

A TEXTBOOK OF ENVIRONMENT AND HEALTH

*Based on syllabus of Bachelor of Public Health of
Different Universities of Nepal*

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2012

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Unit 1: Concept of Environment:

Environment (from the French *environner*: to encircle or surround) means each and every thing outside the organisms which influences in any way, directly or indirectly the life activities of the organisms. The environment includes all the external factors such as air, water, soil, light etc which have an influence on the activities of the organisms. In modern concept, environment includes not only the water, soil, air that form our environment but also the social and economic condition under which we live.

The environment for any living organism has never been constant or static. It has always been changing. Many species on the earth could not cope up with the changing environment as a result of which they have since vanished and many are on the state of vanishing. Nature selects those species which can cope or adapt with changing environment. Actually environment creates favorable conditions for the existence and development of living organisms.

Types of Environment:

Environment can be divided into two categories:

- (1) Natural environment
- (2) Man made environment

(1) Natural environment: The kind of environment which is created by the nature is natural environment. Thus it is called god gifted environment. The natural environmental system operates through self regulating mechanism. The components of natural environment are air, water, soil, radiation, forest etc.

(2) Man-made/Anthropogenic environment: The environment which is created by man is called anthropogenic or socio-cultural environment. It refers to all the physical infrastructures built by man and social and cultural which he has developed. Generally the socio-cultural environment consists of everything around us which is developed by man himself through his skills, tools and social institutions.

Factors affecting environment:

There are mainly four categories of ecological factors which influence the environment. These are:

(1) Topographic/Physiographic factors: Topography factors are concerned with the physical geography of the earth in the area. The main physiographic factors are altitude and direction of mountain and valley, steepness and exposure of slope etc. Topographic factors influence vegetation by producing variations in the climate of geographical region.

(2) Climatic factors: It includes atmospheric gases, light, temperature, humidity, rainfall etc. They play important role in the species composition and development of plants and animals. The basic physiological, processes such as photosynthesis, transpiration, seed germination, flowering etc of plants are directly governed by climatic factors and thus it is much concerned in environment.

(3) Edaphic factors: Edaphic factors include the structure and composition of soil along with physical and chemical characteristics. Soil is the medium which supply essential plant nutrients to the plants, habitat for numerous soil organisms. The species composition of organisms depends upon the nature of soil.

(4) Biotic factors: It includes all types of interactions between different forms of life eg. Man, animals, plants, and microorganisms. Life of organisms is affected by the combination of all these ecological factors which are inter-related with each other.

Concept of ecology:

The term ecology is derived from the Greek word oikos, meaning house or place to live and logos meaning the study. Therefore ecology is the study of organisms in their natural home or habitat. Ecology is the science of the interrelations between living organisms and their environment. The life and environment are interdependent. If there were no life on earth, its environment today would have been quite different.

Sub-division of ecology:

In regards to sub-division, ecology is usually divided into plant ecology and animal ecology. Plant ecology is the study of animals in relation to the environment. Similarly animal ecology is the study of animals in relation to the environment. However animal ecology cannot be properly understood without background of plant ecology. Because of very close relationship between plants and animals, this division carries no meaning.

Further ecology is often divided into:

- (1) Autecology: It includes the study of the ecology of an individual or a particular species of organism.
- (2) Synecology or community ecology: It includes the study of the communities or entire population. It deals with the inter-relationship between plants and animals and this forms the basis of community.
- (3) Habitat ecology: It is the branch of ecology that deals with the study of habitats and their effects on the living organisms on earth. It includes forest ecology, grassland ecology, wetland ecology, marine ecology, desert ecology etc.
- (4) Population ecology: It includes the study of the inter-relationship of different groups of organisms, including the structure and distribution of population.
- (5) Ecosystem ecology: It deals with the study of the organisms including nutrient cycling, energy flow and productivity.
- (6) Taxonomic ecology: It includes the ecology of various taxonomic groups as avian ecology, insect ecology, microbial ecology etc

(7) Human ecology: It deals with population ecology and man's relation to environment especially man affecting the biosphere and vice-versa.

(8) Radiation ecology: It deals with the study of effects of radioactivity on the organisms and their environment.

(9) Limnology: It is the study of fresh water ecology, i.e. study of lakes, ponds, rivers and their environment.

(10) Terrestrial ecology: It is the study of forest, grassland, cropland, desert etc

(11) Marine ecology or Oceanography: It is the study of sea, oceans and their organisms.

(12) Applied ecology: It is the study of forestry, conservation and management of wild life, insect control, aquaculture, horticulture, animal husbandry etc

Scope of Ecology:

Ecology is a multidisciplinary science and it includes not only life sciences but chemistry, physics, geology, climatology, meteorology, geography etc. The scope of ecology is quite vast. It plays an important role in agriculture, management of forest and grassland, conservation of soil, wild life, pest control, public health pollution control toxicology etc.

Concept of Ecosystem

Living Organisms and their non living environment are inseparably interrelated and interact upon each other. Any unit that includes all of the organisms (i.e community) in a given area interacting with the physical environment so that a flow of energy leads clearly defined trophic structure, biotic diversity and materials cycles (ie. exchange of materials between living and non living parts) within the system is called an ecological system or ecosystem. (Odum, 1971)

The term ecosystem was first proposed by A.G Transley in 1935, who defined it as Ecosystem is the system resulting from the integration of all the living and non-living factors of the environment.

Structurally ecosystem can be divided into two major components.

I) Abiotic components (Non living)

II) Biotic components (Living)

I) Abiotic component:

It includes i) the amount of inorganic substances such as Nitrogen, Phosphorus, Carbon, Hydrogen etc involved materials cycles.

ii) amount and distribution of organic materials such as proteins, carbohydrates, lipids etc present either in the biomass or in the environment

iii) Climate of the given region

II) Biotic component:

This is indeed the trophic structure of any ecosystem, where living organisms are distinguished on the basis of their nutritional relationships. From this trophic (nutritional) standpoint, an ecosystem has two components.

1) Autotrophic component

Members of the autotrophic component are known as Producer. The component is constituted mainly by green plants including photosynthetic bacteria. They are capable of synthesizing food from non-living simple inorganic substances and complex organic substance is build up.

2) Hetrotrophic component

The organisms involved in hetrotrophic components are known as Consumers as they consume the matter build up by the producer (autotrophs) and ohter component is decomposers. The consumers are further categorized as:

i) Macrocosumers: eg. herbivores (Primary consumers), carnivores, or omnivores.

ii) Microconsumers:

These are popularly known as Decomposers. They are saprotrophs (osmotrophs) and include chiefly bacteria, actinomycetes and fingi. They break down complex compounds of dead or living protoplasm, absorb some of the decomposition or breakdown products and release inorganic nutriençs in environment, making them available again to autotrophs.

Human Impact on Ecosystem: (Activity of Man and Environmental degradation)

The activity of man has slowly been degrading the quality of global environment/ecosystem. Major aspects of human activity responsible for environmental degradation are:

- (1) Over-exploitation of natural resources
- (2) Pollution of the environment

(1) Over-exploitation of natural resources:

The world population now stands at about 7 billion. To maintain it in a reasonably comfortable state, a huge amount of food, material and other resources are needed. Natural vegetation over a large stretch of land has been destroyed to be replaced by agricultural systems which are intensively managed to produce as much as eatables as possible. All other resources which could possibly feed the mankind are tapped. For materials other than eatables, such as fibres, wool, cement, stone, metals etc. both biotic and abiotic resources are exploited. The growing demands have turned exploitation into

over exploitation now. This has brought the natural systems ie. ecosystem on the state of collapse.

(2) Pollution of the environment

With a rapid growth of human population, which caused an ever-rising drain on natural ecosystem, the amount of waste materials produced by human society has also multiplied. Dilution no longer remained a solution. As wastes grew in amount their nature also changed. Insecticides, plastics, polymers, heavy metals, etc which are the wastes of persistent nature, worsened the problem. Discharge of waste gases grew so much in volume that acid rains appeared. Even the stratosphere has become polluted by human made CFCs. The ozone content is diminishing. Pollution now spoils more and more surface deposits of fresh water everyday and threatens the sub-surface aquifers as well. The pollution of soil damages more and more agriculture land every year. The whole ecosystem has slowly been subjected to an ever rising stress caused by human activity. It has already begun to lose species after species.

The Effects of Human activity on the Global Ecosystem:

The pollution of environment and over-exploitation of natural resources have become so extensive as to threaten the existence of entire life on this planet.

Changes brought about by the unscrupulous action of man can be summed up in the following two major categories:

- (1) Steady impoverishment of biological systems
 - (a) Reduction in ecosystem complexity and diversity
 - (b) Reduction in genetic diversity
- (2) Changes in global bio-geo-chemical cycles.

(1) Steady impoverishment of biological systems

An importance consequence of the rapid rise in man's population has been an ever rising demand for space. Human habitations are fast expanding and encroaching upon natural systems. Forests are cleared, grasslands invaded, hills tops leveled, wetlands drained and even land under water is reclaimed to provide space for human establishments. The soil is bared, flora and fauna exterminated, natural ecosystem are destroyed and are replaced by such as artificial system as agriculture, horticulture, animal farm etc. These activities tend to reduce biological diversity of the system.

(a) Reduction in Ecosystem complexity and diversity:

Man has been oversimplifying the structural complexities and diversity which occur in natural undisturbed ecosystem. Agriculture for example is just an applied management of tropic chain. The complicated, many tiered tropic structure of a natural system is reduced to two links, primary producer and man. Man sets up an artificial agricultural ecosystem protects the biomass which develops in his field from pathogens, insects, birds and other herbivores. However simple tropic structure is more vulnerable to catastrophic change. An unforeseen host-specific pathogen could reduce or eliminate the single species which happens to constitute the entire population of producers. In a complicated ecosystem,

with each trophic level composed of a number of species, several alternatives are available for the energy to flow, for materials to circulate in the system which is thus maintained in operative state. Man also tends to simplify microbial community present in the soil or water bodies. Use of chemical fertilizers and intensive agriculture lead to depletion of organic materials on which microbial population depends for nutrition while insecticides wash down to soil kill susceptible organism directly. Sewage, waste water from industries and surface runoffs from agriculture fields pollute aquatic systems in which susceptible organisms are suppressed. The resistant ones survive and build up large population.

(b) Reduction in genetic diversity:

Man has slowly and consciously been reducing the no. of plants and animals which he breeds. The varieties or species in which he is no longer interested are vanishing one after the other. Selection of varieties for better output, resistance to environmental condition, better tests and flavors etc. has preserved by man through cultivation. E.g. rice plants in Nepal.

(2) Changes in Bio-geo-chemical cycle:-

Ruthless exploitation and pollution of environment has disturbed the operations of all important bio-geo-chemical cycle. The magnitude of waste materials has been growing persistently. These waste or their decomposition products are regularly added to various compounds of the environment in significant quantities to disturb even the global cycles. Man has been extracting substantial quantities of materials which represent biological output of past ages, at a rate much faster than the rate of their formation. So our deposits of various mineral elements and metals are good source of which are being depleted at a very fast rate. Human activities have led to an enhanced rate of input of carbon into the atmosphere which has caused a measurable rise in the concentration of atmospheric CO_2 . This is due to increase use of organic matter, coal, petroleum and natural gas as fuel and the combustion of carbonate rocks for manufacture of cement and lime. Thus natural carbon cycle is affected. A small rise in concentration of CO_2 in the atmosphere shall have no effect on plants and animals. However, CO_2 is a green house gas and absorbs infra-red and heat effectively which cause an effect called green house effect and global warming. Similarly, nitrogen cycle is affected by using a lot of nitrogenous fertilizers in agricultural lands.

Unit 2: Ecosystem approach to Human Health

HEALTH -AN ECOSYSTEM APPROACH

Human health cannot be considered in isolation. It depends highly on the quality of the environment in which people live: for people to be healthy, they need healthy environments. The Ecohealth (ecosystem approach) approach is anthropocentric managing the ecosystem revolves around seeking the optimal balance for human health and well-being, rather than simply on environmental protection. Thus, its objective is not to preserve the environment as it was before human settlements appeared. The presence of human beings creates a new dynamic whereby people's social and economic aspirations need to be considered, particularly since people have the power to control, develop, and use their environment in a sustainable way, or to abuse it. That is an original aspect of this approach.

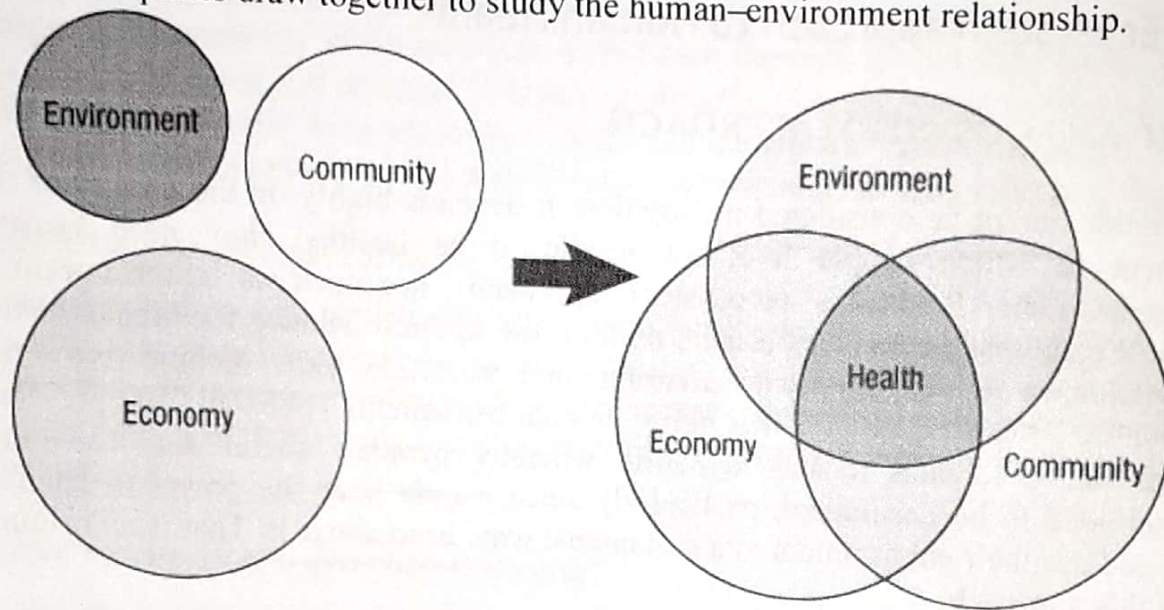
Discoveries in health and progress in healing techniques have considerably reduced the incidence of infectious disease in industrialized countries and, to a lesser extent, in developing countries. Despite some progress, environmental factors still dramatically affect the health of many people. WHO estimates that approximately three million children die each year from environment-related causes and more than one million adults die of work-related illnesses or injuries. Between 80 and 90 percent of diarrhea cases are caused by environmental factors. In developing countries, between 2.0 and 3.5 billion people use fuels that give off smoke and other harmful substances. In rural areas, poor animal husbandry practices result in the spread of animal-transmitted diseases and resistance to antibiotics.

Many ecological disasters can be directly traced to careless exploitation of the environment, with human beings becoming both perpetrator and victim. Our health closely mirrors the health of our surroundings. This is the basis of the Ecohealth approach, which recognizes the inextricable links between humans and their biophysical, social, and economic environments, and that these links are reflected in an individual's health.

The impact of environmental factors on human health is now well established. In North Africa, for example, 70 percent of wild plants have a household use, either as medication or food. But despite its importance, African forestland, which covers 22 percent of the continent, lost more than 50 million hectares between 1990 and 2000. For its part, Latin America contributed 190 of the 418 million hectares of forests lost throughout the world during the last 30 years. The loss of biological diversity associated with this kind of disappearance may have direct consequences on human health since about 75 percent of the world's population uses traditional medicines, derived directly from natural sources.

In this context, it is impossible to improve the environment without including the human population, with its inherent social, cultural, and economic concerns, in the management of resources (Figure 1). In fact, the more we try to stabilize ecosystems by external

measures, such as irrigation, drainage, fertilizers or pesticides, the more we diminish their ability to regenerate themselves. A sectoral approach is no longer adequate: co-management of human activity and the environment is essential. This challenge requires that disciplines draw together to study the human–environment relationship.



The traditional approach

The ecosystem approach

Figure 1. The ecosystem approach gives equal importance to environmental management, economic factors, and community aspirations. Traditional methods focus more on the latter two, to the detriment of the environment (adapted from Hancock 1990).

The economy, the environment, and community needs all affect the health of the ecosystem. Focusing on just one of these factors to the detriment of others compromises ecosystem sustainability. The Ecohealth approach is thus part of the sustainable development process. It promotes positive action on the environment that improves community well-being and health. The underlying hypothesis of the Ecohealth approach is that the programs it generates will be less costly than many medical treatments or primary health care interventions.

