectious and non-
infectious waste). This hospital also extended its facility to the neighboring clinics and hospitals by treating their produced waste for incineration.

13. Health-care waste management in India – A NEERI Study

Health-care waste management in India is receiving greater attention due to recent regulations (the Biomedical Wastes (Management & Handling) Rules, 1998). The prevailing situation was analysed covering various issues like quantities and proportion of different constituents of wastes, handling, treatment and disposal methods in various health-care units (HCUs) by National Environmental Engineering Research Institute, Nagpur. The waste generation rate ranges between 0.5 and 2.0 kg per bed per day. It is estimated that annually about 0.33 million tonnes of waste are generated in India. The solid waste from the hospitals consists of bandages, linen and other infectious waste (30-35%), plastics (7-10%), disposable syringes (0.3-0.5%), glass (3-5%) and other general wastes including food (40-45%). In general, the wastes are collected in a mixed form, transported and disposed of along with municipal solid wastes. At many places, authorities are failing to install appropriate systems for a variety of reasons, such as non-availability of appropriate technologies, inadequate financial resources and absence of professional training on waste management.

14. Hospital solid waste management practices in Limpopo Province, South Africa.

The shortcomings in the management practices of hospital solid waste in Limpopo Province of South Africa were studied by the Department of Ecology and Resource Management, School of Environmental Sciences, University of Venda, Thohoyandou looking at two hospitals as case studies. Apart from field surveys, the generated hospital waste was weighed to compute the generation rates and was followed through various management practices to the final disposal. The findings revealed a major policy implementation gap between the national government and the hospitals. While modern practices such as landfill and incineration were used, their daily operations were not carried according to minimum standards. Incinerator ash
was openly dumped and wastes were burned on landfills instead of being covered with soil. The incinerators used were also not environmentally friendly as they use old technology. The findings further revealed that there was no proper separation of wastes according to their classification as demanded by the national government. The mean percentage composition of the waste was found in the following decreasing order: general waste (60.74%) > medical waste (30.32%) > sharps (8.94%). The mean generation rates were found to be 0.60 kg per patient per day.

15. Medical waste treatment and disposal methods used by hospitals in Oregon, Washington, and Idaho.

This study carried out by Department of Public Health, Oregon State University, Corvallis, USA investigated medical waste practices used by hospitals in Oregon, Washington, and Idaho, which included the majority of hospitals in the U.S. Environmental Protection Agency's (EPA) Region 10. During the fall of 1993, 225 hospitals were surveyed with a response rate of 72.5%. The results reported here focus 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 programs. 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. 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. Hospitals were asked to identify all methods they used in the treatment and disposal of medical waste. Percentages,
therefore, add up to greater than 100% because the majority chose more than one method. Hospitals in Oregon and Washington used microwaving and ETD methods to treat medical waste, while those in Idaho did not. No hospital in any of the states reported using irradiation as a treatment technique. Most hospitals in Oregon and Washington no longer operated their incinerators due to more stringent regulations regarding air pollution emissions. Hospitals in Idaho, however, were still operating incinerators in the absence of state regulations specific to these types of facilities.

The studies can be summarized in the tabular form (Table 2.18) as below:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Study / Year</th>
<th>Results</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Examination of the aspects of clinical waste management in hospitals of UK focusing on issues of security and safety. (2006)</td>
<td>- All hospitals had a central cart storage area but the overall security arrangements for waste carts were inadequate. Overall waste carts with gaping lids &amp; protruding sacks were common. - Proper segregation and disposal of waste followed. - Failure in proper containment of clinical waste in hospitals breached several codes of practice and operational good practice guidelines.</td>
<td>- Safe handling and secure storage of clinical waste was needed - Waste carts should be well maintained.</td>
</tr>
<tr>
<td>2.</td>
<td>BMW management practices at Balrampur Hospital, Lucknow, India (2003).</td>
<td>- Infectious &amp; non-infectious wastes are dumped together. - Waste is collected after 2-3 days by Municipal Corporation. - Laboratory waste material disposed off directly into municipal sewer &amp; reaches Gomti River.</td>
<td>- There is need for strict enforcement of legal provisions - Better environment management system for the disposal of BMW is needed.</td>
</tr>
<tr>
<td>S. No.</td>
<td>Study / Year</td>
<td>Results</td>
<td>Inference</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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</table>
| 3.    | To study the biomedical waste management scenario of the hospitals of Delhi (2006). | - Big network of Health Care Institutions in Delhi  
- Delhi is generating 7000 metric tons of waste out of which 70 tons is BMW.  
- Government hospitals & Major private hospitals have their own arrangement for treatment of BMW.  
- Government has taken initiative to establish centralized waste treatment facilities.  
- Government hospitals have their own incinerators, autoclaves and shredders. | -Proper coordination between Government hospitals, nursing homes and centralized biomedical waste treatment facilities is needed.  
- Periodic inspection should be carried out to keep a proper check on BMW Management activities. |
Training Session - 12.5% hospitals  
Storage areas - 62.5%  
Disposal incinerator – 62.5%  
Municipal Land Fills - 25%  
Open air - 12.5%  
Well documented guidelines – 25% | Need of providing proper training & awareness regarding practices of waste disposal. |
| 5.    | Evaluation of handling practices of waste in 60 hospitals in Dhaka (2008) | 5562 kg day waste generated  
i.e.1.9 kg/ bed/day  
77.4% Hazardous  
22.6% non hazardous | -No systematic mgt.  
-Lack of awareness regarding appropriate laws & policies. |
| 6.    | Level of awareness of various aspects of BMW in a district of Gujarat (2004) | Doctors aware of laws related to BMW but details were not known.  
Auxiliary staff had poor knowledge.  
No effective waste segregation, collection, transportation and disposal system. | Urgent need to educate & train all workers. |
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Study / Year</th>
<th>Results</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>Waste Mgt. in hospitals of Mauritius (2004).</td>
<td>Hazardous waste = $y = 0.006x - 0.19$ Where x = no. of beds. Varies 0.17 kg to 0.72 kg / patient / day 10% of solid wastes hazardous. Waste water – BOD, COD, TSS found high.</td>
<td>Proper mgt. is need of the hour.</td>
</tr>
<tr>
<td>8.</td>
<td>Variation in hospital waste quantities in Kuwait (2004).</td>
<td>BMW - 4.89 to 5.4 kg / patients / day. Hazardous waste – 53% of total qty. Minimal wastes qty. on weekends.</td>
<td>- Rates comparable with other hospitals. - Segregation to be followed properly</td>
</tr>
<tr>
<td>9.</td>
<td>Existing waste mgt. system in Tanzanian hospitals (2003-05)</td>
<td>Increase in medical waste due to rise in population, poor BMW systems &amp; more use of disposables. Disposal was 50% open pit burying, 30% burying &amp; 71% hospitals used dustbins for transportation. Low incineration capacity in hospitals.</td>
<td>- Very poor BMW mgt - Need for proper Training.</td>
</tr>
<tr>
<td>11.</td>
<td>Generation &amp; disposal of BMW in Chandigarh. (2003).</td>
<td>Total BMW - 811.35 kg / day. Generation Rate – 0.6 kg/day / bed to 0.25 kg / day / bed</td>
<td>Major hospitals are well equipped but smaller ones dispose off BMW along with municipal waste.</td>
</tr>
<tr>
<td>S. No.</td>
<td>Study / Year</td>
<td>Results</td>
<td>Inference</td>
</tr>
<tr>
<td>-------</td>
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</tr>
<tr>
<td>13</td>
<td>Analysis of prevailing BMW practices in various healthcare units in India by NEERI (2000)</td>
<td>Generation rate – 0.5 to 2.0 kg/bed/day Annual generation – 0.33 million tonnes Bandages / Linens – 30.35 % Plastics - 7.10% Disposal syringes – 0.3 to 0.5% Glass - 3.5% Other waste including food – 40 – 45%</td>
<td>Generally the BMW disposed / along with municipal waste. Appropriate disposal systems not installed at many places, absence of proper training &amp; awareness.</td>
</tr>
<tr>
<td>15.</td>
<td>Study of various medical waste treatment &amp; disposal methods in Oregon, Washington &amp; Idaho (U.S.A) of 225 hospitals. (1998).</td>
<td>Use of pvt. haulers for transportation for treatment - 61.5% hospital Mixing with municipal sewage - 46.6% Land fills - 41.6% Autoclaving – 32.3 % Not clear about definition of infectitious waste. Therefore segregation not being followed.</td>
<td>Less operation of incinerators due to air pollution emissions. Overall good scenario.</td>
</tr>
</tbody>
</table>
2.9.2 WATER POLLUTION