In Kenya, malaria kills between 75 and 100 children every day. Traditional programs to fight this disease have failed. In the Mwea region, the immense tracts of rice paddies that are covered with water six months of the year offer an ideal habitat for mosquitoes. The community has responded with insecticides and antimalarial drugs, but both the mosquitoes and the parasites have become more resistant. By taking into consideration, the villagers and the research team have implemented solutions that improve the environment. The rice-paddy flooding time has been reduced and the rice crops are alternated with soybean crops that grow in dry conditions. The mosquitoes' habitat has thus been reduced and people's diet has improved. The children are no longer reduced to eating rice three times a day, a diet that leads to protein deficiency. The families have also been encouraged to surround their houses with plants that repel insects.

Health as Biomedical concept:

According to this concept, health is an absence of diseases and if one is free from disease, that person is considered to be healthy. This concept is based on Germ theory of disease causation which was developed during late 18th century.

Health as Psychological concept:

Health is one which is influenced by social, psychological, cultural, economic and political factors of the people concerned.

Health as Holistic concept:

The holistic model is a synthesis of Ecological, Biomedical and Psychological concept. It implies that all sectors of society have an effect on health, in particular, agriculture, animal husbandry, food, industry, education, housing, public works, communications and other sectors. The emphasis is on the promotion and protection of health.

Agroecosystem:

Agroecosystems (Agriculture ecosystem) are defined as "a biological and natural resource system managed by humans for the primary purpose of producing food as well as other socially valuable nonfood goods and environmental services." It is an artificial or man-engineered ecosystem in order to obtain more food, medicine, and other useful products. Man becomes responsible for the replacement of natural self regulating system. i.e. direct interference and manipulation by man. To secure maximum production, man makes much planned manipulations in the physico-chemical environment. These include addition of fertilizers to soil, use of chemical pesticides for diseases control, proper irrigation practices etc.

Agroecosystem differ from natural or semi-natural solar powered ecosystem, such as lakes and forests, in three basic ways

- i) Auxillary energy that augments the solar energy input is under the control of humankind and consists of human and animal labor, fertilizers, pesticides, irrigation water, fuel powered machinery and so on.
- (ii) Diversity of organisms and crops is greatly reduced to maximize yield of specific food crops or other products and
- (iii) The dominant plants and animals are under the artificial selection rather than natural selection.

Agroecosystem can be divided into 3 broad types:

(1) Pre-industrial agriculture:

It is Self-sufficient and labor intensive agriculture which provides food for farmer and family and for sale or barter (exchange) in local markets, but does not produce a large surplus for export.

(2) Intensive mechanized, fuel-subsidized agriculture, termed conventional or industrial agriculture (use of machines and intensive use of chemicals):

It produces food exceeding local needs for export and trade, thus making food a commodity and a major market force in the economy rather than providing only life support good and services.

(3) Low-input sustainable agriculture (LISA):

Emphasis on sustaining crop yields and profits while reducing inputs of fossil fuels, pesticides and fertilizer.

About 60% of the world's croplands are in the pre-industrial category, a large proportion of them in the less developed countries of Asia, Africa, and south America that have large human population. Agroecosystem cover 30% of the world's land area. During the last 50 years, scientific progress (the green revolution) in plant and animal breeding, irrigation, pest and disease control, labour-saving technologies, and food processing enabled food production to keep pace the demands of a growing human population.

High yielding production systems accelerated the "mining" of soil capital. Replenishment of soil nutrients by dependence on chemical fertilizers failed to maintain the structure and biological diversity essential for long term production.

Expansion of agriculture into forests and the conversion of range lands into crop lands aggravated this deteriorating situation. Under nutrient and water-stressed intensive agricultural production systems, farmers increasingly rely on the use of herbicides, pesticides and pharmaceutical drugs to control a wide range of diseases and parasites that threaten their crops and livestock.

Nepal:

About 21% (3.2 million hectares) of the total land area of Nepal is used for cultivation and the principal crops are Rice (45%), Maize (20%), Wheat (18%), Millet (5%) and Potatoes (3%) followed by Sugarcane, Tea, Cotton, Barley, Legumes, Vegetables and Fruits. Crops such as Rice, Soyabean, Millet, Citrus and Mango have high genetic diversity relative to other food crops.

Nepal has a high degree of agroecological diversity that is largely associated with the hills and mountains where variations in factors such as topography, slope altitude allow for an enormous range of biological environments, climatic regimes and varied ecosystem. Farming system in Nepal vary according to the 3 major physiographic regions of the country, namely Terai, the Mid-hills and the mountains

Human Health and Agroecosystems

Human health is directly linked to and dependent on the state of health of the ecosystems that support them because people are an integral component of agroecosystem. Although, increased food production in terms of quantity has largely kept pace with the demands of a growing population, the quality of food available may be declining and maintaining the high rate of production may be difficult.

Food shortages affect about 800 million billion people, but more than two billion people suffer from malnutrition. Although in some cases, nutrient deficiencies are simply characteristic of stable agroecosystems, land degradation aggravates the harmful effects that some factors in agroecosystems have on human nutrition. For example, iron deficiency alone affects 40 to 50% of women worldwide. Two hundred and fifty million children suffer from severe or moderate Vitamin A deficiency with up to 500 thousand preschoolers becoming blind annually. Other widespread deficiencies include zinc and iodine. There is growing evidence that even in developed countries, deficiencies in fibre, folic acid, etc., threaten human health.

Apart from nutrition, naturally occurring heavy metals, vector-borne and non-vector-borne diseases, naturally occurring toxins, agricultural chemicals as well as imports and exports associated with a cash economy, contribute to the health risks faced by people within the context of their agroecosystem.

Land degradation can adversely affect human health by changing the ecology of pathogenic and harmful organisms. One consequence of soil degradation is reduced water holding capacity and greater likelihood of drought-stressed crops. Peanuts subjected to drought develop high concentrations of pre-harvest aflatoxin. Aflatoxin is believed by many to cause acute liver damage and cancer. Although this connection has not been conclusively demonstrated in humans, the fear of its carcinogenic effect motivates a number of governments to regulate trade in potentially-contaminated food crops.

Not only do the condition and management of agroecosystems affect the health of people that depend on it for sustenance, human health also directly influences the ability of people to manage the system itself. For example, Tuberculosis causes major labor shortages and the diversion of family income to cover increased health care costs. Thereby, they contribute significantly to a decline in soil fertility, an increase in agricultural pests and diseases, changes and delays in cropping practices, a decline in the variety of crops grown, and a decline in the people's access to and ability to purchase external farm inputs. HIV/AIDS apparently discourages farmers from making long term investments in soil conservation measures that do not provide immediate income and that carry a significant labor cost.

For pastoralists, a reduction in herd size and a shift towards less labour demanding animals such as pigs and poultry are common. The sale of animals may be required to cover increased health care costs. HIV/AIDS also contributed to a 20 to 50% loss of

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working time for extension services in Uganda and a loss of agricultural skills at both professional and farm levels. Beyond HIV/AIDS, other aspects of poor health make effective management of agroecosystems more difficult.

Concept on human well being

The WHO definition of health introduces the concept of well being. Well being of an individual or group of individuals has objectives and subjective components. The objective components relate to such concerns as generally known by the term "Standard of Living" or "Level of Living". The Subjective component (feelings, experience) of well being (as expressed by each individual) is referred to as Quality of Life.

Standard of Living:

The term Standard of Living refers to the usual scale of our expenditure, the goods we consume and the services we enjoy. It includes the level of education, employment status, food, dress and comforts of modern living.

WHO definition: Income and Occupation, standards of Housing, sanitation and nutrition, the level of provision of health. Educational recreational and other services may all be used individually as measures of socio-economic status and are collectively as an index of the Standard of Living.

There are vast inequalities in the standard of living of the people in different countries of the world. The extents of these differences are usually measured through the comparison of per capita GNP on which the standard of living primarily depends.

(2) Level of Standards:

It consists of 9 components

- (1) Health
- (2) Food consumption
- (3) Education
- (4) Occupation and working condition
- (5) Housing
- (6) Social security
- (7) Clothing
- (8) Recreation
- (9) Leisure and Human Rights

It is considered that health is the most important component of the level of living because its impairment always means impairment of the level of living.

(3) Quality of Life:

It is defined as a composite measure of physical, mental, and social well being as perceived by each individual or by groups of individuals that is to say, happiness, satisfaction, and gratification as it is experienced in such life concerns as health, marriage, family work, financial situation, educational opportunities, self esteem, creativity,

belongings and trust in others. The Quality of Life can be evaluated by assessing a person's subjective feelings of happiness or unhappiness about the various life concerns. It is conceded that a rise in the Standard of Living of the people is not enough to achieve satisfaction or happiness.

Ecosystem services are indispensable to the well-being of people throughout the world. The benefits obtained from ecosystems include: food; natural fibres; a steady supply of clean water; regulation of some pests and diseases; medicinal substances; recreation; and protection from natural hazards such as storms and floods. The state of the environment and ecosystems are modified by patterns of demographic growth, development and consumption, all of which may reduce or increase the supply of ecosystem services.

The well-being of present and future generations depends on the continuous flow of ecosystem services, which are the benefits people obtain from ecosystems.

Links between human well-being and ecosystem services are multiple and complex. Improvements in the well-being of present generations can have negative impacts on the supply of ecosystem services to future generations if those improvements are based on unsustainable exploitation of the environment. In recent years, the study of the relationship between ecosystem services and human well-being has received a fair amount of attention.

Concept of Environmental health:

Environmental health is the branch of public health that is concerned with all aspects of the natural and built environment that may affect human health. Environmental health covers the assessment, correction, control, prevention of environmental factors that can adversely affect health as well as enhancement of those aspects of the environment that can improve human health. Environmental health is focussing on protection from disease through the provision of clean water, waste disposal, safe food, clean air, safe living and working conditions etc.

Environmental health is defined by the World Health Organisation as:

Those aspects of human health and disease that are determined by factors in the environment. It also refers to the theory and practice of assessing and controlling factors in the environment that can potentially affect health.

Environmental health comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling and preventing those factors in the environment that can potentially affect adversely the health of present and future generations.

Environmental health concerns/Scope/Application:

Environmental health addresses all human-health-related aspects of both the natural environment and the built environment. Environmental health concerns include:

- Air quality, including both ambient outdoor air and indoor air quality, which also comprises concerns about environmental tobacco smoke.
- Climate change and its effects on health.
- Disaster preparedness and response.
- Food safety, including in agriculture, transportation, food processing, wholesale and retail distribution and sale.
- Hazardous materials management, including hazardous waste management, contaminated site remediation, the prevention of leaks from underground storage tanks and the prevention of hazardous materials releases to the environment and responses to emergency situations resulting from such releases.
- Housing, including substandard housing abatement
- Childhood lead poisoning prevention.
- Land use planning,
- Liquid waste disposal, including city wastewater treatment plants and on-site waste water disposal systems, such as septic tank systems.
- Medical waste management and disposal.
- Noise pollution control.
- Occupational health and industrial hygiene.
- Radiological health, including exposure to ionizing radiation from X-rays or radioactive isotopes.
- Recreational water illness prevention, including from swimming pools, and ocean and freshwater bathing places.
- Safe drinking water.
- Solid waste management, including landfills, recycling facilities, composting and solid waste transfer stations.
- Toxic chemical exposure whether in consumer products, housing, workplaces, air, water or soil.
- Vector control, including the control of mosquitoes, rodents, flies, cockroaches and other animals that may transmit pathogens.

Unit 3: Air pollution

Air is never found absolutely clean in nature. Air may be regarded as polluted when it is changed in its quality. The imbalance in quality of air cause adverse effects on the living component of ecosystem. Air pollution is defined as an addition of harmful substances to the atmosphere resulting in damage to the environment, human health, and quality of life. It also signifies the presence in the ambient atmosphere of substances i.e. (gases, particulate matter) generated by the activities of man in concentration that interfere with human health, safety or comfort or injurious to vegetation and animals and other environmental media.

Air pollutants:

Classification of Air pollutants:

The air pollutants may be classified in different ways as follows:

(a) According to origin:

(i) Primary pollutants: Those pollutants which are directly emitted from source into the atmosphere such as Carbon monoxide (CO), Nitrogen dioxide (NO₂), Sulphur dioxide (SO₂) and Hydrocarbons (e.g. Methane) etc.

(ii) Secondary pollutants: Those pollutants which are derived from the primary pollutants due to chemical or photochemical reactions in the atmosphere.

Examples: Ozone, Peroxy-acyl Nitrate (PAN) etc.



Where, M is a third molecule involved in absorption of the excess energy.

(b) According to Chemical composition:

(i) Organic pollutants (e.g. Hydrocarbon and aldehyde)

(ii) Inorganic pollutants:

Carbon compounds (e.g. CO, carbonates)

Nitrogen compounds (e.g. NO_x, and NH₃)

Sulphur compounds (e.g. H₂S, SO₂, SO₃ and H₂SO₄)

(C) According to State of matter:

(i) Gaseous pollutants e.g. CO, NO_x, SO₂

(ii) Particulate pollutants -comprise of finely divided solids or liquids e.g. smoke, fumes, smog and sprays.

Sources and Types of Air pollution:

Pollution of air started from very moment when the primitive man knew to make fire, since then it has increased and still increasing every moment.

Major sources of air pollution:

(A) Natural sources:

The natural sources of air pollution are volcanic eruptions releasing poisonous gases (such as chlorine, carbon monoxide, sulphur dioxide, hydrogen sulphide etc), forest fire, decomposition of organic matter in different ecosystem, deflation of sands and dust, pollen grains of flowers, fungal spores, soil dust etc.

(B) Anthropogenic source:

(1) Emission from vehicles:

The automobile exhausts are responsible for more than 75% of the total air pollution. The automobiles release huge amounts of poisonous gases such as carbon-monoxide (about 77%), nitrogen oxides (about 8%) and hydrocarbons (about 14%) and lead compounds. Lead is added to petrol to increase octane number and to improve engine performance. The problem of vehicular air pollution is very complex because it is caused by number of factors, including poor fuel quality, lack of traffic planning, poor maintenance of vehicles and roads etc.

(2) Industrial source:

Due to expanding industrialization and industrial operations, a huge amount of air pollutants are released into the atmosphere. A large number of industries such as chemical industries, paper and pulp mills, cotton mills, metallurgical plants and smelters, petroleum refineries, mining and synthetic rubber industries are responsible for about 20% of air pollution. The industries need fossil fuels such as coal, petroleum products and natural gas for energy which is used to run machines and for many other purposes. The burning of such fuels produce carbon-dioxide, carbon-monoxide, sulphur dioxide etc. In addition, the smoke coming out from the chimney also contains small particles of dust, carbon particles, metals and other solid particles that depend upon the types of industry and fuel they used.

(3) Agricultural Source:

Different types of agrochemicals are used in agriculture in order to produce large quantity of food and non-food products. These agrochemicals include different types of chemical fertilizer, insecticides, herbicides, fungicides which pollute air pollution. Besides that pollen grains from different crop plants, soil dust during intense wind blown also help to increase pollution in the atmosphere.

(4) Other sources:

Refuse burning, Land filling, Incineration, Forest fire by human activity etc

Types of Air Pollution:

- (1) Outdoor Air pollution
- (2) Indoor Air Pollution
- (3) Transboundary Air pollution

(1) Outdoor Air pollution:

Most outdoor air pollutants in urban areas enter the atmosphere from burning of fossil fuels in power plant and factories and motor vehicles.

(2) Indoor Air pollution:

There are many sources of indoor air pollution in any home. These include combustion sources such as oil, gas, kerosene, coal, wood, and tobacco products; building materials and furnishings as diverse as deteriorated, asbestos-containing insulation, carpet, and furniture made of certain wood products; products for household cleaning and maintenance, personal care, and outdoor sources such as radon, pesticides, and outdoor air pollution.

Sources of Indoor Air Pollutants:

Pollutants	Sources
Respirable particles	Tobacco smoke, stove
Carbon-monoxide	Combustion equipment, stove
Sulphur dioxide	Coal combustion
Carbon-dioxide	Combustion, Respiration
Formaldehyde	Carpet adhesives
Other organic vapors (benzene, toluene etc)	Solvents, adhesives, resin products
Radon	Building materials
Asbestos	Insulation, fireproofing
Mineral fibres	Appliances

The use of biomass fuels such as wood, dung, agricultural waste, and charcoal as cooking and heating fuel is the principle cause of indoor air pollution in the rural areas. Poverty is one of the main barriers to the adoption of cleaner fuels, and the slow pace of development implies that biofuels will continue to be used by the poor. Limited ventilation increases exposure in poor households, particularly for women and young children as they spend long periods of time indoors.

(3) Transboundary Air pollution:

It refers to cross-boundary pollutants generated in one country and felt in other. Such pollution can survive for days or even years and can be transported hundreds or thousands of miles before affecting soil, rivers, lakes, and food at the distant site. Transboundary air pollutants cause a number of different problems e.g formation of ground level ozone that is hazardous to health, formation of acid rain. The main source of this pollution are emission of SO₂, NO_x, Volatile organic compounds and volatile toxic metals such as heavy metals and persistent organic pollutants from transport and energy

usage. The main effects are acidification of water and soil, and smog caused by tropospheric ozone.

Types and Sources of Air Pollutants:

(1) Carbon-monoxide (CO):

It is one of the most serious air pollutants which is mainly released by automobile exhaust. Other sources include combustion processes like open fire, stove, coal mines, cigarette smoke etc. Natural sources of CO are various plants and animals. Actually carbon-monoxide is formed due to incomplete combustion of fossil fuels and other form of organic matter. It accounts for about 52% of the total air pollution. The annual emission on a global scale is 350 million tones (human source 275 and natural 75 million tones), of which the USA alone releases more than 100 million tones of CO into the atmosphere. In atmosphere, carbon monoxide can be oxidized to carbon dioxide. Green plants, soil and oceans are the natural sinks of carbon monoxide. The research shows that temperate forests including the forest soil are capable of removing this gas in efficient way.

(2) Oxides of Nitrogen (NO_x):

Nitrous oxide, Nitric oxide and Nitrogen dioxide (denoted by NO_x) are the three oxides form of nitrogen which are important major air pollutants of the atmosphere. Oxides of nitrogen may be formed either by natural or artificial fixation of nitrogen from the atmosphere or from nitrogen compounds present in the organic matter. Most of these gaseous pollutants are also introduced by burning of fossil fuels, and fertilizer applied in agricultural lands. When the fuels are burnt in air, some of the nitrogen in the air is oxidized to Nitric oxide. Nitrogen dioxide is the responsible gas for the formation of photochemical smog in the air by the process of photochemical reaction with the help of hydrocarbons.

(3) Oxide of Sulphur (SO_x):

Combustion of any sulphur bearing materials produces sulphur-dioxide accompanied by a small quantity of Sulphur trioxide. This mixture is usually denoted as SO_x. Nearly 67% of the global SO_x pollution is due to volcanic activity and other natural sources. The remaining 33% is because of human activities such as combustion of fuels, coal-fired power stations, transportation, refineries, metallurgical operations such as smelting of sulphide ores and chemical plants ie, manufacture of sulphuric acid. Most of the man-made SO_x pollution is concentrated in urban and industrial areas. Oxidation of sulphur dioxide can take place in presence of catalysts such as NO_x. Metal oxides, soot, dust. Under normal humid conditions of the atmosphere, sulphur tri-oxide reacts with water vapor to produce droplets of sulphuric acid aerosol which give rise to the so called acid rain.

(4) Hydrocarbons:

Anaerobic biological decomposition of organic matter, natural gas emission, automobile exhausts, burning of coal, oil, wood and refuse etc are the some sources of hydrocarbons

in the atmosphere. Methane is the major hydrocarbon emitted into the atmosphere. About twenty other hydrocarbons have been identified in ambient atmosphere in areas of heavy vehicular traffic which includes ethane, n-butane, n-pentane, isopentane, isobutene, m-xylene, propane, ethylene, acetylene, toluene etc. Hydrocarbons do not react readily with sunlight, but they are reactive toward other chemical species produced photochemically.

(5) Particulates:

Small solid particles and liquid droplets are collectively termed as particulates. Most of particulates in the environment is contributed by dust particles from various sources, fibrous material of plant and animal origin, fly ash derived from combustion of coal, and organic matter. Particulates range in size from a diameter of 0.0002μ to a diameter of 500μ with life times varying from a few seconds to several months. This life time, however, depends upon the size and density of the particles and turbulence of air. Particles smaller than 10μ in size usually remain suspended in the air for long duration.

On the global scale, the pollutants which account for almost 98% of the total pollution are:

Carbon-monoxide:	52%
Sulphur dioxide:	18%
Hydrocarbons:	12%
Particulates:	10%
Oxides of Nitrogen:	6%
Total	98%

These percentages may vary depending upon the locality.

Effects of air pollution on Human Health:

An average human being breathes about 22,000 times a day and inhales about 16 kg of oxygen. The pollution of air therefore, may have a profound influence on living organisms. Air pollution is a major environmental risk to health and is estimated to cause approximately 2 million premature deaths worldwide per year. In developing countries, exposure to pollutants from indoor combustion of solid fuels on open fires or traditional stoves increases the risk of acute lower respiratory infections and associated mortality among young children. Indoor air pollution from solid fuel use is also a major risk factor for chronic obstructive pulmonary disease (COPD) and lung cancer among adults. The effects of Particulate Matter on health occur at levels of exposure currently being experienced by most urban and rural populations in both developed and developing countries. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as of lung cancer. In EU, average life expectancy is 8.6 months lower due to exposure to PM_{2.5} produced by human activities.

Pollutants	Typical effects
Carbon monoxide (CO)	<p>Toxicity, Blood Poisoning, CNS impairment (CO combines with haemoglobin forming carboxyhaemoglobin which is useless for respiratory purposes and hence leads to death.)</p> <p>Under normal condition: $O_2 + Hb \longrightarrow O_2Hb$ (oxyhaemoglobin) In presence of CO: $O_2Hb + CO \longrightarrow COHb + O_2$ (Carboxyhaemoglobin)</p> <p>Immediate response-loss of judgment Further exposure to higher levels-metabolic disorders such as asphyxiation (unable to breath) and cause death.</p>
Sulphur dioxide (SO ₂)	<p>Increased breathing rate and feeling of air starvation, suffocation, aggravation of asthma and chronic bronchitis, irritation of throat and eyes.</p>
Oxides of Nitrogen (NO _x)	<p>Headache, impairment of lung, loss of appetite, bronchitis, pulmonary emphysema etc</p>
Carbon-dioxide(CO ₂)	<p>Toxic in large quantities, Hypoxia (condition in which not enough oxygen reaches the body tissue).</p>
Hydrocarbons	<p>Some hydrocarbons have Carcinogen effects, Lachrymatory effect</p>
Ozone (O ₃)	<p>Irritation of lungs, eyes and respiratory tract</p>
Arsenic (As) (Fungicides, Herbicides as source)	<p>Inhalation, Ingestion or absorption through skin can cause bronchitis, nasal irritation or dermatitis.</p>
Lead (Automobile emission, lead arsenate pesticides)	<p>Liver and kidney damage, abnormalities in fertility and pregnancy, mental retardation in children etc.</p>

Dusts	Respiratory diseases, toxicity from metallic dusts, silicosis, anthracosis etc
Ammonia (NH ₃) Chemical industry, incineration	Damage to respiratory tracts and eyes, corrosive to mucous membranes
Formaldehyde (HCHO) e.g. Incineration, combustion of fuels	Irritation of eyes, skin and respiratory tract

Effects of Air pollution on Plants:

(1) Sulphur-dioxide (SO₂):

Plants are affected at lower concentrations of SO₂ than human beings. SO₂ enters plant mainly through stomatal apertures (more than 95% of the gaseous pollutants). The sensitive species such as Wheat, Barley and Cotton are adversely affected if exposed to more than 100 µg SO₂/m³ of the air. Necrosis and loss of yield are the main damages caused by SO₂. A widely accepted view is that SO₂ after entering to leaf gets oxidized to SO₃, which in turn combines with water to form sulphuric acid. The acid interferes in metabolic process leading to reduction in productivity.

(2) Nitrogen Oxides (NO_x):

Higher concentrations of NO₂ damage the leaves of plants, retard the photosynthetic activity and cause chlorosis. Vehicular exhaust consisting of about 10 ppm of NO₂ checks metabolic activities in plant tissues.

(3) Particulate pollutant:

Particulates such as dust, soot deposited on plant leaves block the stomata of plants, thus inhibiting the rate of transpiration. Deposited particulate pollutants restrict the absorption of CO₂, thereby reducing the rate of photosynthesis. It thus retards the growth of plants and crop production. Dust mixed light rain, forms a thick crust on the upper leaf surfaces which shields the bright sunlight necessary for carbon assimilation.

(4) Ozone:

Ozone flecking is observed in citrus and tobacco plants. At 0.02 ppm it damages pea, tomato and other plants. Ozone retards the growth of plants thereby affecting the food production. At 0.08 ppm it decreases floral development and pollen germination in certain plants. Vegetation damage may be in the form of Chlorosis and leaf abscission.

(5) Carbon-monoxide (CO):

At higher level (100-1000 ppm) carbon-monoxide affects the plant, the visible effects being leaf curling, reduced size, leaf drop, premature aging.

Effects of Air pollution on Farm Animals:

Arsenic, Lead and fluorides are the main pollutants which cause damage to livestock. These air borne contaminants accumulate in vegetation and forage and poison the animals when they eat the contaminated vegetation.

Arsenic:

Livestock suffer arsenic poisoning (from insecticides used by farmers, and industrial operations) with symptoms like salivation, thirst, liver damage and affect in Central Nervous system.

Lead:

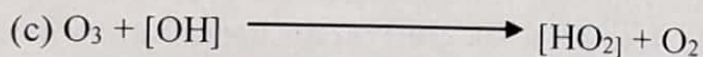
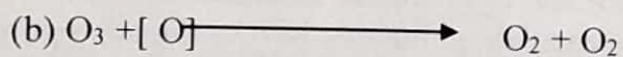
Lead poisoning (from use of lead arsenate sprays and automobile exhausts) occurs in horses and other animals with symptoms such as foaming at the mouth, and breathing troubles, damage in the nervous system etc.

Effects of Air pollution on Ozone layer:

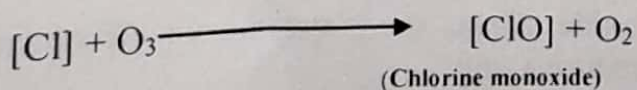
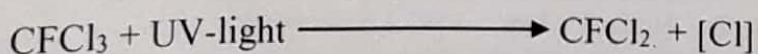
Ozone is present at all altitudes in the atmosphere, but found mainly in the stratosphere. The presence of ozone layer in the stratosphere is of vital significance for all living organisms, because the harmful ultra violet rays of solar radiation are not allowed to enter the earth's atmosphere by ozone layer.

Ozone is destroyed by chlorine, released to volcanic activity and also by reaction with

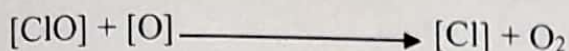
- Nitric oxide
- Atomic oxygen and
- Reactive hydroxyl radical, which are also present in the atmosphere, by following reaction.



Ozone, in the Stratosphere, is mainly found to be destroyed by man-made Chlorofluorocarbon (CFCs). The CFC molecules, escaping into the atmosphere, decompose to release chlorine in the ozone layer (by photo-dissociation) and each atom of chlorine, thus liberated, is capable of attacking several ozone molecules.



This reaction is followed by



which generates Chlorine atoms, so that a long chain process is involved, which conserves Chlorine atoms. Consequently, each chlorine atom can destroy as many as 100,000 ozone molecules before it is returned to the troposphere. (Chlorine acts as a catalyst and is unchanged in the process).

Effects of Air pollution on Global climate:

Human activities are changing the composition as well as behavior of the atmosphere at an unprecedented rate. The pollutants from a wide range of human activities are increasing the global atmospheric concentration of certain heat trapping gases, which act like a blanket, trapping heat close to the surface that would otherwise escape through the atmosphere to the outer space. This process is known as green house effect. The gases such as carbon dioxide, methane, nitrous oxide, CFCs, ozone etc present in the atmosphere are capable of absorbing radiation and radiated energy back to the earth. Thus more heat is generated and the temperature of the earth is increased. This process is known as global warming.

The Intergovernmental Panel on Climate Change (IPCC) estimates it has warmed 1.2 to 1.4°F (0.7 to 0.8°C) over the past century and projects a further 3 to 7°F (2 to 4°C) over the 21st century. The increases may appear minor compared to short-term weather changes from night to day and winter to summer. In global climate terms, however, warming at this rate would be much larger and faster than any of the climate changes over at least the past 10,000 years.

The Intergovernmental Panel on Climate Change (IPCC) also suggests that temperature increases above the range of 3.5 to 5.5°F (2 to 3°C) over the next 100 years would dramatically increase the negative impacts of climate change. Most scientists think that a warming climate will alter the frequency and severity of extreme temperature events. In general, they expect increases in heat waves and decreases in cold spells. These effects will vary from place to place. According to the IPCC, an increase in the average global temperature is very likely to lead to changes in precipitation and atmospheric moisture because of changes in atmospheric circulation and increases in evaporation and water vapor.

Control and preventive Measures of Air pollution:

- Setting and implementation of pollution standards for vehicles and industries
- Using emission control equipment in vehicles and industries
- Using electric vehicles
- Using electricity instead of Coal and other petroleum products in industries
- Using solar energy and biogas instead fuel woods
- Levying high tax on high polluting industries and vehicles
- Regular maintenance of roads

- Constructing tall chimney
- Planting trees to absorb green house gas such as carbon-dioxide
- Using ventilation system to reduce indoor air pollution
- Using improved cooking stoves (ICS) instead of simple traditional one
- Disposal of solid waste by appropriate technology

WHO recommendation on Air pollution control:

(1) Containment: i.e. prevention of escape of toxic substances into the ambient air. Containment can be achieved by a variety of engineering methods such as enclosures, catalytic converter etc

(2) Replacement: i.e. replacing a technological process causing air pollution by a new process that does not. Examples: Increased use of electricity, natural gas for cooking, transportation instead of coal and diesel.

(3) Dilution: some air pollutants are removed by vegetation so establishment of green belts (buffer zone) between industrial and residential areas is necessary. The capacity of dilution is however, limited.

(4) Legislation: Air pollution is controlled in many countries by suitable legislation. Legislation must cover such matter such as creating smokeless zone, enforcement of standards for ambient air quality, height of chimney.

(5) International Action: Monitoring and study of air pollution in worldwide scale warning of air pollution.

Steps taken to improve Kathmandu's air quality

Year	Action
Government	
1991	Ban on import of new three-wheelers
1995	Introduction of in-use vehicle emission standards and emission testing of vehicles
1996	Financial incentives for electric vehicles
1997	Environment Protection Act and Regulations
1999	Import of unleaded fuel
1999	Removal of over 600 diesel three-wheelers from Kathmandu
1999	Ban on the import of new two-stroke three wheelers
2000	Introduction of EURO I equivalent norms for new vehicles
2002	Establishment of six permanent monitoring stations in Kathmandu
2003	Introduction of National Ambient Air Quality Standards
2004	Two-stroke three wheelers removed from Kathmandu
2004	Moving Chimney Bull Trench Brick Kilns banned from Kathmandu
Private Sector	
Since 1996	Electric vehicle entrepreneurs have invested more than Rs. 450

	million in building and operating more than 600 electric three wheelers.
2006	Hulas Motors has developed an electric four-wheeler van
Municipalities	Public awareness and infrastructural development
NGOs	Air quality monitoring and research Public awareness and advocacy campaigns Development of an electro-bus
International Organization	
2000-05	DANIDA (Danish International Development Assistance) assisted ESPS project set up air quality monitoring stations, promoted electric vehicles.
2002-06	Winrock International, together with other partners of KEVA (Kathmandu Electric Vehicle Alliance), promoted electric vehicles through technical support and advocacy.
Since 2003	Swiss Development Cooperation (SDC) is promoting Vertical Shaft Brick Kilns.

National policies related to Air quality management

- National Conservation Strategy, 1987
- Industrial Policy, 1992
- Nepal Environmental Policy and Action Plan (NEPAP), 1993
- National Transport Policy, 2001
- 10th Five Year Plan 2002-07
- Sustainable Development Agenda for Nepal, 2003
- Interim Constitution 2007

Legislation related to air quality management:

- (1) Industrial Enterprise Act, 1992
- (2) Vehicle and Transport Management Act, 1993
- (3) Environmental Protection Rules, 1997
- (4) Environment Protection Act, 1996
- (5) Fiscal Act, 2003/2004
 - Incentives to electrical vehicles
 - Nepal Vehicle Mass Emission Standard 2056 made compulsory for all imported vehicles.
 - Ban on import of secondhand and reconditioned vehicles and two-stroke engine vehicles

Unit 4: Water and water pollution

Water in pure form is not found under natural conditions in streams, rivers, lakes, groundwater or oceans. It always has something dissolved or suspended in it. In general water is considered to be polluted when it contains enough foreign materials to render it unfit for a specific beneficial use such as drinking, washing, recreation, industrial use or aquaculture. For drinking purpose the water should be safe and wholesome.

Safe and Wholesome water:

It has been defined as water that is

- (1) Free from pathogenic agents
- (2) Free from harmful chemical substances
- (3) Pleasant to the taste
- (4) Usable for domestic purposes

Water is said to be polluted or contaminated when it does not fulfill the above criteria.