2.9.2.1 Characteristics of Wastewater from Health-Care Establishments
Wastewater from health-care establishments is of a similar quality to urban wastewater, but may also contain various potentially hazardous components viz.

a) Microbiological pathogens
   The principal area of concern is wastewater with a high content of enteric pathogens, including bacteria, viruses, and helminths, which are easily transmitted through water. Contaminated wastewater is produced by wards treating patients with enteric diseases and is a particular problem during outbreaks of diarrhoeal disease.

b) Hazardous chemicals
   Small amounts of chemicals from cleaning and disinfection operations are regularly discharged into sewers.

c) Pharmaceuticals
   Small quantities of pharmaceuticals are usually discharged into the sewers from hospital pharmacies and from the various wards.

d) Radioactive isotopes
   Small amounts of radioactive isotopes will be discharged into sewers by oncology departments.

2.9.2.2 Potential Hazards of Wastewater from Health-Care Establishments
In some developing and industrializing countries, outbreaks of cholera are periodically reported. Although links between the spread of cholera and unsafe wastewater disposal have not been sufficiently studied or documented, they have been strongly suspected, for instance during recent African outbreaks (Democratic Republic of the Congo, Rwanda), and during the 1991-92 cholera epidemic in southern America. Little information is available on the transmission of other diseases through the sewage of health-care establishments.
In developed countries, water use is commonly high and the sewage therefore greatly diluted; effluents are treated in municipal treatment plants and no significant health risks are expected, even without further specific treatment of these effluents. Only in the unlikely event of an outbreak of acute diarrhoeal diseases should excreta from patients be collected separately and disinfected. In developing countries, where there may be no connection to municipal sewage networks, discharge of untreated or inadequately treated sewage to the environment will inevitably pose major health risks.

The toxic effects of any chemical pollutants contained in wastewater on the active bacteria of the sewage purification process may give rise to additional hazards. General standards for discharge of environmental pollutants are given in Annexure D.

2.9.2.3 Waste Water Management

The basic principle underlying effective wastewater management is a strict limit on the discharge of hazardous liquids to sewers. In countries that do not experience epidemics of enteric disease and that are not endemic for intestinal helminthiasis, it is acceptable to discharge the sewage of health-care establishments to municipal sewers without pretreatment, provided that the following requirements are met:

- the municipal sewers are connected to efficiently operated sewage treatment plants that ensure at least 95% removal of bacteria;
- the sludge resulting from sewage treatment is subjected to anaerobic digestion, leaving no more than one helminth egg per litre in the digested sludge;
- the waste management system of the health-care establishment maintains high standards, ensuring the absence of significant quantities of toxic chemicals, pharmaceuticals, radionuclides, cytotoxic drugs, and antibiotics in the discharged sewage;
- excreta from patients being treated with cytotoxic drugs may be collected separately and adequately treated (as for other cytotoxic waste).
If these requirements cannot be met, then the treatment of wastewater should include the following operations:

- **Primary treatment**
- **Secondary biological purification.** Most helminths will settle in the sludge resulting from secondary purification, together with 90-95% of bacteria and a significant percentage of viruses; the secondary effluent will thus be almost free of helminths, but will still include infective concentrations of bacteria and viruses.
- **Tertiary treatment.** The secondary effluent will probably contain at least 20 mg/litre suspended organic matter, which is too high for efficient chlorine disinfection. It should therefore be subjected to a tertiary treatment, such as lagooning; if no space is available for creating a lagoon, rapid sand filtration may be substituted to produce a tertiary effluent with a much reduced content of suspended organic matter (<10mg/litre).
- **Chlorine disinfection.** To achieve pathogen concentrations comparable to those found in natural waters, the tertiary effluent is subjected to chlorine disinfection to the breakpoint. This may be done with chlorine dioxide (which is the most efficient), sodium hypochlorite, or chlorine gas. Another option is ultraviolet light disinfection.

Disinfection of the effluents is particularly important if they are discharged into coastal waters close to shellfish habitats, especially if local people are in the habit of eating raw shellfish.

**Sludge treatment**

The sludge from the sewage treatment plant requires anaerobic digestion to ensure thermal elimination of most pathogens. Alternatively, it may be dried in natural drying beds and then incinerated together with solid infectious health-care waste. On-site treatment of hospital sewage will produce a sludge that contains high concentrations of helminths and other pathogens.
For health-care establishments that apply minimal programmes and are unable to afford any sewage treatment, the following measures should be implemented to minimize health risks:

- Patients with enteric diseases should be isolated in wards where their excreta can be collected in buckets for chemical disinfection; this is of utmost importance in case of cholera outbreaks, for example, and strong disinfectants will be needed.
- No chemicals or pharmaceuticals should be discharged into the sewer.
- Sludge from hospital cesspools should be dehydrated on natural drying beds and disinfected chemically (e.g. with sodium hypochlorite, chlorine gas, or preferably chlorine dioxide).
- Sewage from health-care establishments should never be used for agricultural purposes.
- Hospital sewage should not be discharged into natural water bodies that are used to irrigate fruit or vegetable crops, to produce drinking water, or for recreational purposes.