Water Quality Standards/Parameters:

- (I) Physical Aspects
- (II) Chemical Aspects
- (III) Microbiological Aspects

(I) Physical Aspects:

The consumer judges the water quality by its physical characteristics. The provision of drinking water that is not only safe but also pleasing in appearance, taste and odour is a matter of high priority. The acceptability of drinking water can be influenced by many different constituents. These are:

(1) Turbidity:

Turbidity in drinking water is caused by particulate matter (clay, silt, organic matter) that may be present as a consequence of inadequate treatment in plant. It is a measure of the cloudiness of water- the cloudier the water, the greater the turbidity. Turbidity interferes with disinfection and microbiological determination. Water with turbidity of less than 5 NTU (Nephelometric Turbidity Unit) is usually acceptable to consumer.

(2) Colour:

Colour in drinking water may be due to the presence of coloured organic matter (primarily humic substance), metals such as iron, manganese or highly coloured industrial wastes (carpet dyeing industry). Decomposition of organic matter results into

the formation of humic acid which dissolves and gives a dirty yellow color. The guideline value is upto 15 True Color Unit (TCU)

(3) Taste and Odour:

Taste in water is due to presence of inorganic salts such as Sodium chloride, Magnesium sulphate, Magnesium chloride etc. Odour is due to decaying of organic matter under anaerobic conditions and because of accumulation of certain odorous gases like ammonia and hydrogen sulphide. Taste and odour may be by-product of water treatment (i.e. Chlorination). No health based guideline value is proposed for taste and odour.

(4) Temperature:

Cool water is generally more palatable. Low water temperature tends to decrease the efficiency of treatment process including disinfection and may have deleterious effect on drinking water quality. However, high water temperature enhances the growth of microorganism, taste and odour etc. No guideline value is recommended for temperature.

We cannot judge the quality of drinking water by physical characteristics alone. Detailed chemical and microbiological examinations are also needed for complete assessment.

(II) Chemical Aspects/Parameters:

(1) Chlorides:

Chloride occurs normally in all types of water. It is generally present at low concentration in natural surface water. Levels in unpolluted water are often less than 10 mg/l. It is generally present in the form of NaCl, KCl, and CaCl₂. The guideline value for chloride is 250 mg/l.

(2) Hardness:

It is property of water that prevents the lather formation with soap. Principal cations imparting hardness are calcium and Magnesium. Other cations are Iron, Strontium, and Manganese etc. Principal anions are bicarbonate, carbonate, sulphate, chloride etc.

Water with a hardness of approximately 200 mg/l may cause scale deposition in the distribution system and will result in excessive soap consumption. On heating, hard water forms deposit of calcium carbonate scale.

Classification of Hard water:

	Classification	Level of Hardness
(a)	Soft water	< 50 mg/l
(b)	Moderately hard	50-150 mg/l
(c)	Hard water	150-300 mg/l
(d)	Very hard water	>300 mg/l

Drinking water should be moderately hard.

WHO, Calcium = 75 mg/l (desirable) 200 mg/l (Maximum permissible level)
Magnesium = 30 mg/l (desirable) 150 mg/l (Maximum permissible level)

(3) Ammonia:

The term ammonia includes the non-ionized (NH_3) and Ionized (NH_4^+). Ammonia in water originates from decomposition of organic matter, agricultural activities etc. Ammonia in water is an indicator of possible bacterial, sewage and animal waste pollution. WHO guideline value for ammonia 1.5 mg/l

(4) pH:

Measure of the intensity of acidity or alkalinity and measures the hydrogen ions in the water. Most natural water is generally alkaline due to presence of sufficient quantities of carbonates. pH has no direct adverse effect on health. Higher value of pH hasten the scale formation in water heating apparatus. High value also reduces germicidal effect/potential of chlorine ($\text{pH} > 8$). pH below 6.5 starts corrosion in pipes, thereby releasing toxic metals such as Zn, Pb, Cd, and Cu etc.

WHO standard for pH is 6.5-8.5

(5) Iron:

Iron in water is found in two states: Ferrous and Ferric. Anaerobic ground water may contain ferrous iron at concentrations upto several mg/l without discoloration or turbidity in water when directly pumped from well. On the exposure to the atmosphere, ferrous iron oxidizes to ferric iron, gives objectionable reddish brown colour to the water. Above 0.3 mg/l Iron stains laundry. WHO standards, Permissible limit is 0.3 mg/l

(6) Total Dissolved Solids (TDS):

TDS in water is mainly due to inorganic salts e.g. chlorides, carbonates, bicarbonates, nitrates, phosphates and sulphate of calcium. Magnesium, Sodium, Potassium and Iron etc. TDS has an important effect on taste of drinking water. The palatability of water with TDS level of less than 600 mg/l is generally considered as Good. Drinking water becomes increasingly unpalatable if greater than 1200 mg/l. Extremely low concentration of TDS gives insipid taste. WHO standard, Permissible limit is 500 mg/l.

(7) Hydrogen Sulphide:

It is found in higher concentration where organic matter is high. The rotten eggs odor of H_2S is particularly noticeable in some ground water and in stagnant drinking water as a result of oxygen depletion and the subsequent reduction of sulphate by bacterial action. Sulphide is oxidized rapidly to sulphate in well aerated water and H_2S level in oxygenated water supplies are normally very low. WHO standard: Not detectable by consumers.

(8) Sodium:

Sodium is present in a number of minerals, the principal one is being rock salt (sodium chloride)

Sea water contains relatively high levels of sodium i.e. 10 gm of sodium per litre. Artificial sources in water are: De-icing roads, sewage effluents, Water treatment chemicals such as sodium fluoride, sodium hydroxide, sodium carbonate, sodium bicarbonate and sodium hypochlorite etc WHO standard for sodium is 200 mg/l

(9) Zinc:

Zinc imparts an undesirable astringent taste to water. Drinking water seldom contains zinc at concentration above 0.1 mg/l. Zinc concentrations in tap water generally vary between 0.01 and 1 mg/l. However the concentration of zinc in tap water can be considerably higher in surface water owing to the leaching of zinc from pipes, zinc containing fittings.

(10) Manganese:

Manganese concentrations below 0.1 mg/l are usually acceptable to consumers. At concentration exceeding 0.15 mg/l, manganese imparts an undesirable taste to beverages and strains on clothes. WHO standard for manganese is 0.1 mg/l.

(11) Copper:

The presence of copper in water supply, although not constituting a hazard, may interfere with the intended domestic uses of water. Staining of laundry and sanitary ware occurs at copper concentrations above 1 mg/l. WHO guideline for Copper is 1.0 mg/l

(12) Arsenic:

Arsenic is introduced in water through the dissolution of minerals, from industrial effluents, pesticides etc. Concentrations in ground water in some areas are sometimes elevated as a result of erosion from natural sources. Guideline value for Arsenic is 0.01 mg/l

(13) Chromium:

Drinking water normally contains very low concentration of chromium (i.e. 5µg/l or less). Guideline value is 0.05mg/l.

(14) Fluoride:

Levels in raw water are normally below 1.5 mg/l but ground water may contain about 10 mg/l in areas rich in fluoride containing minerals. Fluoride is sometimes added to drinking water to prevent dental caries. The guideline value suggested is 1.5 mg/l

(15) Lead:

Lead is present in tap water to some extent as a result of its dissolution from natural sources, but primarily from household plumbing system containing lead in pipes, fittings etc. The amount of lead dissolved from the plumbing system depends on

several factors including pH, temperature, water hardness, and standing time of water. The health based guideline of lead is 0.01 mg/l

(16) Mercury:

It is present in inorganic form in surface and ground water at concentrations usually less than 0.5µg/l. The kidney is the main organ for inorganic mercury, where as methyl mercury affect mainly the central nervous system. The guideline value for total Mercury is 0.001 mg/l

(17) Dissolved Oxygen (DO):

DO is a measure of the concentration of dissolved oxygen present in a body of water. DO is an important measure of water quality and the ability of surface waters to support a well-balanced aquatic ecosystem. The dissolved oxygen content of water is influenced by water temperature and chemical or biological processes taking place in the distribution system. Depletion of DO in water supplies can encourage microbial reduction of nitrate to nitrite and sulphate to sulphide, giving rise to odour problem. It can also cause an increase in the concentration of ferrous iron in solution. No health based guideline value has been recommended.

(18) Nitrate and Nitrite:

They are naturally occurring ions. Naturally occurring nitrate level in surface and ground water are generally few milligrams per liter. In many ground waters, an increase of nitrate level has been observed owing to the intensification of farming practice. It has been observed that nitrate concentration above 45 mg/l cause methemoglobinemia in infants. (Nitrate in water get converted to nitrites in human intestine and nitrites combine with haemoglobin to form methaemoglobin and interferes with oxygen carrying capacity of the blood). WHO guidelinen for nitrate is 45 mg/l.

Substances and parameters in drinking water that may give rise to complaints from consumers

S.No.	Constituents or characteristics	Levels likely to give rise to consumer complaints	Reasons for consumer complaints
<u>Physical parameters</u>			
1	Colour	15 TCU	appearance
2	Taste and odour	-	Should be acceptable
3	Temperature	-	Should be acceptable
4	Turbidity	5 NTU	apperance
<u>Inorganic constituents</u>			
5	Aluminium	0.2 mg/l	Depositions, discolouration
6	Ammonia	1.5 mg/l	Odour and taste
7	Chloride	250 mg/l	Taste and corrosion
8	Copper	1 mg/l	Staining in laundry and sanitary ware

8	Hardness	-	Scale deposition, Soap consumption (high hardness), possible corrosion (low hardness),
9	Hydrogen sulphide	0.05 mg/l	Odour and taste
10	Iron	0.3 mg/l	Staining in laundry and sanitary ware
11	Manganese	0.1 mg/l	Staining in laundry and sanitary ware
12	Dissolved oxygen	-	Indirect effect
13	pH	-	Corrosion (low pH), taste, soapy feel (high pH)
14	Sodium	200 mg/l	Taste
15	Total dissolved solids	1000 mg/l	Taste
16	Zinc	3 mg/l	Appearance, taste

(III) Microbiological Aspects:

- (a) Bacteriological aspect
- (b) Virological aspects
- (c) Biological aspects

(a) **Bacteriological aspect:**

Natural and treated waters vary in microbiological quality. The drinking water should be free from bacteria indicative of pollution with excreta. Failure to provide adequate protection, effective treatment and disinfection of drinking water will expose the community to the risk of outbreaks of intestinal and other infectious diseases.

Indicators:

- (i) Coliform organisms
Coliform groups include both faecal (e.g. *E. coli*) and non-faecal organisms (*Klebsiella aerogens*)
- (ii) Faecal streptococci
- (iii) *Cl. perfringens*

(b) **Virological Aspects:**

It is recommended that, to be acceptable, drinking water should be free from any viruses infections for man. Disinfection with 0.5 mg/l of free chlorine residual after contact period of at least 30 minutes at a pH of 8.0 is sufficient to inactivate virus.

(c) **Biological Aspects:**

- (i) Protozoa:

Species of protozoa known to have been transmitted by the ingestion of contaminated drinking water include *Entamoeba histolytica*, *Giardia sp* etc. These organisms are can

be introduced in to water supply through human or in some instances animal faecal contamination. Drinking water should not contain any pathogenic intestinal protozoa.

(ii) Helminths:

The infective stages of many parasitic roundworms and flatworms can be transmitted to man through drinking water. A single mature larva or fertilized eggs can cause infection and such infective stages should be absent from drinking water.

(iii) Free living organisms:

Examples of free living organisms in water are Algae, Fungi. The most common problem is interference in the operation of water treatment process, colour, turbidity, taste and odour of finished water.

Sources of water Supply and availability in Nepal:

About 97% of the earth's water supply is in the ocean which is unfit for the human consumption and other uses, because of its high salt content. Of the remaining 3%, 2% is locked in the polar ice caps and only 1% is available as fresh water in rivers, lakes, streams, ground water which is suitable for human consumption.

There are three main sources of water supply

1. Rain
2. Surface water
 - a) River and Streams
 - b) Reservoir
 - c) Lakes and Ponds
3. Ground water
 - a) Shallow wells
 - b) Deep wells
 - c) Springs

Water is one of the most important natural resources of Nepal. The major sources of water are glaciers, rivers, rainfall, lakes and ground water. Of these, rivers are the largest source in terms of water volume. There are over 6,000 rivers in the country with an estimated total length of 45,000 Km (DHM 1998). The country has 660 lakes of more than 1 hectare. Big lakes are used for irrigation, hydropower generation, fishing and others. About 75% of the total annual rainfall (Average 1700 mm) falls during the summer monsoon season. Ground water remains an important source of water, particularly in the Terai region and Kathmandu valley.

Surface water is the major source of drinking water in Nepal (WECS 2004). The major rivers of Nepal are the Koshi, the Gandaki, the Karnali, and the Mahakali all of which originate in the Himalayas.

River basin	Catchment area Km ² , estimated		Average Discharge (m ³ /s)	Annual Discharge (billion m ³ /year)
	Total	Nepal		
1. Himalayan river				
Koshi	60,400	27,863	1,409	45
Gandaki	34,960	31,464	1,600	50
Karnali	43,679	41,058	1,397	44
Mahakali	15,260	5,188	573	18
2. Mahabharat rivers		17,000	461	14
3. Siwalik rivers		23,150	1,682	53
Total		145,723	7,122	224.5

Source: WECS (2004)

The Koshi is the largest river basin occupying a catchment area of 27,863 km² (46%) in Nepal with an average discharge 1,409 cubic meter per second at Chatara. Some 23% of Nepal's population live in this river basin. The Gandaki river basin in the central region includes about 90% of the river's total catchment area. The Karnali and the Mahakali river basins lie in the west

of Nepal. Some 22% of Nepal's population live in the Karnali basin. The Mahakali River acts as the border between Nepal and India. About 34% of its catchment area lies in Nepal. The Babai, Bagmati, Kamala, Kankai, and West Rapti are medium-sized rivers originating from the Mahabharat range. These rivers, like the Himalayan rivers, are perennial. The innumerable southern rivers originating from the Siwalik hill range are shallow and mostly dry up during the dry season. These rivers are used by the managed irrigation schemes of small-scale farmers for seasonal supplementary irrigation (source: Environmental Assessment of Nepal)

Type of Water Sources Used by Households

Nepal is a mountainous country with diverse physiographic regions, and thus different sources of drinking water are available for people in different areas. Tap water is the most important source, providing drinking water to almost 53% of all households. Tap water refers to water piped directly from a source as well as to centrally distributed and pretreated water. The second most important source is tube wells. These two sources are important in both urban and rural areas. The relative share of tap water in urban and rural areas is 65% and 51%, respectively, followed by tube wells with 23% and 29%.

Sources of water supply in Urban and Rural areas of Nepal			
Drinking Water Source	Total Households	% of Total U/R hh	% of Total M/H/T Households (hh)

	Number	%	Urban	Rural	Mountain	Hill	Terai
Tap water	2,209,760	52.9	65.4	50.6	72.2	72.2	30.8
Tube well	1,184,156	28.4	23.1	29.4	0.0	2.4	58.6
Well	377,241	9.0	5.9	9.6	6.2	12.0	6.5
Stone spout	267,180	6.4	3.3	7.0	17.1	10.1	1.1
River	61,400	1.5	0.5	1.7	3.4	2.0	0.6
Other	74,721	1.8	1.8	1.8	1.0	1.2	2.5
Households	4,174,457	100	664,505	3,509,952	285,217	1,950,345	1,938,895

hh = Households, M/H/T = Mountain, Hill, Terai, U/R hh = urban or rural households
 Source: CBS (2002)

While tap water is the dominant source in the Mountains and Hills, tube wells dominate in the Terai. All the sources of water listed in are used by some households in all three regions, except tube wells which are not available in the Mountains.

There is a 10 per cent increase in the demand for drinking water every year. There is demand of 320 MLD in Kathmandu Valley alone but KUKL is able to supply only 90 MLD in dry season and 145 MLD in wet season.

Water pollution:

Today water is the most exploited natural resources. Pollution of water bodies is increasing due to rapid population growth, industrial proliferations, increasing living standards and wide spheres of human activities.

Water pollution is any chemical, biological, or physical change in water quality that has a harmful effect on living organisms or makes water unsuitable for desired uses. Water pollution is mainly caused by Natural process and anthropogenic process.

Types and Sources of Water pollution:

(A) Surface water pollution (River, stream, lakes)

(B) Ground water pollution

(A) Surface water pollution:

Surface water comes in direct contact with the atmosphere, streams and surface drains. They are found on the exterior of the Earth's crust and include: Oceans, Rivers, and Lakes etc These waters can become polluted in a number of ways;

Sources: (1) Natural source and surface Runoff (2) Domestic sewage (3) Industrial waste (4) Agriculture runoff

(B) Ground water pollution:

Ground water acts as a reservoir by virtue of large pore space in earth materials, as a conduit which can transport water over long distances and as a mechanical filter which improves water quality by removing suspended solids and bacterial contamination. Today human activities are constantly adding domestic, industrial wastes at an alarming rate. Ground water contamination is generally irreversible i.e. once it is contaminated; it is difficult to restore the original quality of the aquifer. Excessive mineralization of ground water degrades water quality producing an objectionable taste, odor and excessive hardness.

Sources of Ground water pollution:

(1) Domestic sewage (2) Agriculture (3) Municipal landfills (4) Mining (5) Salt water intrusion

Types and sources of water pollutants

(1) Infectious Agent:

Examples: Bacteria, Viruses, Protozoa and Parasitic worms

Major Human Sources: Human and Animal Wastes

Harmful Effect: Diseases

Common Diseases transmitted to Human through Contaminated Drinking Water

Types of Organism	Diseases
Bacteria	Typhoid fever, Cholera Bacterial Dysentery, Enteritis
Viruses	Infectious hepatitis
Parasitic Protozoa	Amoebic Dysentery
Parasitic Worms	Schistosomiasis

(2) Oxygen Demanding Waste:

Examples: Organic waste such as animal manure and plant debris that can be decomposed by aerobic bacteria (oxygen requiring bacteria)

Major Human Sources: Sewage, animal feedlots, and food processing facilities etc

Harmful effects: Large population of bacteria decomposing these wastes can degrade water quality by depleting dissolved oxygen in water. This causes fish and other forms of oxygen consuming aquatic life to die.

(3) Inorganic Chemicals:

Examples: Water soluble i) acids, ii) compound of toxic metals such as lead, Arsenic, Selenium and iii) Salts such as Sodium chloride in ocean water etc.

Major Human Sources: Surface runoff, industrial effluents and household cleansers.

Harmful effect:

- i) make freshwater unsuitable for drinking or irrigation
- ii) cause skin cancer
- iii) damage the nervous system, liver and kidneys (Lead and Arsenic)
- iv) harm fish and other aquatic life
- v) lower crop yields
- vi) accelerate corrosion of metals exposed to such water

(4) Organic Chemicals:

Examples: Oil, gasoline, pesticides, detergents etc

Major Human Sources: Industrial effluents, household cleansers, surface runoff from yard and farms.

Harmful effect:

- i) threaten human health by causing nervous system damage (some pesticides), reproductive disorders, and some cancers
- ii) harm fish and wild life.

(5) Plant Nutrient:

Examples: Water soluble compound containing Nitrate (NO_3^-), Phosphate (PO_4^{3-}) and ammonium ions (NH_4^+).

Major Human Sources: Sewage, Manure, and runoff from agriculture.

Harmful effects:

- (i) Can cause excessive growth of algae and other aquatic plants which die, decay and deplete water of dissolved oxygen, and kill fish.
- (ii) Drinking water with excessive levels of nitrate lowers the oxygen carrying capacity of the blood and can kill unborn children and infants (Blue baby Syndrome)

(6) Sediment:

Examples: Soil, Silt

Major Human Sources: Land Erosion

Harmful effects:

- (i) cloud water and reduce photosynthesis

- (ii) disrupt aquatic food webs
- (iii) settle out and destroy feeding and spawning grounds of fish
- (iv) clog and fill lakes, artificial reservoir, stream.

(7) Radioactive materials:

Examples: Radioactive isotopes of radon, uranium, cesium and thorium

Major Human Sources: Nuclear power plants, Mining and processing of uranium and other ores, Nuclear weapons production, natural sources.

Harmful effects:

Genetic mutation, birth defects, and certain cancers.

(8) Heat (Thermal pollution):

Examples: Excessive heat

Major human sources: Water cooling of electric power plant, some types of industrial plants etc.

Harmful effects:

Lowers DO levels and makes aquatic organisms more vulnerable to disease, parasites, and toxic chemicals.

Point and Non-Point sources of water pollution:

Point Sources discharge pollutants at specific locations through pipes, ditches, or sewers into the bodies of surface water. ie. Point source comes from specific, localized and identifiable sources.

Examples include (1) Factories (2) Sewage treatment plant (which remove some but not all pollutants), (3) active and abandoned underground mines and (4) Oil tankers

Point sources are at specific places, they are fairly easy to identify, monitor, and regulate.

Non-Point sources are sources that cannot be traced to any single site of discharge. They are usually large land areas that pollute water by runoff, sub surface flow, or deposition from the atmosphere. Examples include runoff of chemicals into surface water from croplands, livestock feedlots, forests, urban streets, lawns and parking lots and acid deposition. Non point pollution from agriculture includes sediments, inorganic fertilizers, manure, salt dissolved in irrigation water, and pesticides.

Water and water related diseases:

Man's health may be affected by ingestion of contaminated water either directly or through food and by the use of contaminated water for purpose of personal hygiene and recreation.

The lack of clean drinking water for some 1.1 billion people in this world has dramatic consequences: approximately 4 billion cases of diarrhoea are reported annually, of which 2.5 million ends in death. Every day around 6000 children die due to the lack of safe

drinking water. Criteria for improving water supplies only consider water availability and its accessibility. However, since the drinking water quality is not taken into account, the situation is far worse as more than 1.1 billion people are exposed to unsafe drinking-water.

The World Health Organization says that every year more than 3.4 million people die as a result of water related diseases, making it the leading cause of disease and death around the world. Most of the victims are young children, the vast majority of whom die of illnesses caused by organisms that thrive in water sources contaminated by raw sewage.

Water related diseases may be classified as

- (1) Biological
- (2) Chemical

(1) Biological

(i) Water borne diseases (faecal contamination)

Diseases caused by ingestion of water contaminated by human or animal excrement, which contain pathogenic microorganisms is water borne diseases.

e.g. Diarrhoea (*E. coli*), Bacillary dysentery (*Shigella* sp.), Cholera (*Vibrio cholerae*), Typhoid and paratyphoid fever (*Salmonella typhi* and *S. paratyphi*).

ii) Water washed diseases

Diseases occurring due to inadequate use of water or diseases caused by poor personal hygiene and skin and eye contact with contaminated water is called water washed diseases.

e.g. Trachoma, Scabies etc

iii) Water based diseases

Diseases caused by parasites found in intermediate organisms living in contaminated water is called water based diseases. Infections are spread either through skin penetration (*Schistosomiasis*) or through ingestion (Guinea worm diseases). At least 600 million people are at risk of infection and 200 million are infected with *Schistosomiasis*.

iv) Water related vector borne diseases

Diseases spread by insects that depend on water. E.g. Malaria, Filariasis, Dengue fever, sleeping sickness.

(2) Chemical:

A number of chemical contaminants have been shown to cause adverse health effects in humans as a consequence of prolonged exposure through drinking-water.

Nitrate:

Nitrates may be found naturally in water or may enter water supplies through a number of sources (fertilizers, animal wastes, septic systems). High nitrate-containing water is a serious health concern for pregnant women and infants under the age of 6 months. Bacteria in the infants' digestive tracts may convert the relatively harmless nitrate to nitrite. In turn, the nitrite combines with some of the hemoglobin in blood to form methemoglobin that cannot transport oxygen. This condition is known as Blue Baby Syndrome.

To protect those at risk, the Maximum Contaminant Level (MCL) for nitrate in water is 45 mg/l as nitrate (NO_3) or 10 mg/l measured as nitrogen (N). The MCL for nitrite is 1 mg/l measured as nitrogen.

Fluoride:

Like most elements, fluoride appears to be both beneficial to health and potentially toxic. The dental benefits of fluoridated water are well documented. Fluoride concentrations of 1.0 milligrams per liter or greater will reduce the incidence of dental cavities. However, concentrations over 2.0 milligrams per liter can darken tooth enamel causing fluorosis.

Arsenic:

Long-term exposure to arsenic via drinking-water causes cancer of the skin, lungs, urinary bladder, and kidney, as well as other skin changes such as pigmentation changes and thickening (hyperkeratosis). Increased risks of lung and bladder cancer and of arsenic-associated skin lesions have been observed at drinking-water arsenic concentrations of less than 0.05 mg/L. Absorption of arsenic through the skin is minimal and thus hand-washing, bathing, laundry, etc. with water containing arsenic do not pose human health risk.

Water Purification/Water Treatment in small scale:

The objectives of water treatment are:

- ✓ To remove color, objectionable odor and taste
- ✓ To remove dissolved gases, dissolved and suspended impurities and harmful chemicals
- ✓ To remove pathogenic microorganism

The overall objective is to make water safe for drinking and domestic purpose. The following treatment methods can be used in domestic/household level.

1. Boiling

Boiling is a very effective method of disinfecting water, but it is energy consuming. The water should be brought to a 'rolling' boil for 5 minutes. Apart from the high cost of the

energy involved in boiling, the other disadvantage is the change in taste of the water. This can be improved by aeration, by vigorously shaking the water in a sealed container after it has cooled.

2. SODIS:

SODIS, which stands for Solar Water disinfection, is a simple method that utilizes the synergy of the UV-A (radiation effect) and infrared light (thermal effect) to kill the bacteria and viruses in the water. SODIS is a cheap and effective method for decentralized water treatment, usually applied at the household level and is recommended by the World Health Organization as a viable method for household water treatment and safe storage. The system uses PET (Polyethylene) transparent plastic bottles that are exposed to the sunshine for several hours.

Method of SODIS:

Water from sources is filled into transparent water bottle (PET bottle). For oxygen saturation, bottles can be filled three quarters at first, and shaken for 20 seconds (with the cap on), then filled completely. Highly turbid water (turbidity higher than 30 NTU) must be filtered prior to exposure to the sunlight. Filled bottles are then exposed to the sun for 5-6 hours. Better temperature effects can be achieved if bottles are placed on a corrugated roof as compared to thatched roofs. The treated water can be consumed directly. The risk of re-contamination can be minimized if water is stored in the bottles. The water should be consumed directly from the bottle or poured into clean drinking cups. Re-filling and storage in other containers increases the risk of contamination.

3. Chemical disinfection:

Many chemicals can disinfect water such as chlorine, ozone, Iodine, potassium permanganate but the most commonly used chemical is chlorine i.e. Chlorination

a) Chlorination:

Chlorination is probably the best and cheapest method of sterilization of water and it is the most effective in checking pathogenic microorganisms. For chlorination, chlorine may be used in different forms either in solid (Bleaching powder, chlorine tablets), liquid (Sodium hypochlorite solution) or gas (Chlorine gas). Bleaching powder or chlorinated lime is a white powder with a pungent smell of chlorine. 2.5 gram of bleaching powder is required for 1 cubic meter water disinfection.

b. Potassium permanganate:

c. Iodine solution

4. Filtration:

The process of filtration usually consists in allowing the water to pass through thick layer of filter candle. During the process of filtration, the suspended impurities and number of bacteria present in water are considerably reduced. Some filters, for example, are impregnated with silver

which acts as a disinfectant and kills bacteria, Impurities retained by the surface of the candle need to be brushed off under running water at regular intervals.

Water purification/Water treatment in Large Scale:

River, streams rains, ground water etc are the various natural sources of water which may contain a varieties of impurities in most cases. The impurities present in water vary greatly from one place to another. Treatment of water obtained from different source is therefore, essential so that treated water may be used safely for domestic, industrial and other purposes. Treatment of water in large scale involves:

1. Pre-treatment (Storage and Aeration)
2. Filtration
3. Disinfection

1. Pre-treatment:

a. Storage:

In some cases, the raw water drawn from rivers is stored for some period before the actual treatment starts. The storage improves the quality of water by natural sedimentation of silt and inactivation of several pathogenic organisms. In general, the storage of water can provide 90% suspended solids settle down in 24 hours and more than 50% reduction in most pathogenic organisms in hours to few hours.

b. Aeration:

The process of aeration consists in bubbling compressed air through raw water or impure water and removes iron as iron hydroxide, hydrogen sulphide and other volatile substances. Aeration of water promotes taste and removes odour by exchange of gases between water and the atmosphere. It increases the content of Oxygen in water, giving it freshness. Aeration is performed by two methods, natural aeration and artificial aeration. Aeration is carried out mostly for ground water in water treatment plant.

2. Filtration:

Filtration is the most important stage of water treatment process, because 98-99 % of the bacteria are removed by filtration, apart from other impurities. There are two types of filters which are used in both developed and developing countries. They are slow sand filter (biological) and rapid sand filter (mechanical).

(A) Slow sand filter:

It was first used in 1804 A.D in Scotland. It is generally accepted as the standard method of water purification.

A slow sand filter consists basically of the following components:

1. Supernatant (raw) water
2. Bed of graded sand
3. Under-drainage system
4. Filter control valves system

1. Supernatant water:

The depth of supernatant water varies from 1 to 1.5 m above the sand bed. It provides waiting period of some hours (3 to 12 hrs, depending upon filtration velocity) for the raw water to undergo partial purification by sedimentation, oxidation and particle agglomeration. The level of supernatant water is always kept constant.

2. Sand bed:

It is the most important part of the filter. The thickness of sand bed is about 1 m and effective diameter is 0.2-0.3mm. The sand should be clean and free from clay and organic matter. The sand bed is supported by a layer of graded gravel 0.3-0.4 cm deep which prevents the fine grains being carried into the drainage pipe. The sand bed presents a vast surface area; one cubic meter of filter sand presents 15,000 sq.meters of surface area. Water percolates through the sand bed very slowly (2 or more hrs) and a number of purification process such as sedimentation, adsorption, oxidation and bacterial action take place in this layer.

Vital Layer: The surface of sand bed gets slowly covered with a slimy growth known as 'Schmutzdecke', Vital layer, Zoogel layer or biological layer. This layer is slimy and gelatinous and consists of thread like algae and numerous forms of life including plankton, diatoms and bacteria. The formation of vital layer is known as 'ripening of the filter'. It may take several days for the vital layer to form fully and when fully formed it extends for 2 to 3 cm into top portion of the sand bed. The vital layer is the heart of the slow sand filter. It removes organic matter, holds back bacteria and oxidizes ammonical nitrogen into nitrates and helps in yielding a bacteria free water. Until the vital layer is fully formed, the first few days filtrate is usually to run waste.

3. Under drainage system:

At the bottom of the filter bed is the under-drainage system. It consists of porous or perforated pipes which provide an outlet for filtered water and supporting the filter medium above. Once the filter bed has been laid, the under drainage system cannot be seen.

4. Filter control:

The filter is equipped with certain valves and devices which are incorporated in the outlet pipe system. The purpose of these devices is to maintain a constant rate of filtration.

Filter cleaning:

Normally the filter may run for weeks or even months without cleaning. When the bed resistance increases to such an extent that the regulating valve has to be kept fully open, it is time to clean the filter bed. At this stage, the supernatant water is drained off and the

sand bed is cleaned by scraping off the top portion of the sand layer to a depth of 1 or 2 cm.

Advantage of Slow sand filter:

- ✓ Simple to construct.
- ✓ Cost of construction is cheaper than that of rapid sand filter.
- ✓ It can remove 99.9 - 99.99% bacteria.

(B) Rapid sand filter/Mechanical sand filter:

In modern water treatment plants, the rapid sand filter has largely replaced the slow sand filter. It is popular in highly industrialized countries. The following steps are involved in the purification of water by rapid sand filter.

1. Coagulation:

The raw water is treated with a chemical coagulant such as alum, the dose of which varies from 5 to 40 mg or more per litre depending upon the turbidity and colour.

2. Rapid mixing:

The treated water is then subjected to violent agitation in a mixing chamber for a few minutes. This allows a quick and thorough dissemination of alum throughout the bulk of the water.

3. Flocculation:

It involves a slow and gentle stirring of the treated water in a flocculation chamber for about 30 minutes. This slow and gentle stirring results in the formation of a white flocculent precipitate of aluminium hydroxide. The thicker the precipitate or floc diameter, the greater the settling velocity.

4. Sedimentation:

In the process of sedimentation, the floc laden particles are allowed to settle on the bottom of the settling tank in stationary conditions for time periods varying from 2-6 hrs.

5. Filtration:

Filtration is the step, carried out after sedimentation in which water is passed through a porous medium usually consisted of a bed of sand. The aim of filtration is to remove the small floc particles and microorganisms still remained in water after sedimentation. The sand retains all the suspended matter and allows to pass water only.

Filter bed: The effective size of sand particles is usually 0.4-0.7 mm and the depth of sand bed is usually about 1 m. Below the sand bed, is a layer of graded gravel (0.3 m to 0.4 m) deep. The gravel supports the sand bed and permits the filtered water to move freely towards the underdrains. The depth of water on the top of sand bed is 1 to 1.5 meter (5-6 feet). The under drains at the bottom of the filter beds collect the filtered water.