WASTE MINIMISATION, RECYCLING AND REUSE

Waste minimization

Significant reduction of the waste generated in health-care establishments and research facilities can be achieved by the implementation of certain policies and practices, viz;

- **Source reduction**: measures such as purchasing restrictions to ensure the selection of methods or supplies that are less wasteful or generate less hazardous waste.
- **Recyclable products**: use of materials that may be recycled, either on-site or off-site.
- **Good management and control practices**: apply particularly to the purchase and use of chemicals and pharmaceuticals.
- **Waste segregation**: careful segregation (separation) of waste matter into different categories helps to minimize the quantities of hazardous waste.
A number of examples of policies and practices that tend to minimize quantities of waste are summarized below:

**Source reduction**
- Purchasing reductions: selection of supplies that are less wasteful or less hazardous.
- Use of physical rather than chemical cleaning methods (e.g. steam disinfection instead of chemical disinfection).
- Prevention of wastage of products, e.g. in nursing and cleaning activities.

**Management and control measures at hospital level**
- Centralized purchasing of hazardous chemicals.
- Monitoring of chemical flows within the health facility from receipt as raw materials to disposal as hazardous wastes.

**Stock management of chemical and pharmaceutical products**
- Frequent ordering of relatively small quantities rather than large amounts at one time (applicable in particular to unstable products).
- Use of the oldest batch of a product first.
- Use of all the contents of each container.
- Checking of the expiry date of all products at the time of delivery.

Careful management of stores will prevent the accumulation of large quantities of outdated chemicals or pharmaceuticals and limit the waste to the packaging (boxes, bottles, etc.) plus residues of the products remaining in the containers. These small amounts of chemical or pharmaceutical waste can be disposed off easily and relatively cheaply, whereas disposing off larger amounts requires costly and specialized treatment, which underlines the importance of waste minimization.

Waste minimization usually benefits the waste producer: costs for both the purchase of goods and for waste treatment and disposal are reduced and the liabilities associated with the disposal of hazardous waste are lessened.

All health-service employees have a role to play in this process and should therefore be trained in waste minimization and the management of
hazardous materials. This is particularly important for the staff of departments that generate large quantities of hazardous waste.

Suppliers of chemicals and pharmaceuticals can also become responsible partners in waste minimization programmes. The health service can encourage this by ordering only from suppliers who provide rapid delivery of small orders, who accept the return of unopened stock, and who offer off-site waste management facilities for hazardous wastes.

Reducing the toxicity of waste is also beneficial, by reducing the problems associated with its treatment or disposal. For example, the Supply Officer could investigate the possibilities of purchasing PVC-free plastics that may be recycled or of goods supplied without unnecessary packaging.

**Safe reuse and recycling**

Medical and other equipment used in a health-care establishment may be reused provided that it is designed for the purpose and will withstand the sterilization process. Reusable items may include certain sharps, such as scalpels and hypodermic needles, syringes, glass bottles and containers, etc. After use, these should be collected separately from non-reusable items, carefully washed (particularly in the case of hypodermic needles, in which infectious droplets could be trapped), and may then be sterilized. Although reuse of hypodermic needles is not recommended, it may be necessary in establishments that cannot afford disposable syringes and needles. Plastic syringes and catheters should not be thermally or chemically sterilized; they should be discarded. Long-term radionuclides conditioned as pins, needles, or seeds and used for radiotherapy may be reused after sterilization.

Certain types of container may be reused provided that they are carefully washed and disinfected. Containers of pressurized gas, however, should generally be sent to specialized centres to be refilled. Containers that once held detergent or other liquids may be reused as containers for sharps waste (if purpose-made containers are not affordable) provided that they are puncture-proof and correctly and clearly marked on all sides.
Recycling is usually not practised by health-care facilities, apart, perhaps, from the recovery of silver from fixing-baths used in processing X-ray films. However, recycling of materials such as metals, paper, glass, and plastics can result in savings for the health-care facility—either through reduced disposal costs or through payments made by the recycling company.

In temperate climates, the heat generated by on-site incinerators may be an attractive and cost-effective option for heating hospital premises.

In determining the economic viability of recycling, it is important to take account of the costs of alternative disposal methods and not just the cost of the recycling process and the value of the reclaimed material.

### 2.9.3 AIR POLLUTION

Air pollution occurs when the air contains gases, dust, fumes or odour in harmful amounts. That is, amounts which could be harmful to the health or comfort of humans and animals or which could cause damage to plants and materials.

The substances that cause air pollution are called pollutants. Pollutants that are pumped into our atmosphere and directly pollute the air are called primary pollutants. Primary pollutant examples include carbon monoxide from car exhausts and sulphur dioxide from the combustion of coal.

Further pollution can arise if primary pollutants in the atmosphere undergo chemical reactions. The resulting compounds are called secondary pollutants. Photochemical smog is an example of this.

Air pollution initially was recognized more as a nuisance than as a threat to human health. Some laws, however, were enacted to prevent air pollution as early as 1306. In that year, Edward I of England ordered that the burning of sea coal in craftsman's furnaces be prohibited because of the foul-smelling fumes produced. Centuries later, Elizabeth I banned, for similar aesthetic reasons, the burning of coal in London while Parliament was in session.\(^{101}\)
As the years passed, air pollution got worse, and yet it was still not widely recognized as a threat to human health. Although there were some scientists and health professionals who recognized air pollution as a public health problem, most of the early control efforts were targeted at the aesthetic or welfare effects of air pollution. In the late 1800s and early 1900s, many smoke control ordinances were enacted in England and the United States.

2.9.3.1 Effects of Air Pollutants on Health

Air pollution can affect our health in many ways with both short-term and long-term effects. Different groups of individuals are affected by air pollution in different ways. Some individuals are much more sensitive to pollutants than others. Young children and elderly people often suffer more from the effects of air pollution. People with health problems such as asthma, heart and lung disease may also suffer more when the air is polluted. The extent to which an individual is harmed by air pollution usually depends on the total exposure to the damaging chemicals, i.e., the duration of exposure and the concentration of the chemicals must be taken into account.

Examples of short-term effects include irritation to the eyes, nose and throat, and upper respiratory infections such as bronchitis and pneumonia. Other symptoms can include headaches, nausea, and allergic reactions. Short-term air pollution can aggravate the medical conditions of individuals with asthma and emphysema. In the great "Smog Disaster" in London in 1952, four thousand people died in a few days due to the high concentrations of pollution.