Backwashing:

Rapid sand filter needs frequent washing daily or weekly depending upon the turbidity of raw water. As the filtration proceeds, the suspended impurities and bacteria clog the filter. The filter soon become dirty and begins to lose its efficiency. So filter is subjected to a washing process known as Backwashing. Backwashing is a process of washing by reversing the flow of water through sand bed. Backwashing dislodges the impurities and clean up the sand. The washing is stopped when the clear sand is visible.

Advantages:

- ✓ Rapid sand filter can deal with water directly. No preliminary storage is needed.
- ✓ The filter beds occupy less space.
- ✓ Filtration is rapid, 40-50 times that of the slow sand filter.
- ✓ Washing of filter is easy.
- ✓ There is more flexibility in operation.

Comparison of Rapid sand and slow sand filter:

S.no.	Characteristics	Slow sand filter	Rapid Sand filter
1	Rate of Filtration	0.1-0.4 m ³ /m ² /hr	5-15 m ³ /m ² /hr
2	Effective size of sand	0.2 - 0.3 mm	0.4 – 0.7 mm
3	Preliminary treatment	Plain Sedimentation	Chemical coagulation and sedimentation
4	Washing	By scraping the sand bed	By Backwashing
5	Removal of Turbidity	Good	Good
6	Removal of Colour	Fair	Good
7	Removal of Bacteria	99.9 – 99.99%	98-99 %

3. Disinfection:

The final filtrate from sand filter, though of great clarity, is not always free from microorganisms. Therefore, disinfection of water by chlorination, ozonation is the most important step in obtaining hygienically safe water. The process of disinfection refers to the reduction of microbial population to a safe level that is harmless to human beings. Some of the common methods of disinfection are described below.

a) Chlorination:

Chlorine is powerful disinfectant which usually takes the form Hypochlorous acid(HOCl), hypochlorite ion (OCl), Chloramines, or remains as chlorine gas in water depending upon the pH and the presence of ammonium salts. The effectiveness of chlorine against microbes depends on the initial dose of chlorine, organic matter content in water and pH of the water.

The chemical action of chlorine is that when it reacts with water, it forms hypochlorous acid (HOCl) and hydrochloric acid (HCl). The hypochlorous acid reacts with bacterial enzymes to interfere with the metabolism inside the cell. When pH of water is greater than 8.5, the hypochlorous acid is dissociated into hypochlorite ion and hydrogen ion.

From the study, it shows that hypochlorous acid is 70-80 times more powerful than hypochlorite ion. Therefore less pathogens are killed in such condition. Thus the germicidal effect of chlorine is highly dependent upon the pH of water. Chlorination also removes soluble iron, manganese and hydrogen sulfide from water.

When chlorine is first added to water containing some impurities, the chlorine immediately reacts with the dissolved inorganic and organic substances and is then unavailable for disinfection. The amount of chlorine used up in this initial reaction is called the chlorine demand of the water. If dissolved ammonia is present in the water, the chlorine reacts with it to form compounds called chloramines. Only after the chlorine is satisfied and the reaction with all the dissolved ammonia is complete is the chlorine actually available in the form of HOCl and OCl⁻. Chlorine in the form of HOCl and OCl⁻ is called Free available chlorine, whereas chloramines are referred to as combined chlorine. Free chlorine is often the preferred form for disinfection of the drinking water. It works faster than combined chlorine, and it does not cause objectionable taste and odors. Combined chlorine is also effective as a disinfectant, but it is slower acting.

A process called breakpoint chlorination is sometimes used to ensure the presence of free chlorine in public water supplies. To do this, it is necessary to add enough chlorine to the water to satisfy the chlorine demand and to react with all the dissolved ammonia. When this occurs, it is said that the chlorine breakpoint has been reached. Chlorine added beyond the breakpoint will be available as a free chlorine residual in direct proportion to the amount of chlorine added. The chlorine demand and the breakpoint dose vary, depending on the water quality. Sometimes, chlorine doses up to 10 mg/l are needed to obtain a free chlorine residual of 0.5 mg/l.

b) Ozonation:

Ozone is a powerful oxidizing agent which eliminates undesirable taste, odor and color. It is stronger disinfectant than chlorine and is able to inactivate most viruses in addition to bacteria. Although ozone is a very effective disinfectant, it breaks down quickly and cannot be used to maintain disinfection in the distribution system. That means it does not leave a measurable residual in water. The ozone dosage required for water treatment varies from 0.2 to 1.5 mg/l.

Well disinfection:

Wells are main source of water supply in the rural areas. The most effective and cheapest method of disinfecting well is by bleaching powder.

Steps in well disinfection:

1. Find the volume of water in well

(a) Measure the depth of water column.....(h) meter

(b) Measure the diameter of well.....(d) meter

(c) Substitute the value of (h) and (d) in

$$\text{Volume of water (litre)} = \frac{3.14 \times d^2 \times h}{4} \times 1000$$

2. Find the amount of bleaching powder required for disinfection.

In general, 2.5 grams of good quality of bleaching powder would be required to disinfect 1000 litres of water.

3. Dissolve Bleaching powder in water.

The bleaching powder required for disinfecting the well is placed in bucket and made into a thin paste. The contents are stirred well and allowed to sediment for 5 to 10 minutes when lime settles down. The supernatant solution which is chlorine solution is transferred to another bucket and the lime is discarded.

4. Delivery of chlorine solution into the well:

The bucket containing the chlorine solution is lowered some distance below the water surface and the well water is agitated by moving the bucket violently both vertically and laterally. This should be done several times so that the chlorine solution mixes intimately with the water inside the well.

5. Contact period:

A contact period of one hour is allowed before the water is drawn for use.

6. Chlorine test:

The free residual chlorine should be 0.5 mg/l at one hour contact period.

Water pollution Control:

(Preventive and control measures)

1. Setting and implementation of national standards for industrial wastes
2. Discourage the direct disposal of domestic sewage
3. Discourage the excessive use of chemical fertilizers and chemical pesticides in agricultural fields.
4. Not allowing open defecation in and around water sources or in any places.
5. Soil erosion, Landslide and flood are to be controlled.
6. Using less harmful chemicals in industries as possible.
7. Discourage the use of river banks as solid waste disposal site.

The waste water (sewage) can be treated by following procedure:

Waste water treatment:

The purposes of treatment of liquid waste water are:

- To render the liquid waste inoffensive as far as nuisances are concerned.
- to separate the pollutants from water and make the water usable for industrial or domestic purposes.

- To prevent destruction of aquatic life.

Primary treatment (Mechanical treatment):

Waste water usually contains large quantities of floating materials such as paper, plastics, cans, wood etc. These larger objects are removed by metal bars. It is called **mechanical bar screening**. The water then goes to **grit chamber** where velocity of water is reduced so as to most of the grits and sand settling on the bottom. The smaller and lighter particles take longer time to settle under gravity. This slower process takes place in the **primary sedimentation tank**. Finely divided suspended solids and colloidal particles cannot be efficiently removed by plain sedimentation by gravity. In such cases, chemical coagulation is employed. Salts of iron, Aluminium, activated silica etc are usually used as coagulants.

Secondary treatment (Biological treatment):

Primary treatment removes most of the solid and particulate materials. Waste water now have a plenty of dissolved organic matter. It may also contain a little amount of very fine organic particulate matter, such organic pollutants which are removed in secondary treatment. It is also known as biological treatment. It involves particularly the Trickling filters and activated sludge processes.

Trickling filter: Incoming waste water after primary treatment is sprayed over a circular filter beds by a rotating boom. This is a pipe with holes along its length and the water emerges in horizontal jets. The filter bed is usually about 1.5 m deep and surrounded by a circular brick wall. The filter consists of various combinations of materials such as sand, gravel etc. As waste water moves down, the microbial populations which occur in different zones of the filter bed cause rapid oxidation of organic matter content of water. The filters are equipped with compressed air through pipes under filter bed in order to provide sufficient oxygen for microbial population. Otherwise deficiency of oxygen in filter bed causes problem of emitting undesirable smell and reduces the rate of decomposition process.

Activated sludge process: It involves slow passage of waste waters, through a large tank in which a large number and variety of microorganisms are added. Activated sludge is used for decomposition of fine organic matter as it consists complex mixture of microbes. Compressed air is blown through the bottom of the tank which provides oxygen necessary for the aerobic decomposition.

Tertiary Treatment:

Most of the organic matter present in the water is decomposed during secondary treatment. However waste water contains plenty of nitrates, phosphates and ammonium salts which are the bio-products of biodegradation. In addition, these waters contain large population of microbes such as bacteria, algae, fungi, protozoans etc. These nutrients and biological agents are removed in tertiary treatment.

The main function of tertiary treatment is to decrease the load of nitrogen and phosphorus compounds present in the effluents by the following processes.

1. Precipitation: Phosphorus can be removed by precipitation with coagulants such as aluminium sulphate and ferric chloride. Lime can also be used to precipitate phosphorus.
2. Air stripping: Ammonia present in waste water can be removed in this process. The pH of the water is raised usually by addition of lime, and the ammonia driven out of the solution by doing vigorous agitation with air.
3. Carbon adsorption: The undesirable taste and odour are removed by adsorption on activated charcoal.
4. Desalination: The residual salts in the waste water can be removed by ion-exchange, reverse osmosis process etc.
5. Advanced Biological system: The use of shallow oxidation ponds allow water to be purified by the action of the aerobic bacteria and algae which are capable to remove nitrate and phosphate in water by the photosynthesis process.
6. Chlorination: The waste water is chlorinated to kill disease causing microorganisms that is present in the waste water. The treated water is then discharged into aquatic ecosystem.

Unit 5: Solid waste

Definition:

Any unwanted or discarded material from residential, commercial, industrial, mining and agricultural activities that cause environmental problems may termed as wastes.

Waste classification:

- 1) Solid waste
- 2) Liquid waste
- 3) Hazardous waste.

1) Solid waste:-

Solid waste is defined as any unwanted or discarded material that is not liquid or gas. It is often called as the third pollution after air and water pollution, is that material, which arises from various human activities and is normally discarded as useless or unwanted.

Sources of Solid wastes (Types of Solid wastes according to different sources):

Sources	Examples
1) Residential	Food waste, paper, textile, plastics, rubber, yard waste, glass, tin cans, consumer electronic waste etc.
2) Commercial	Paper, cardboard, plastic, wood, glass, metals
3) Institutional (School, College, Government and Private institution etc)	Paper, Packaging materials, also contains hazardous waste e.g. Chemicals from laboratories.
4) Industrial	Highly heterogeneous in nature and are industry specific.
5) Agricultural	Animal farms, poultry farm waste etc.
6) Municipal services wastes	Street sweepings, (roadside litter, tree trimmings, dead animals etc.
7) Construction and demolition	Concrete, wood, dirt etc

2) Liquid waste:

Examples: Sewage, waste water, industrial discharges etc.

These may also contain plenty of semi-solid and solid in suspended state.

3) Hazardous waste:

Any useless, unwanted and discarded material that may pose a threat to human health and / or environment is called hazardous waste. They include toxic (poisonous or carcinogenic), caustic, acidic, explosive, infectious and radioactive materials.

Source:

Examples

Industry:

acids caustics, lead, oil, grease, phenols, ammonia etc.

Household: batteries, paints etc.
Agriculture: pesticides such as insecticides, herbicides, fungicides etc.

Waste generation:

Waste generation is essential due to discarding of unwanted materials away for disposal. It is a continuous activity which is not very controllable. Huge quantities of municipal solid wastes are generated in all the cities of the world. The volume of solid waste generated depends on different factors:

1. Geographic location
2. Season of the year
3. Standards of living
4. Cultural habits
5. Public attitudes

Waste generation according to Municipality of Kathmandu valley

Municipality	Generation in 2004 (tons)	Collection in 2004 (tons)	Projected generation, 2015
Kathmandu	308.4	250	547.9
Lalitpur	75.1	52	135.4
Bhaktapur	25.5	19	46.2
Madhyapur Thimi	14.3	5	27.8
Kirtipur	11.6	4	18.1
	434.9	330	775.4

Source: Nippon Koei 2005

Above table shows that, the five municipalities generate daily approximately 435 tons of solid waste, of which more than 70% comes from Kathmandu Metropolitan City in 2004 and collection is 330 tons. The research shows that the lowest income families tend to have lowest rates of waste generation ranging between 0.4 to 0.7 kg per household and economically well off families produce with 2.0 kg waste per day. The trend suggests that the greater the economic prosperity, the higher the amount of solid waste produced.

Composition of waste in Kathmandu:

Composition is term used to describe the individual components that make up a solid waste stream and their relative distribution, usually based on percent by weight.

Composition of municipal waste in Nepal changes over time as consumption patterns change. Various studies carried out since 1976 indicate that around two-thirds of the municipal solid waste generated in Kathmandu Metropolitan City is organic: this has remained relatively unchanged over the years. The amounts of plastic, paper, metal, and textiles in municipal solid waste have changed significantly (UNEP 2001; CBS 2005). Electronic waste such as parts of mobile phones, computers, televisions, and so on are new visible constituents of solid waste in the Kathmandu Valley. However no data for electronic waste in Nepal are available at present.

The total solid wastes from Kathmandu are composed of different waste materials which are given below:

Waste	%
1) Organic	69.6
2) Paper	9
3) Plastic	9
4) Glass	3
8) Construction materials	2
5) Metal	1
7) Rubber	1.4
4) Clothes	3
9) Others	2

Source: - KVMP, 2002

Waste	%
1) Organic	63.22
2) Paper	9.02
3) Plastic	10.8
4) Glass	5.42
8) Construction & demolition waste	4.5
5) Metal	0.42
7) Rubber & Leather	1.2
8) Textiles	2.3
Others	3.12

Source: World Bank, 2009

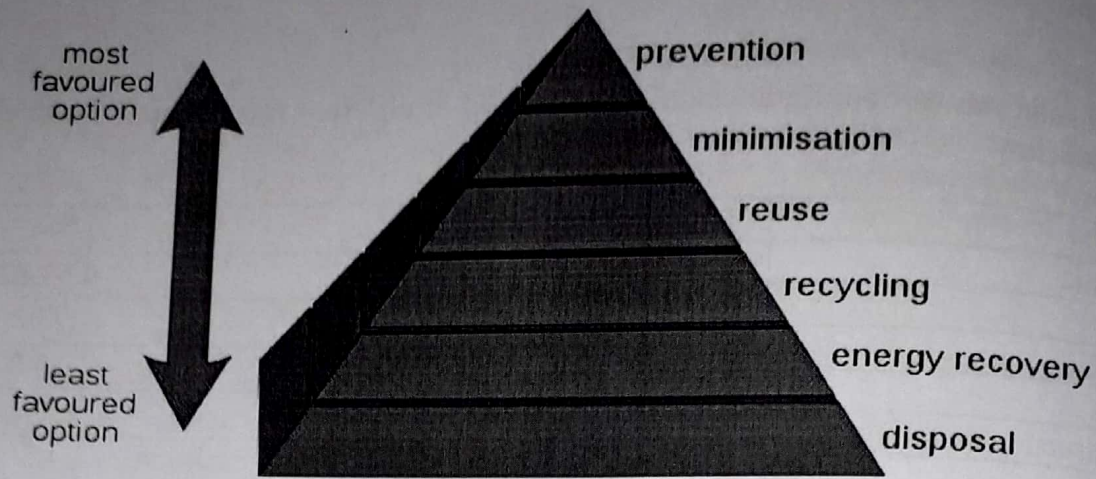
According to KVMP (2002), out of total solid waste, nearly 70% of waste belongs to organic which can be easily composted. From the data of World Bank, it shows that percentage of organic waste is now reduced which is around 63%. The above figure also reveals that the plastic waste is increasing which is 10.8% in 2009 and 9% in 2002.

Solid Waste Management:

It comprises of purposeful and systemic control of generation, storage, collection transport, separation, processing, recycling recovery and disposal of solid waste.

Waste hierarchy:

The waste hierarchy refers to the "3 Rs" reduce, reuse and recycle, which classify waste management strategies according to their desirability. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste.



Waste Minimization: 3R concept (Integrated approach to waste management):

3Rs- Reduction
Reuse
Recycling

1) Reduction:

i.e cutting back on waste generation in the first place (source reduction)

Methods of Reduction:

- i) reducing the volume of products.
- ii) increasing the useful life time of products.
- iii) reducing the amount of packaging
- iv) decreasing consumption.

2) Resuse:

i.e using a product repeatedly instead of throwing it away.

Eg, refillable glass beverage bottle, Clothes shopping bags etc

Benefits

- i) Extends resource supplies
- ii) Reduces energy use and pollution
- iii) Create local jobs related to their collection and refilling.

3) Recycling:

Recycling can be defined as the collection and separation of materials from the waste stream and their subsequent reuse or processing to produce a marketable product.
eg. Paper recycling; Newspaper into newspaper, Aluminium cans into aluminium cans.