Long-term health effects can include chronic respiratory disease, lung cancer, heart disease, and even damage to the brain, nerves, liver, or kidneys. Continual exposure to air pollution affects the lungs of growing children and may aggravate or complicate medical conditions in the elderly. It is estimated that half a million people die prematurely every year in the United States as a result of smoking cigarettes.

Research into the health effects of air pollution is ongoing. Medical conditions arising from air pollution can be very expensive. Healthcare costs,
lost productivity in the workplace, and human welfare impacts cost billions of dollars each year.

Pollution also needs to be considered inside our homes, offices, and schools. Some of these pollutants can be created by indoor activities such as smoking and cooking. In the United States, people spend about 80-90% of their time inside buildings, and so their exposure to harmful indoor pollutants can be serious. It is therefore important to consider both indoor and outdoor air pollution.

In hospitals also special consideration should be given to air pollution as it is a place where air pollution should be minimum i.e. no hazards to its clients—the patients who already have compromised health and is also a source of pollution. Equipment breakage and waste incineration may release pollutants into the air and may contribute to health concerns in hospitals and in the community. Hospitals implement pollution prevention strategies not only to help comply with federal, state, local, and tribal laws but also to further minimize impacts on human health and the environment.

2.9.3.2 Kinds of Air Pollutants from Hospitals

Hospital operations can produce emissions of toxic air pollutants such as mercury and dioxin.\textsuperscript{102}

**Mercury**

- Mercury can be used in thermometers, blood pressure cuffs, thermostats, fluorescent lights, and other products found in hospitals. At room temperature, elemental mercury is a liquid and emits toxic vapors, which can be inhaled into the lungs and absorbed into the bloodstream.
- Mercury is very toxic to humans. It impacts the kidneys, liver, respiratory system, and central nervous system.
- When emitted indoors, mercury will eventually leak into the outdoor air through doors, ventilation systems, and other openings. It can also reach outdoor air through the incinerations of mercury-containing products.
Polyvinyl Chloride (PVC)

- PVC is used in plastic products such as IV bags, surgical tubing, other medical supplies, and construction materials.
- PVC is a source of toxic air pollutants when incinerated. Some hospitals incinerate their waste onsite.
- Dioxin is a potent carcinogen and interferes with normal reproduction and development at low doses.

2.9.3.3 Measures to reduce Air Pollution

Making changes in hospital operations can stop pollutants at the source and increase efficiency. By evaluating and improving work practices, hospitals can decrease emissions, reduce operational costs, and protect employee and public health. Examples of changes in work practices that help reduce air pollution include:

Replacing Sources of Mercury

- Use alternatives to mercury thermometers, mercury blood pressure cuffs, and other equipment.
- Switch to mercury-free preservatives.
- Insist on using recovered and recycled mercury in all products that do not yet have mercury-free alternatives.

Locating Sources of Mercury

- Use a mercury audit on a regular basis to locate sources of mercury.
- Formulate a plan to reduce sources of mercury.

Communicating Mercury Dangers

- Develop a training and communication program.
- Train employees to look for ways to reduce mercury pollution.
- Develop and implement a protocol to prevent hospital employees from improperly disposing of mercury.

Reducing PVC Use

- Conduct a PVC audit.
- Look for PVC-free products to replace PVC products.
- Use PVC-free medical devices, construction and furnishing products whenever possible.
As a community, one can help to reduce air pollution from hospitals in the following ways:

Make Connections

- Get to know local hospital administrators because they know best about the materials and procedures used in their hospitals and the regulations with which they must comply.
- Keep local media aware of progress by sending them updates. Publicity can reward success and attract more public involvement.

Make a Plan

- One idea is to form a work group that includes local hospital administrators to develop and implement workable pollution reduction plans.

Locate Resources

- Try to find governmental and nonprofit contacts who can provide help with analysis, technical information, equipment, and funding.

Lobby for Pollution Prevention Certification

- Help hospitals lobby societies such as the American Hospital Association to sponsor a certification for those who actively strive to reduce air emissions.

Encourage a “Top Down” Pollution Prevention Approach

- Many hospitals are part of a larger hospital system that includes doctors’ offices, outpatient clinics, and laboratories.
- Lobby hospitals to aggressively implement pollution prevention measures in all parts of its system.

Help Hospitals Raise Mercury Awareness in the Surrounding Community

- Encourage hospitals to sponsor a “mercury turn-in” event in the surrounding community to collect mercury thermometers and batteries. This opportunity will allow them to inform the community about mercury dangers. Such an event will promote the hospital as a cooperative partner within the community.
2.9.3.4 Microbial Pollution through Hospitals

Microbiological transmission in healthcare setting is inevitably a very potential risk. The main routes are droplets, contact, common vehicle and airborne transmissions. Infection control for patients, healthcare providers and visitors is of paramount importance in the healthcare process in medical facilities. Proper air conditioning of medical care facilities is helpful in prevention and treatment of diseases.

Need for air conditioning of hospital facilities

Proper air conditioning is helpful in the prevention and treatment of diseases. The factors determining the need for air conditioning in hospital facilities are:

a) The need to restrict air movement within and between various departments.

b) The specific requirements for ventilation and filtration to dilute and remove contaminants in the form of airborne microorganisms, viruses, odour, hazardous chemicals and radioactive substances.

c) Different types of temperature and humidity requirements for various areas.

d) Permit accurate control of environmental conditions.

e) Control of air quality and air movement

Infection Sources and Control Measures

Bacterial Infection. Infectious bacteria are transported by air. Droplet or infectious agents of 5 mm or less in size can remain airborne indefinitely. It has been shown that 90 to 95 per cent effective filters remove 99.9 percent of all bacteria present in hospitals.

Viral Infection

Epidemiological evidence and other studies indicate that many of the airborne viruses that transmit infections are sub-micron in size, thus there is no known method to effectively eliminate 100 per cent of the viable particles. HEPA filters and/or Ultra-Low Penetration (ULPA) filters provide the greatest efficiency currently available. Therefore, the isolation rooms with appropriate
ventilation pressure relationships are the primary means used to prevent the spread of airborne viruses in the hospital environment.

Outdoor air in comparison to room air is virtually free of bacteria and viruses. Infection control problems frequently involve a bacterial or viral source within the hospital. Ventilation air dilutes the viral and bacterial contamination within the hospital. Properly designed, constructed and maintained ventilation systems preserve the correct pressure relationship between functional areas; they remove airborne infectious agents from hospital environment.

2.9.3.5 Indoor Air Quality in Hospitals

Indoor air quality in hospital is a complex multi-faceted issue. Contaminants come with dust, air and visitors as well as originate inside the hospital complex and threaten the quality of environment. Most common contaminants are microbes and organic compounds. Ventilation and filtration provides a means of combating contaminants by diluting their concentration.

Acceptable indoor air quality can be achieved by following the fundamental principles:

a) Contaminant source control.

b) Proper ventilation.

c) Humidity management.

d) Adequate filtration.