Advantages of Recycling:

- 1) It efficiently reduces the quantity of waste to be landfilled.
- 2) Reduces transportation cost.
- 3) Saves/ reduces energy use.

Process of Waste Disposal:

(1) Waste Storage:

Storage of waste at the source of generation is essential step towards Solid Waste Management.

It is common practice in most of the cities that the waste generated is thrown on the streets or heaped up near the corner of roadside or near some dump point. This practice should be prohibited.

Waste Storage Bins:

- 1) Refuse collection Bins (Slums)
- 2) Litter bins (On city roads)
- 3) Plastic Refuse Bin

For a family of 5 members a bin having a capacity of $\frac{1}{2}$ cubic feet would be needed and require $1\frac{1}{2}$ or 2 cubic feet, if collection is done once in 3 days.

Municipal authorities shall establish and maintain storage facilities in such a manner as not to create unhygienic condition around it.

Criteria:

- i) Waste stored is not exposed to open atmosphere and shall be aesthetically acceptable and user- friendly.
- ii) Storage facilities shall be created/ established by taking into account quantities of waste generation in a given area and the population density. A storage facility shall be sited such that the user finds it easy to approach.
- iii) Storage facility or bins shall have easy to operate design for handling, transfer and transportation of waste.

2) Waste Collection:

It is first stage of solid waste management. Waste collection includes not only the gathering or picking up solid wastes from the various sources, but also the hauling of these wastes to the location where the contents of the collection vehicles are emptied. There are different methods of waste collection and can vary considerably depending on

- i) The level of community participation.
- ii) The waste generation
- iii) The type of buildings, slums and refuse

Common types of waste collection systems in cities:

- i) House to house waste collection
- ii) Kerbside collection
- iii) Dump to dump collection
- iv) Collection by street sweepings
- v) Relay system

i) House to house waste collection system (Door to Door waste collection):

In this system, waste collection vehicle comes and stops as close as possible to the entrance of the building. Waste bin is then picked up by municipal worker and emptied into the waste collection truck or two worker team will go to the community container in the premises and carry waste for depositing into the vehicle. It is appreciated by many citizens.

ii) Kerbside waste collection:

In this type of collection, each household is required to bring their waste bins near the kerbside when the waste collection truck comes on its waste collection round. The arrival of waste vehicle is announced by bell ringing. The System is less appreciated.

iii) Dump to Dump Collection:

In areas where residents are not able to keep the garbage within their premises/ compounds till the garbage vehicles comes, the people tend to throw their garbage on the street. To control this kind of littering of roads, municipal bodies are required to provide temporary waste dumping points garbage at these waste collection points. Usually such waste collection sites are on the kerbside at suitable points in the form of fixed or movable refuse bins. Containers/ skips are kept instead of bins (e.g. market place)

iv) Waste Collection by Municipal Street Sweepings System:

Road sweepings generally dry containing mainly paper, leaves, and plastic bags, inert materials are collected. The pre- determined area is swept by a sweeper and the sweepings are lifted and loaded into a hand barrow and then carted in a wheel barrow to the nearby collection point where a refuse container is located.

v) Relay System of Waste Collection:

In this system, waste collection vehicle is parked where a platform of appropriate height is provided. The platform has a staircase for climbing. The waste brought to the point is carried to the platform and is dumped in standing vehicle. When the vehicle is fully loaded, it is sent away for unloading and other empty vehicles is placed at that place. This system is effective where there is continuous inflow of waste. As the waste goes directly to the vehicle body, the collection point remains clean and neat. This system therefore has been accepted by the city people.

Waste Collection Vehicles:

- 1) Handcart with Hand Barrows
- 2) Human Pedal-Cart (Tricycle)
- 3) Dumper Truck
- 4) Conventional Truck
- 5) Tractor

(3) Transfer operations:

Transfer operation become a necessity when haul distances to available processing centers or disposal sites increase so that direct hauling is no longer economically feasible. Transfer stations are used to accomplish transfer of solid wastes from collection by small vehicles

4) Transportation:

The transportation of waste to disposal sites is a very important aspect of solid waste management. The action involved are waste collection from road side refuse, depositing into refuse vehicle, transporting waste to the treatment/ disposal sites and placing at the disposal site.



Waste measurement (Photo: Kishor Maharjan)

Unloading waste into Teku transfer station (Photo: Kishor Maharjan)



(5) Waste Treatment and Disposal:

Solid waste may be treated or processed prior to final disposal. There are several advantages on treatment of solid wastes.

- i. It reduces the total volume and weight of waste material that requires final disposal.
- ii. Volume reduction helps to land resources, since land is ultimate sink for most waste materials.
- iii. Waste processing also changes its forms and improves its handling characteristics.

Waste Treatment and Disposal Methods of Solid wastes:

- (1) Composting
- (2) Vermicomposting
- (3) Incineration
- (4) Pyrolysis
- (5) Pelletization
- (6) Sanitary land filling
- (7) Open dumping

Resource Recovery from Solid Wastes:

- (1) Composting
- (2) Vermicomposting
- (3) Pelletization
- (4) Anaerobic treatment of Solid waste
- (5) Recycling (paper, Plastics, Metals, Rubbers etc)

(1) Composting:

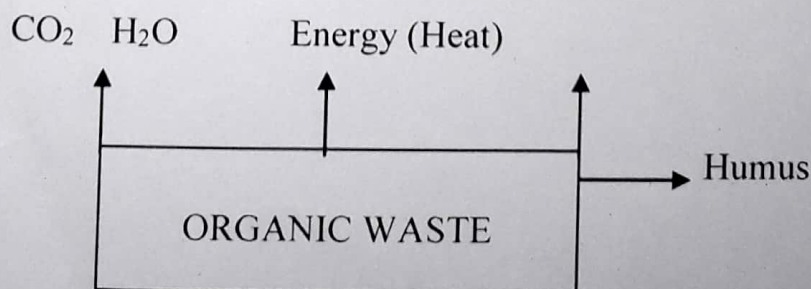
Composting is the process of biologically converting biodegradable organic waste materials into stable end product by microbial activities.

Composting: some benefits

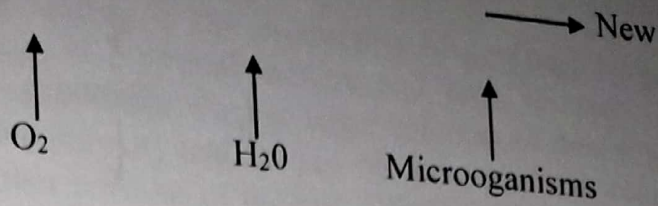
Compost allows the soil to retain more plant nutrients over a longer period.

- It supplies part of the 16 essential elements needed by the plants.
- It helps reduce the adverse effects of excessive alkalinity, acidity, or the excessive use of chemical fertilizer.
- It makes soil easier to cultivate.
- It helps keep the soil warm in winter.
- It aids in preventing soil erosion.
- The quantities of solid waste that require landfilling are considerably reduced.

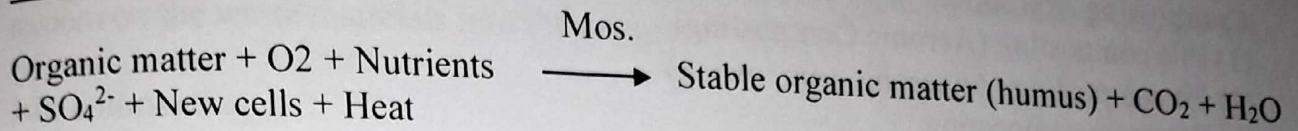
Composting Process:



Microorganisms



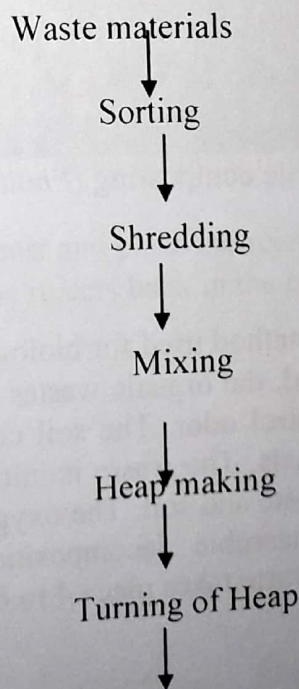
Aerobic Decomposition:

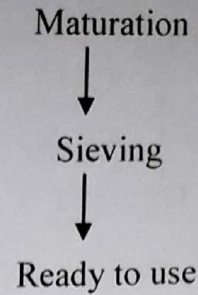


Factors in Process of Composting:

Parameters	Comments
(1) C:N Ratio	25:1 (Most desirable)
(2) Shredding	About 1 inch
(3) Moisture	50-60%
(4) Temperature	High temperature for 2-5 days, Significant??
(5) pH	Below 8.5 and greater 4.5

Steps of Compost Preparation:





Composting Methods:

- (1) Pile composting (Aerobic Composting)
- (2) Pit composting (Anaerobic composting)
- (3) Windrow composting
- (4) Bin composting

Pile composting (Aerobic Composting):

In pile method, the segregated and shredded waste is kept in piles. These piles are provided with a grid of perforated pipes which are used to supply air. The waste mass may be heated to desired temperature (i.e. upto 70 °C). The waste materials are composted in a period of 2 to 3 months.



Fig. Pile composting (Photo: Kishor Maharjan)

Pit composting:

It is a common anaerobic method used for biological conversion of organic component of solid wastes. In this method, the organic wastes are filled in a pit. A final layer of soil is provided at the top to control odor. The soil cover also prevents breeding of flies and disturbances by stray animals. The waste is initially stabilized aerobically as there exist some air in the voids of waste and soil. The oxygen present in the pore-air is completely utilized and after that anaerobic decomposition starts and the waste is stabilized. Complete stabilization of waste takes place 4 to 6 months depending upon the type of the waste.

Windrow Method:

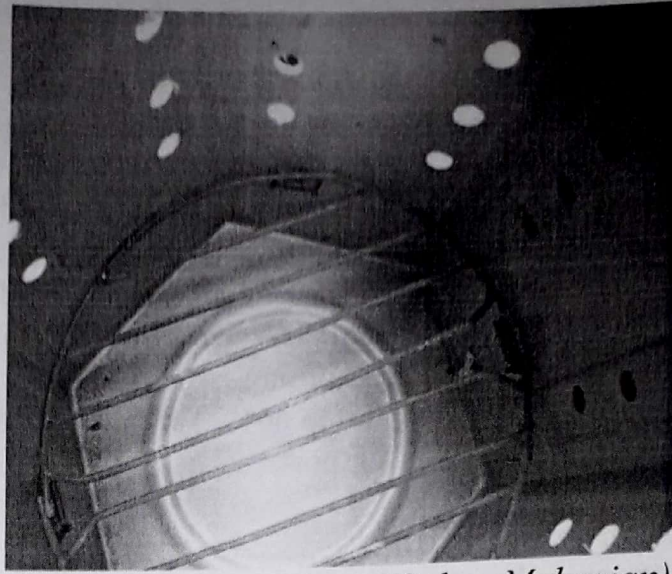
In agriculture, **windrow composting** is the production of compost by piling organic matter or biodegradable waste, like animal manure and crop residues, in long rows (windrows). This method is suited to producing large volumes of compost. These piles are generally turned to improve porosity and oxygen content, mix in or remove moisture, and redistribute cooler and hotter portions of the pile. Windrows of wastes of about 1.5 to 2 m height and 4 to 5 m width are prepared. The size of windrows also depends upon the size of equipment available for turning. Turning is carried out at regular intervals. The moisture content is maintained between 50 to 60%. This system takes about 4 to 6 weeks to convert the waste materials into the compost.

Bin composting:

Bin composting is a popular home composting of recycling organic materials in present days. It is an effective way of reducing the volume and altering the physical composition of solid wastes while at the same time producing a useful product called compost.

For composting of organic waste, following points should be remembered.

1. Take a compost bin and place it at a convenient location (kitchen, garden, balcony etc).
2. Separate organic waste (food waste, garden clippings etc).
3. Cut the waste into small pieces (about 1 inch in length/diameter) so that it degrades quickly.
4. The moisture content of the waste should be about 50%, which means the waste should feel moist when touch it, but the water should not be dripping from it.
5. If waste has a lot of green stuff like leaves and vegetables, add some brown material like saw dust to balance to C: N ratio in the waste.
6. Place the waste in the bin close the lid. In the beginning, you may have to put some straw or paper at the bottom (1st compartment) of the bin to prevent the waste from falling down into the bottom compartment.
7. Sprinkle some liquid EM or old compost or garden soil to activate the degradation process.
8. Stir compost about once a week to ensure that it is well aerated. Lack of Oxygen causes waste to smell as it degrades.
9. Compost should be ready in about three months. It will be dark brown in colour and have an earthy smell.
10. Use the fork to harvest the compost and place the rejects back in the bin.
11. Screen the compost and place the rejects back in the bin.



Bin composting (Photo: Kishor Maharjan)

(2) Vermicomposting:

It is a method of making compost which involves joint action of earthworms and microorganism.

Importance of Vermicomposting:

- Management of Organic waste
- Simple technology
- Eco-friendly
- Waste reduction at the source

Preparation of Vermicompost:

1. Selection of Container
2. Making outlets
3. Preparation of Beds (e.g. saw dust, coconut coir, paper, straw etc)
4. Spreading of cow dung/tea waste (if available)
5. Placement of compost making worms (*Eisenia foetida*)
6. Covering with organic waste
7. Covering the container.

Vermicompost collection:

1. Removal of surface food.
2. Take the prepared compost/ or turn the container upside down.
3. Arrange the contents (Vermicompost) in a cone shape.
4. Leave for 10 minutes
5. Let the earthworms gather at the bottom
6. Collect the Vermicompost from the top.
7. Transfer the earthworms in a new container.

Precautive Measures:

- Water quantity
- Temperature control
- Light Intensity
- Maintain pH
- Change into new Bed
- Control from enemies of Worms

(3) Incineration:

Incineration is the process where waste is completely combusted under high temperature and controlled air flow. Incineration is a dry oxidation process, which reduces organic matter and combustible waste into inorganic, incombustible matter and results in a significant reduction in the volume and weight of the waste. No pre-treatment is required for incineration and waste is rendered unrecognizable as it is burned to ashes. With the use of this technology, almost all kind of waste can be treated. However, certain categories of waste like reactive chemical waste, radioactive waste, PVC plastics, Waste with mercury or cadmium content should not be treated by incinerators.

Incinerators can range from extremely sophisticated, high temperature operating plants to very basic combustion units that operate at much lower temperature. All types of incinerator if operated properly eliminate pathogens from waste and reduce the waste to ashes. However, certain types of health care waste e.g. pharmaceutical or chemical waste require high temperature for complete destruction. Basically there are two types of incinerator used for hospital waste. They are:

- a) Double chamber Pyrolytic incinerator
- b) Single chamber incinerator

a) Double chamber Pyrolytic incinerator:

It is most reliable and commonly used treatment process for hospital waste. This type of incinerator consists of two chambers: Pyrolytic chamber and Post combustion chamber. In the Pyrolytic chamber, the waste is combusted producing ashes and gases at a temperature ranging between 800 and 900 °C. Gases produced from the combustion are burned in the post combustion chamber at a temperature between 900-1200 °C, reducing its toxicity before mixing with the ambient.

Single chamber incinerator:

It has single chamber where waste is burned by adding some fuel. Air inflow is usually through natural ventilation and the temperature inside the incinerator reaches upto 400 °C. Single chambered incinerators can also be made locally by using drum or by brick/concrete. However many chemical wastes will persist if the temperatures do not exceeds 200 °C. Although this type of incinerator is usually cheap to construct and operate, the gases emitted by this incinerator usually consists of Sulphur dioxide, Hydrogen chloride, Hydrogen fluoride, black smoke, Carbon monoxide, fly ash, nitrogen oxide, heavy metals and volatile organic chemicals. This type of incinerator can be used for infectious and pathological waste and also for general waste. Pharmaceutical and chemical waste, genotoxic waste, radioactive waste and inorganic compounds and thermally resistant waste cannot be treated.

Advantages of Incinerators:

Advantages of using incinerators for treating medical waste are as follows:

- It reduces the mass and volume of waste.
- It causes destruction of infectious organisms.
- It adds aesthetic value as it destroys the organic components of the waste which is often objectionable to public.
- It avoids contact with hazardous waste by general working force.

Disadvantages:

- It emits potential source of air pollution. Low quality incinerator could cause air pollution. Air pollutants: SO₂, HCl, HF, Black smoke, CO, NO, Heavy metals.
- Increased cost of incineration, high cost of installation, operation, repair and maintenance of equipment.
- Formation of dioxins and furans with increased of PVC chemicals is particularly dangerous.