The temperature and humidity conditions in hospital environment can inhibit or promote the growth of bacteria and activate or deactivate viruses. Ventilation systems are used to provide air virtually free of dust, dirt, odour, chemicals and radioactive pollutants.

Contamination can be dispersed into the air of the hospital environment by one of the many routine activities of normal patient care. Because of the dispersal of bacteria resulting from such necessary activities, air-handling system should provide air movement patterns to minimise the spread of contamination.

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The sense of thermal comfort results from an interaction between temperature, relative humidity, air movement, clothing, activity levels and individual physiology. The temperature and relative humidity measurements are indicators of thermal comfort. The medical care needs of patients require thermal comfort provided by air conditioning system.

**Operating Room Air Conditioning Requirements**

The primary task of the ventilation system in an operating room is to provide an acceptable indoor climate for personnel and patients, to remove odour, released anaesthetic gases and to reduce the risk of infection in the operating area. The greatest amount of bacteria found in operating rooms comes from the surgical team and is a result of their activity during surgery.

During an operation most members of the surgical team are in the vicinity of the operating table, creating the undesirable situation of concentrating contaminants in this highly sensitive area. Studies of operating room air distribution systems and various air delivery systems indicate that these are the most effective methods for air movement pattern in operation theatres for limiting the concentration of contaminants to an acceptable level.

**Operating Room Ventilation**

To maintain oxygenation for 10 persons in the operating room, a volume of about 28 m$^3$ air will be required per hour. How much outside air is required for the dilution of odour will depend on the nature and intensity of odour producing sources. It is indicated by some studies that air supplied at 0.24 m$^3$ per minute per person is the critical level of odour suppression.

A ventilation rate of 10 air changes per hour reduces the level of any contamination present in the air by about 99 per cent. 15 to 20 air changes per hour should be sufficient for comfort, to ensure pressurisation in the operation room and to maintain considerable control of airborne microorganisms in an operation room of the size of about 40 sq metre, if an average surgical team is involved. Another study shows that bacteriological contamination of the air is markedly reduced by the use of ultra clean air filters.
Airborne contamination in operating room is mainly derived from the personnel in the operation theatre and their activities. The number of individuals present, ventilation and airflow implements the bacterial count in operation theatre. Proper design and ventilation of operation theatre is the most important means of controlling airborne infection in operation theatre.

Empty Operation Theatre
The empty operation theatre should have:

a) Less than 35 colony-forming units (CFU) of bacteria/m³ of air.
b) Less than one CFU of Clostridium perfingens or Staphylococcus aureus in 30 m³.
c) During operation less than 180 CFU/ m³ of air using ultra clean laminar flow in the theatre.
d) Less than 20 CFU/ m³ at the periphery of the enclosure and less than 10 CFU/ m³ at the centre.

direction of Air Flow
Direction of airflow should be from clean to less clean areas. Airflow rate of 0.28 -0.47 m/sec is desirable across an open door to prevent back flow into cleaner area. In Ultra clean air enclosure, the airflow should not be less than 0.2 m/sec at one metre above the door.

Isolation Rooms
Patients harbour transmittable microorganisms. Various modes of transmission contaminate the environment creating the necessity to control infections. Available systems are:

a) Standard Pressure Room- for patients who require contact or droplet isolation. (Class- S)
b) Negative Pressure Room - for patients who require airborne droplet nuclei isolation to reduce transmission of disease via the air-borne route. (Class-N)
c) Requirement of separate exhaust system dedicated to each room, removing a quantity of air greater than that of the supply system.
d) Maintain an air change rate greater than or equal to 12 air changes per hour or 145 litres per second per patient.
e) Directs the exhaust directly to outside.

f) Positive Pressure Room- rooms with a positive pressure relative to the ambient pressure to isolate immunocompromised patients such as certain transplant and oncology patients. The aim is to reduce the risk of airborne transmission of infection to susceptible patients (Class-P).

Isolation Room Pressures

<table>
<thead>
<tr>
<th>Room Type</th>
<th>Room</th>
<th>En-suite</th>
<th>Airlock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class N</td>
<td>-30 pa</td>
<td>-15 pa</td>
<td>-15 pa</td>
</tr>
<tr>
<td>Class P</td>
<td>+30 pa</td>
<td>+15 pa</td>
<td>+15 pa</td>
</tr>
</tbody>
</table>

Air Lock Function

(a) Provides a barrier against loss of pressurisation and against entry/exit of contaminated air in/out of the isolation room when the door to the airlock is opened.

(b) Provides a controlled environment in which protective garments can be donned without contamination before entry into the isolation room.

(c) Provides a controlled environment in which equipment and supplies can be transferred from isolation room without contaminating the surrounding areas.

Humidity Control

One of the aspects of humidity is that bacteriological microorganisms ride on dust particles whose attract ability to one another is favoured by low relative humidity resulting in increased static energy. Low relative humidity is reported to be suitable for Klebsiella pneumoniae activity. There is a three-fold decrease in the biological decay of a hospital strain of Staphylococcus at 75 per cent relative humidity as compared to 39 per cent relative humidity. High humidity in the hospital enhances the danger of growth of Pseudomonas aeruginosa.

Humidity in operation room is believed to contribute to the prevention of dehydration of exposed tissue. At relative humidity of about 50 per cent, a very thin invisible film of moisture forms on the operation equipment and other
This film of moisture conducts static electricity to earth before a spark producing potential is built up. To minimise the explosion risk, the relative humidity required is 40-65 per cent.

The benefit to the clientele, prompt recovery, restoration of quality of life, disability limitation, prevention of hospital acquired infection, enhancing the productivity of the equipment and staff cannot be quantified in to the exact financial terms. A single case of hospital acquired infection requires at least double the duration of stay in hospital, which leads the antibiotic cost to manifold, leads to increase in the cost due to management of antecedent complications and loss of productive man-hours, justifies the case for air conditioning. The hospitals/medical institution deals with life of the clientele, the lives saved by providing appropriate therapeutic, diagnostic and treatment facilities justify that the investment for air conditioning is a small cost for better quality care to the patients. National Ambient Air Quality Standards are given in Annexure E.

2.9.3.6 Case Studies:

1. Bio-aerosols in indoor environment: composition, health effects and analysis.\textsuperscript{104}

A study was conducted by the Department of Microbiology, Sri Ramachandra Medical College and Research Institute, Sri Ramachandra University, Porur, Chennai, Tamil Nadu to study the Bio-aerosols in indoor environment.

Bio-aerosols are airborne particles that are living (bacteria, viruses and fungi) or originate from living organisms. Their presence in air is the result of dispersal from a site of colonization or growth. The health effects of bio-aerosols including infectious diseases, acute toxic effects, allergies and cancer coupled with the threat of bioterrorism and severe acute respiratory syndrome (SARS) have led to increased awareness on the importance of bio-aerosols. The evaluation of bio-aerosols includes use of variety of methods for sampling depending on the concentration of microorganisms expected.
There have been problems in developing standard sampling methods, in proving a causal relationship and in establishing threshold limit values for exposures due to the complexity of composition of bio-aerosols, variations in human response to their exposure and difficulties in recovering microorganisms.

Currently, bio-aerosol monitoring in hospitals is carried out for epidemiological investigation of nosocomial infectious diseases, research into airborne microorganism spread and control, monitoring biohazardous procedures and use as a quality control measure. In India there is little awareness regarding the quality of indoor air, mould contamination in indoor environments, potential source for transmission of nosocomial infections in health care facilities. There is an urgent need to undertake study of indoor air, to generate baseline data and explore the link to nosocomial infections. The study provides results on composition, sources, modes of transmission, health effects and sampling methods used for evaluation of bio-aerosols, and also suggests control measures to reduce the loads of bio-aerosols.

2. Study of the Indoor Air Quality in Hospitals in South Chennai, India — Microbial Profile

A 3-month pilot study (February—April 2006) was conducted by Centre for Environmental Studies, College of Engineering, Anna University and Department of Microbiology, Sri Ramachandra University, Porur, Chennai, Tamil Nadu to determine the quality of indoor air in hospitals in the Tamil Nadu region of India and to characterize the predominant aerobic bacteria and fungi present. The main objectives were (1) to sample the indoor air of three different hospitals in Chennai for bioaerosols to generate baseline data using the Petri plate gravitational settling (passive) method of sampling; and (2) to isolate and identify potentially pathogenic organisms prevalent in the hospital environment. Indoor air samples were collected from various wards at the different hospitals and processed for the identification of various predominant bacteria and fungi.
The overall counts of Gram-positive organisms were found to be higher than Gram-negative organisms. Of these isolates, Staphylococci and Micrococci were the predominant Gram-positive bacteria, while Klebsiella sp. and Pseudomonas sp. were the predominant potentially pathogenic Gram-negative bacteria isolated. Among yeasts and molds, Aspergillus niger and A. flavus were commonly isolated.

3. Nosocomial aspergillosis and building construction.106

A study undertaken by University of South Florida, USA found that healthcare-associated infections (HAI) with Apergillus pose a serious threat to those most severely immune suppressed patients. Outbreaks of nosocomial aspergillosis have occurred mainly among neutropenic patients, but with several important exceptions. HAI due to aspergillosi has occurred in association with environmental disturbances including but not limited to: hospital construction, maintenance, demolition and renovation; contaminated fireproofing materials; air filters in hospital ventilation systems, and via contaminated carpeting.

It behooves those in the practice of patient care to prevent these situations before they occur, as opposed to dealing with them once they happen. The framework of the six links in the infectious disease process was used to examine healthcare-associated invasive aspergillosis: causative agent, portal of entry, susceptible host, portal of exit, reservoir and mode of transmission. Two particular interventions: the Protective Environment (PE), and the Infection Control Risk Assessment (ICRA), were outlined. Building construction projects and the number of neutropenic patients are likely to continue to increase. Therefore, future directions need to focus on reducing the susceptibility of the susceptible host and reducing the exposure to Aspergillus from environmental sources. In addition, recently released guidelines with control measures aimed at reducing environmental exposure to Aspergillus need to be further studied.
4. Preparations and limitations for prevention of severe acute respiratory syndrome in a tertiary care centre of India

In February 2002, a few cases of a mysterious plague-like disease were admitted to PGIMER. The diagnosis was initially missed, and the patients were not isolated until a formal diagnosis was made. By that time, infection had been transmitted from a visitor to another patient in the ward; a 28-year-old man, who later died. The need to screen all patients with suspected infectious disease in the medical emergency outpatient department of infection was recognized. Therefore, a short-term observation study of infection control practice was performed in the medical emergency outpatient department (EMOPD) of PGIMER, Chandigarh, when threatened by an outbreak of severe acute respiratory syndrome (SARS).

The physical space, entry and exit system, location, registration area, lobby/corridor, waiting area, triage area, examination rooms, observational beds, emergency X-ray room and laboratory treatment rooms, nurse’s station, staff rest rooms, stores, police post and public relations office were observed. In addition, the patient/attendant load, patient flow, and medical staff practice were observed, and information displayed on SARS or other infectious diseases was noted.

The EMOPD has four entrances manned by security guards. These open into a spacious, well lit lobby. There are separate emergency wards for medicine and surgery (total 110 beds), and 28 observational beds. On an average, 80-100 patients are admitted daily and almost twice that number of attendants accompany them. A computed tomography (CT) scan/radiology department, seven operating theatres, a blood bank, an attendant waiting room, laboratory, and a public relation officer’s room are attached to the EMOPD. No isolation facility is available. At any one time, there is a consultant, two senior residents, three junior residents, four nursing staff and a sanitary staff member present.

The flow of patients and their attendants was not systematic and their movement was uncontrolled. Two or three or even more attendants usually
accompanied one patient. At the entrance, there was no sign showing the direction to the patient reception area. The corridor was overcrowded, leaving little space for movement of patients, nurses and doctors. There was a central air conditioning system with different airflow control units, but no negative-pressure isolation room or other isolation facility. The floors were wet mopped two or three times per day and once a day with cresol. The emergency operation theatres were fumigated monthly.

It was felt that the layout of an emergency department affects the chances of spread of infection. Open wards with many beds separated by curtains and no controlled ventilation have been regarded as contributory factors to the spread of the virus.

PGIMER EMOPD has a core type of design. Two kinds of change are possible:

(a) **Structure.** The EMOPD initially contained 35-40 beds, but now has 110, leaving little scope for further expansion. To prevent spread of infection, a permanent ‘triage/control room’ should be established near reception for screening patients. This should include a cubicle for examination of critically ill infectious disease patients. If doctor/nurse suspects that s/he should have an option to isolate the suspected cases in an isolation room/ward located nearby.

(b) **Function.** This could be changed without undue disturbance and cost, provided that the building has sufficient flexibility. The flow of patients and visitors can be easily regulated. A sign should be placed at the entry of EMOPD instructing people where to report first. Proper directions to patients/attendants should be displayed inside the hall. A systematic patient flow control mechanism should be installed and a screening system for patients’ attendants should also be initiated. Only one attendant (at the most two, in case of serious emergency) should be allowed into the EMOPD. A public health nurse (PHN) along with an emergency medical officer-surveillance and screening (EMO-S&S) should be posted permanently in the EMOPD.
There is a definite need to make the EMOPD safer for immunocompromised and susceptible patients and their attendants. The study highlights the vulnerability of EMOPD in India for spread of infectious diseases even in centers of excellence.

### 2.9.4 NOISE POLLUTION - A NUISANCE VALUE IN HOSPITALS

*Noise pollution* is unwanted human-created sound that disrupts the environment. The word ‘noise’ comes from the Latin word ‘nausea’ meaning seasickness. Deleterious effect of noise on patient care has been a focus of concern for physicians from ancient times.\(^{108}\)

#### 2.9.4.1 IMPACT OF NOISE

Noise impacts patients in many ways including\(^ {109}\):

- Sleep deprivation
- Increased anxiety
- Increase in noise-induced stress
- A "startle reflex" resulting in physiological responses:
  i. Facial grimacing
  ii. Increase in blood pressure
  iii. Higher respiratory rate
  iv. Increased heart rate and vasoconstriction
- Hearing loss-The mechanism for chronic exposure to noise leading to hearing loss is well established. The elevated sound levels cause trauma to the cochlear structure in the inner ear, which gives rise to irreversible hearing loss. The pinna (visible portion of the human ear) combined with the middle ear amplifies sound levels by a factor of 20 when sound reaches the inner ear. In Rosen's seminal work on serious health effects regarding hearing loss and coronary artery disease, one of his findings derived from tracking Maaban tribesmen, who were insignificantly exposed to transportation or industrial noise. This population was systematically compared by cohort group to a typical U.S. population. The findings proved that aging is an almost
insignificant cause of hearing loss, which instead is associated with chronic exposure to moderately high levels of environmental noise.

- **Cardiovascular health** - High noise levels can contribute to Cardiovascular effects and exposure to moderately high (e.g. above 70 db(A)) during a single eight hour period causes a statistical rise in blood pressure of five to ten mmHg; a clear and measurable increase in stress; and vasoconstriction leading to the increased blood pressure noted above as well as to increased incidence of coronary artery disease.

- **Annoyance** - Though it pales in comparison to the health effects noted above, noise pollution constitutes a significant factor of annoyance and distraction in modern artificial environments. The meaning listeners attribute to the sound influences annoyance, so that, if listeners dislike the noise content, they are annoyed.
  a) If the sound causes **activity interference**, noise is more likely to annoy (for example, sleep disturbance)
  b) If listeners feel they can **control the noise source**, the less likely the noise will be annoying. If listeners believe that the noise is subject to **third party control**, including police, but control has failed, they are more annoyed.
  c) The **inherent unpleasantness** of the sound causes annoyance. What is music to one is noise to another.
  d) **Contextual sound.** If the sound is appropriate for the activity it is in context. If one is at a racetrack the noise is in context and the psychological effects are absent. If one is at an outdoor picnic the racetrack noise will produce adverse psychological and physical effects.

Continuous noise may alter a patient's memory, increase agitation, lower pain tolerance and lead to feelings of isolation.

Noise may also impact hospital employees causing:

- Stress related symptoms.
- Depression.
- Irritability and decreased concentration in the work place.
• Reduced efficiency and decreased productivity.
• Increased medical and nursing errors.

2.9.4.2 Sources of Hospital Noise

Figure 2.11: Source of Hospital Noise

By measuring noise during peak and off-peak hospital hours, analysts can detect and correct the noise. Noise meter readings established by a pollution control board offer quantitative readings that help predict, and therefore prevent, future noise problems. The various sources of noise in a hospital are tabulated in Table no.2.19.
<table>
<thead>
<tr>
<th>Sources of Noise</th>
<th>Primary Area</th>
<th>Secondary Area</th>
<th>Tertiary</th>
<th>Location</th>
</tr>
</thead>
</table>
| **People**       | • Unwanted movements of people (patients/employees)  
                  • Pooling of intermediate customers during consultation timing (representatives)  
                  • Exchange of information between employees (human voice)  
                  • Too many attendants accompanying the patients  
                  • Frequent visiting of patient’s attendants in the nursing station/laboratory services for enquiries  
                  • Pooling of students in the nursing station  
                  • Mishandling of accessories, which creates excessive noise  
                  • Load glucometer carts  
                  • Staff tend to have mini-conference in the hallway creating noise  
                  • Frequent movement of people in parking facility creates unavoidable noise  
                  • Overcrowding of patient attendants in the canteen  
                  • Noise due to renovation/repair work done in the hospital  
                  • Noise created by people from outside the hospital (public meeting announcements) |
| **Equipment**    | • Ambulance noise  
                  • Patient vehicles  
                  • Mobility aids sounds  
                  • Telephone sounds  
                  • Overhead paging systems  
                  • Lifts operating noise  
                  • Equipment handling  
                  • Noise in laboratories  
                  • Mobility aids and wheelchair sounds while transferring patients  
                  • Lifts operating noise  
                  • Telephones, trip alarms and intercom sound of beepers, bed rails, and ventilators  
                  • Portable X-ray machine sounds, blaring T.V.  
                  • Buzzers, beepers, multiple monitors, nurse call systems and doors  
                  • Frequent movements of vehicles  
                  • Handling of equipment in the laundry and linen services  
                  • Noise created during transfer of incoming essential materials in the purchase departments  
                  • Utensils handling noise in canteens  
                  • Vehicle sounds |
| **Environment/system** | • Improper/confused facility arrangements  
                           • Lack of display boards showing facilities available in the hospital leads to unwanted enquires resulting in noise  
                           • Centralized nursing stations  
                           • Facility arrangements warranting noise in inpatient wards  
                           • Excessive students to patient ratio creates noise during clinical teaching  
                           • Lack of knowledge in handling the equipments by workers involved in maintenance departments  
                           • Lack of space required for supportive services  
                           • Hospital floor, wall and ceilings are hard and reflect sound rather than absorb it |
2.9.4.3 Strategies to Solve Noise Pollution

The following strategies have been suggested to reduce noise problems in hospitals:

1. Establish stringent standards impacting patient safety.
2. Evaluate the current hospital noise through patient satisfaction surveys and by measuring the decibel levels.
3. Review the hospital's repair and maintenance policy and ensure it reflects the need for equipment to operate effectively and quietly.
4. Conduct an auditory impact query as part of every remodel and construction project, equipment purchase and staff event.
5. Change the ceiling tiles periodically from sound reflecting to sound absorbing tiles allowing patients to sleep better.
6. Convert a centralized nurse station to a decentralized nurse station.
7. Provide curtains and Plexiglas barriers in multi-bed rooms to provide both visual and auditory protection.
8. Use music therapy to replace noxious sounds with pleasant sounds – music improves restfulness and sleep, and induces relaxation.
9. Provide guidance and instruction during staff education and employee orientation sessions on the importance of maintaining appropriate noise levels.
10. Outline specific procedures regarding:
   - Private discussions in public areas
   - Use of pagers and cell phones
   - Nurse call systems
   - Telephone use
11. Place signs and slogans throughout the hospital – silent hospital help healing (SHHH) – and give patients, staff and visitors buttons that show a nurse with her finger to her lips.
12. Use sound meters to record ambient noise level at periodic times throughout the day.
13. Reduce waiting time in the outpatient departments. Schedule consulting times for the patients and fix appointments with the
physicians during registration. Reducing the waiting time in turn reduces noise in the outpatient departments.

14. Display the location of offices and consultants at the reception area, and provide directories on each floor to minimize the need for visitors and patients to ask for directions.

15. Use an individual activity network diagram for each student in the hospital and ensure the faculty oversees the students in the clinical setting. This will minimize overcrowding of students in the clinical setting and streamline student activities.

16. Implement a SHHH program to recognize hospital staff and/or departments that excel at providing and maintaining a noise free environment.

Using quantitative and qualitative measures to identify and monitor noise levels in hospitals is critical to hospital efficiency. Reducing noise and maintaining a quiet facility will improve patient care and enhance the reputation of the hospital.

In exercise of the powers conferred by clause (ii) of sub-section (2) of section 3, sub-section (1) and clause (b) of sub-section (2) of section 6 and section 25 of the Environment (Protection) Act, 1986 (29 of 1986) read with rule 5 of the Environment (Protection) Rules, 1986, the Central Government made the rules for the regulation and control of noise producing and generating sources, namely The Noise Pollution (Regulation and Control) Rules, 2000. Ambient Air Quality Standards in Respect Of Noise are given below in Table 2.20:

<table>
<thead>
<tr>
<th>Table 2.20</th>
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</thead>
<tbody>
<tr>
<td>Ambient Air Quality Standards in Respect Of Noise</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area Code</th>
<th>Category of Area/Zone</th>
<th>Limits in dB(A) Leq*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Day Time</td>
</tr>
<tr>
<td>(A)</td>
<td>Industrial area</td>
<td>75</td>
</tr>
<tr>
<td>(B)</td>
<td>Commercial area</td>
<td>65</td>
</tr>
<tr>
<td>(C)</td>
<td>Residential area</td>
<td>55</td>
</tr>
<tr>
<td>(D)</td>
<td>Silence Zone</td>
<td>50</td>
</tr>
</tbody>
</table>
NOTE:
1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 p.m.
3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.
4. Mixed categories of areas may be declared as one of the four above-mentioned categories by the competent authority.
   dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.
   A "decibel" is a unit in which noise is measured.

2.9.4.4 Case Study

1. Quiet – Hospital Zone

   The study’s author Millman, a professor in the School of Medicine and director of the Sleep Disorders Clinic at Rhode Island Hospital suggested that hospitals modify the sounds produced in the critical-care setting and find ways to screen patients from noise pollution. The sounds came from various sources, such as loud voices, televisions, equipment alarms, intercoms and beepers.

   For the study, researchers monitored overnight the link between peak sound levels and arousals from deep sleep in six elderly patients. They found a very strong correlation between the number of sound peaks and sleep arousals. For example, not counting interruptions by nurses or doctors, the researchers found 29 peak sound levels were associated with 28 sleep arousals in one patient during a one-hour period. In another patient, 34 sound peaks were correlated with 42 arousals in one hour.

   In fact, the study’s findings were part of a larger problem. Some of Millman’s previous researches showed that peak sound levels in a hospital during a 24-hour period were consistently above 70 decibels. The sources of
Millman suggested that hospitals redesigning or constructing critical care settings use the study's findings to create sites that minimize noise pollution such as arranging patients in individual rooms. Other ways to reduce noise are to move equipment alarms away from patients, relocate nurse's stations away from rooms, switch beepers to vibrating mode and train doctors and nurses to speak more softly. An alternative approach may be to determine if the use of ear plugs or noise cancellation equipment leads to better sleep quality in patients, he said.

The peak sound level recommended for hospitals by the Environmental Protection Agency is 45 decibels during the day and 35 decibels at night.

2. Hospital noise makes sleep difficult

After eight nights in the hospital for debilitating headaches, Laurel Carpenter was ready to go home and finally get what the doctor ordered a good night's sleep.

From a private room in a Los Angeles hospital last summer, Carpenter had endured a torrent of interruptions and noise that could wake even the sedated. The cacophony of screeching cart wheels, telephones, shouts from the hallway coupled with the frequent rousings for meals, medication and vital-signs checks made continuous rest virtually impossible. And then there was the fire drill.

"I was asleep and I came out of my pain-medicated stupor, trying to get out of bed, wondering what in the world was going on," said the 48-year-old Los Angeles resident. "The alarm rang for 15 or 20 minutes. I thought I was going to go crazy."

Carpenter's experience is far from uncommon. Hospitals that take patient satisfaction surveys find that noise levels and lack of sleep regularly top the complaint list. And a sizable body of research over the last dozen
years bears out what many overnight patients already know: the hospital is a lousy place to sleep.

"Noise is a problem inherent in every major hospital in the United States," said Dr. Mathew Lee, medical director of the Rusk Institute of Rehabilitation Medicine at New York University Medical Center. "Its impact on patients is almost always underestimated."

The clamor of hospitals is more than a mere annoyance: its negative effect on sleep appears to slow the healing process. Excessive noise and sleep deprivation are believed to diminish the strength of the immune system, lower pain tolerance levels and extend hospital stays. A lack of sleep also may retard the body's ability to generate new cells to repair damaged tissue.

3. Noisy Hospitals Never Give Patients a Rest

A hospital can be a loud place - with peak noise levels rivaling the racket produced by a jackhammer -- making it difficult for patients to get much-needed sleep, says a Mayo Clinic nursing team study in the February issue of the American Journal of Nursing.

"Adequate sleep is important to the healing process, and sleeping in the hospital is notoriously difficult. Our continuous improvement team wanted to find specific causes for the problem, and see what concrete steps we could take to help solve it," Cheryl Cmiel, the study's lead author, says in a prepared statement. She and her colleagues measured overnight hospital noise levels. They found peak noise levels as high as 113 decibels -- about the same as a jackhammer or chainsaw -- occurred at around 7 a.m. during the morning shift change. The 11 p.m. shift change also generated high noise levels.

4. Why people don't sleep well in hospitals

The study has prompted various changes aimed at reducing noise levels on the ward and increasing patients' chance of a decent night's sleep. The nurses have decreased the noise of shift turnover by having staff reports take place in an enclosed room, not at the nurses' desk. Noisy roll-type towel...
dispensers are replaced with silent folded-towel versions. Cardiac monitor settings are moved to lower volumes in patients rooms and the doors of the rooms are closed routinely.

When noise levels were recorded after these alterations, they were down as much as 80 per cent. And patients really appreciated the change - especially the closed doors and general quietness of the unit.