(4) Pyrolysis:

It is a chemical change due to partial combustion of solid wastes in the absence of oxygen. It is also known as thermal decomposition where external source of heat is employed. In Pyrolysis process, the combustible constituents of the solid waste are heated in a special retort like chamber known as a pyrolysis reactor in 600 to 1000 °C in Oxygen free environment.

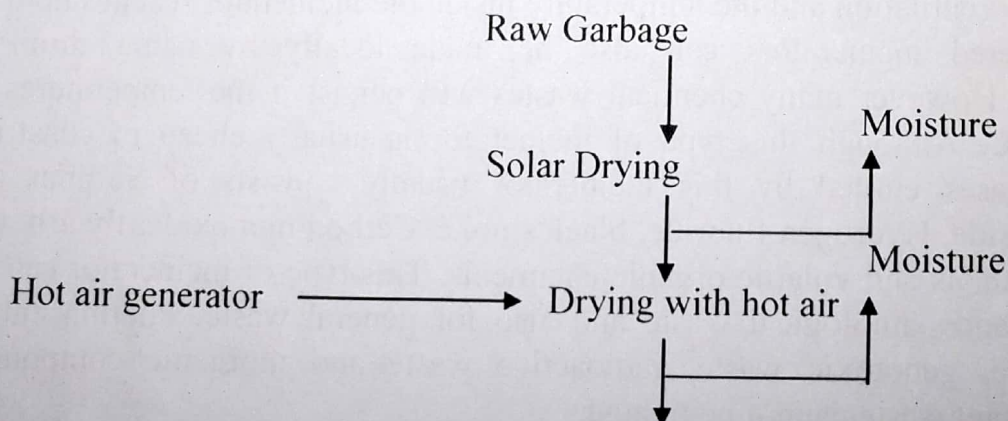
Advantages:

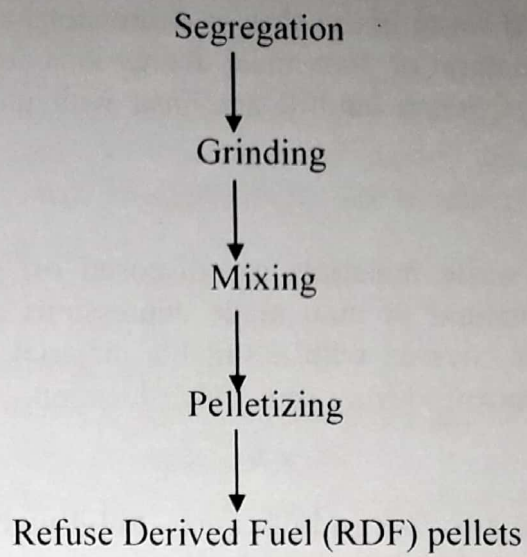
- Volume reduction
- Production of Fuel gases (Methane)
- Char produced can be converted to Activated charcoal for use in water and sewage treatment.

(5) Pelletization:

It is a process of converting domestic solid waste into small pellets of size generally about 3 inches in length and 1 inch in diameter.

Methods of Preparation:





(6) Landfilling:

Landfilling is physical facilities used for disposal of solid wastes in the surface soils of the earth. Landfilling includes monitoring of the incoming waste stream; placement and compaction of the waste. Landfills for the disposal of Hazardous wastes are called secure landfills.



Landfilling in Sisdol, Nuwakot (*photo: Kishor Maharjan*)

Types of Landfills:

Classified as Trench Landfills, Area Landfills, and Slope landfills (depending upon area of land available).

Trench Landfill:

Disposed off solid waste in trenches or depressions is called trench landfill. It is suitable for areas where natural or man made depressions are available and water table is deep. Sides and base of trench landfill are lined with impermeable materials to protect the ground water.

Area landfill:

In this method, waste materials are disposed off on the ground surface. These are provided where natural or man made depressions are not available and extraction is difficult. Waste is covered with a suitable material, usually a layer of soil. The cover materials/soil is borrowed from some other location.

Slope landfills:

Slope landfills are provided in hilly areas. Solid waste is disposed off on local foothills after providing a suitable liner and a leachate collection system.

Sanitary Landfills:

Sanitary landfilling involves proper planning and application of engineering principles and construction techniques to minimize public health and environmental impacts. Dumping of solid waste in a scientifically designed land is called Sanitary land fill. Landfills are obtained by spreading waste in thin layers, compacting it and covering it with soil on daily basis.

Landfill site selection/Disposal site selection:

- Site capacity
- Land use
- Geology (Types of soil, Stability of Land, Ground water table)
- Seasonal fluctuating of rainfall
- Transport distance/Accessibility
- Ground and surface water conditions
- Acceptability by citizens and Safety.

- Landfills should be located away from the community areas (at least 3 km away) but should be easily approachable. It should be located from airport (5 km away).
- It should be well above the ground water table so that the ground water supplies are not polluted. It should not be less than 5 m
- Its soil should be low permeability so that it can be used as satisfactory cover materials.
- Soil to be used for daily cover should be available nearby
- The site selected for landfilling should not be deleterious or offensive to the surrounding environment.

(7) Open Dumping:

Waste is dumped in low lying areas partly as a method of reclamation of land but mainly as an easy method of waste materials. Due to bacterial action, the volume of organic waste decreases considerably and is converted gradually into humus.

The drawbacks of open dumping are:

- The waste is exposed to flies and rodents.
- It is a source of nuisances from the smell and unsightly appearance.
- The loose waste is dispersed by the action of wind.
- The surface and ground water pollution by runoff or infiltration.

Occupational hazards associated with waste handling

Infections

Skin and blood infections resulting from direct contact with waste, and from infected wounds.

Eye and respiratory infections resulting from exposure to infected dust, especially during landfill operations.

Different diseases that result from the bites of animals feeding on the waste.

Intestinal infections that are transmitted by flies feeding on the waste.

Chronic diseases

Incineration operators are at risk of chronic respiratory diseases, including cancers resulting from exposure to dust and hazardous compounds.

Accidents

- Bone and muscle disorders resulting from the handling of heavy containers.
- Infecting wounds resulting from contact with sharp objects.
- Poisoning and chemical burns resulting from contact with small amounts of hazardous chemical waste mixed with general waste.
- Burns and other injuries resulting from occupational accidents at waste disposal sites or from methane gas explosion at landfill sites.

Hazardous Waste:

Any useless, unwanted and discarded material that may pose a threat to human health and or environment is called Hazardous waste. They include toxic (Poisonous or carcinogenic) caustic, acidic, explosive, infectious and radio active materials. Such materials are sometimes called special wastes because they require special handling and treatment. If wastes possesses any of the following four characteristic attributes such as (1) Reactivity 2) Ignitability 3) Corrosivity 4) Toxicity, it is defined as Hazardous.

- (1) Ignitable substances are easily ignited and burn vigorously and persistently. Eg. Volatile liquids, such as solvents whose vapours ignite at relatively low temperatures.
- (2) Corrosive substances include liquids with pH less than 2 or greater than 12.5, and those that are capable of corroding metal containers.
- (3) Reactive substances are unstable under normal conditions. Can cause explosions and / or liberate toxic fumes, gases and vapours when mixed with water.
- (4) Toxic substances are harmful or fatal when ingested or absorbed.

Sources of Hazardous Waste

Sector	Source	Hazardous Wastes
1) Household sector	Batteries, Thermometer, Paints	Mercury, Heavy metals
2) Agricultural sector	Farms	Unused Pesticides, empty containers
3) Commerce and Services	Vehicle servicing, Dry Cleaning, Hospitals	Wastes Oils Halogenated solvents Pathogenic/ infectious waste.
4) Industrial sector	Textile Processing Painting Leather tanning Chlorine production Steel and Glass manufacturing	Cadmium, mineral acids Inks and dyes Chromium Mercury Chromium, Lead Mercury

Health effects of hazardous waste

Common sources	Contaminants	Potential Health effect
<u>1) Household, Commerce and service</u> Household items as Batteries, Thermometer And Paints Photocopy machine Dry Cleaning Agents	Mercury, Heavy metals Chromium Trichloroethane and Trichloroethylene	-Toxic to kidneys -Can cause eye and skin irritation , Chest pain, fatigue -Toxic to kidneys, Potential human carcinogen. -Central Nervous system depression, headache, loss of consciousness.
<u>2) Agricultural sources</u> Herbicides for Vegetation control Pesticides Carbamates:	Chlorophenoxy compounds, 2,4-dichlorophenoxyacetic acid Aldicarb, baygon	- Long term nerve damage -Acute symptoms include headache, fatigue, dizziness, increase salivation, nausea, Vomiting, diarrhea etc.
<u>3) Industrial source</u> Chemical manufacturing Steel and Glass manufacturing	Benzene, Ethylbenzene, Toluene, xylene Chromium, lead Mercury	-Benzene suppress bone marrow function, causing blood changes, Chronic exposure can cause leukemia. - Dermatitis. -All are toxic to kidneys, lead causes decreased mental ability, Weakness, Anemia - Long term exposure to lead can cause permanent kidney and brain damage. -Chromium- human carcinogen.
<u>4) Hospital waste</u>	Infectious, Radioactive,	

Types of hazardous wastes:

- 1) Chemical waste
- 2) Biomedical waste
- 3) Radioactive waste

Control and Management of Hazardous Waste:

The main sources of hazardous wastes are the industrial units. Law requires that industries dispose off their hazardous wastes, only after proper treatment. Unfortunately it is not in practice especially in developing countries. As a result most hazardous wastes are mixed with the municipal wastes. Ultimately hazardous waste reaches the landfills and is leached to the ground water causing disease on human. All the industries producing more than 100kg of hazardous wastes per month should be registered. An inventory of such waste generating agencies and the quantity of the wastes produced per month should be prepared.

The management strategies for hazardous waste include volume reduction, toxicity reduction, recycling, avoiding waste mixing and good house keeping practices (Staff training), waste segregation, planning etc).

Hazardous Waste Treatment Methods:

Some type of hazardous waste can be detoxified or made less dangerous by chemical, biological or physical treatment methods. Treatment of hazardous waste may be costly, but it can serve to prepare the material for recycling or ultimate disposal in a manner that is safer than disposal without treatment. It also can reduce the volume requiring final disposal.

(A) Chemical Treatment Processes:

Chemical processes often used for treatment of hazardous waste include

a) Incineration b) Neutralization c) Precipitation etc.

a) Incineration is a thermal- chemical process that not only can detoxify certain organic wastes, but can essentially destroy them as well. The burning of organic waste at very high temperature converts them to an ash residue and gaseous emission. Combustion detoxifies hazardous waste material by altering its molecular structure and breaking it down into simpler chemical substances. Although ash itself may have to be treated as a hazardous waste, a much smaller volume of waste is left for ultimate disposal. Not all hazardous waste can be incinerated. Heavy metals for e.g. are not destroyed, but enter the atmosphere in vapor form. However, incineration has been successfully applied to potent hazardous wastes such as chlorinated hydrocarbon pesticides, PCBS, and many other organic substances. Special types of thermal processing equipment such as Rotary kiln, Double chamber incinerator are available for burning hazardous waste.

(b) Neutralization:

It refers to pH adjustment for reducing the strength and reactivity of acidic or alkaline wastes. Limestone, for e.g. can be used to neutralize acids and compressed CO₂ can be used to neutralize strong bases.

c) Precipitation:

It refers to a type of reaction in which certain chemicals are made to settle out as a solid material. An example of its application is in the battery industry, where the addition of lime and sodium hydroxide to acidic battery waste causes lead and nickel (both are toxic heavy metals) to precipitate out of solution.

B) Biological Treatment Processes:

It involves the action of living microorganisms. The Microbes utilize the waste material as food and convert it, by natural metabolic processes, into simple substances. It is most commonly used for stabilizing the organic waste in municipal sewage but certain types of hazardous industrial waste can also be treated by this method. Organic waste from the petroleum industry, for e.g., can be treated biologically. It is necessary to inoculate the waste with bacteria that are readily acclimated to it and can use it for food.

C) Physical Treatment Processes:

It can be used to concentrate, solidify or minimize the volume of hazardous waste material. Solidification can be accomplished by encapsulating the waste in concrete or plastic. This produces a solid mass of material that is resistant to leaching. Hazardous wastes can also be solidified by mixing them with lime, water, and cement to form solid, cement like product.

Disposal Methods:

1) Deep well Disposal/Underground Injection:

An option for land disposal of liquid hazardous waste is called deep-well or underground injection. This involve pumping the liquid down through a drilled well into a porous layer of rock. The liquid is then injected under high pressure into the pores and fissures of the rock. The layer or stratum of rock in which waste is stored, usually limestone or sandstone, much lie between impervious layers of clay or rock, this injection zone can be from a few hundred meters to a few kilometers below the surface. The capacity of the geological strata to accept in injected waste depends on its porosity (Void space), permeability (ability to transmit a liquid) and other factors. The injection well must be at least 0.4 km (0.25m) from an underground source of drinking water, and the waste must be injected into a separate geological formation. The well must be cased and cemented for added protection against contamination of any drinking water supplies. The chemical and petroleum refining industries are the largest users and injection wells, together accounting for about 90% of their use as a disposal option. Most active waste injection wells are located in heavily industrialized states or in oil producing states.

2) Secure landfill:

Some landfills are specifically designed to contain hazardous materials. Such facilities are called secure landfills. The engineering features of secure landfills are similar to those of sanitary landfills but the leachate drainage and collection system are more sophisticated, the impermeable liners and Caps are more substantial and the concentration of monitoring wells around the perimeter may be greater. In addition there is commonly an on-site treatment facility where hazardous materials are incinerated, neutralized or otherwise stabilized before being placed in the landfill. The secure landfill is the ultimate repository for all hazardous waste residues and it should be considered as the last resort when all other efforts to eliminate the waste problem fail.

Hospital Waste:

It means any waste which is generated from hospital during diagnosis, treatment or immunization of human beings or animals or in research activities.

Categories of Hospital waste (WHO Classification)

S.No.	Category	Examples
1	Infectious waste	Surgical dressings, culture of infectious agents from lab (human blood), Gloves, Apparatus, Apron etc
2	Pathological waste	Human tissue, organs, body parts, blood & body fluid, fetuses etc
3	Sharps	Any items that can cut or puncture such as needles, blades, syringes, glass, knives etc
4	Pharmaceutical wastes	Expired or unused pharmaceutical products, drugs, vaccines and discarded items used in handling pharmaceuticals such as bottles, boxes, vials etc
5	Chemical waste	Includes chemical from diagnostic & experimental work, cleaning process etc
6	Genotoxic waste	Waste containing substance with genotoxic properties eg. Waste containing cytostatic drugs (often used in cancer therapy)
7	Waste with high content of heavy metals	Batteries, broken thermometer, blood pressure gauges, etc
8	Pressurized containers	Gas cylinder, aerosol cans
9	Radioactive waste	Waste containing radioactive substances eg, unused liquids from radiotherapy or laboratory research, contaminated glassware, packages, urine and excreta from patients treated or tested with radionuclides.
10	General waste	Include paper, cardboard, metal containers, kitchen waste, floor sweepings

Hospital waste Generation:

The National Health Research Council (NHRC) classifies waste generated in health care institutions (HCIs) into three types: general, hazardous, and sharp.

Amount and types of waste generated by selected hospitals (Kg/day)

Hospital	Waste types, Kg/day (%)			Total Kg/day
	General	Hazardous	Sharps	
Bir	521 (74%)	120 (17%)	60 (9%)	701
Om	221 (83%)	31 (11%)	16 (6%)	267
TUTH	456 (74%)	105 (17%)	53 (9%)	614
Patan	304 (74%)	70 (17%)	35 (9%)	410
Prasuti	251 (86%)	26 (9%)	16 (5%)	292
Total	1,752 (77%)	352 (15%)	179 (8%)	2,282

Source: Rawal 2004 and Basyal and Pokharel (2004) cited in poudel et al.2005

Health-care waste management in a hospital:

Good waste management depends on:

- A dedicated Waste Management Team
- Good administration
- Careful planning
- Sound organisation
- Adequate financing
- Full participation by trained staff

Hospital waste management means the management of waste produced by hospitals using such techniques that will help to check the spread of diseases through it.

Steps of waste management:

- (1) Waste segregation/Sorting
- (2) Waste collection
- (3) Waste Transportation
- (4) Waste Storage
- (5) Waste Treatment & Disposal

(1) Waste segregation:

Practice of classifying waste & placing it into the appropriate waste container immediately after the waste is generated. Segregation at source is the most important activity for an effective medical waste management. Effective segregation will reduce costs, promote recycling and protect the health and safety of all. Waste should be segregated into different colour coded containers according to biomedical rules.

Red: Sharps eg. Needles, syringes, blades

Yellow: Pathological Waste

Green: General Biodegradable waste such as food waste, paper

Blue: Non-biodegradable waste such as unbroken glass bottle, plastic paper, rubber (Recyclable)

Brown: Gloves, Plastic pipes

Every health care institution should segregate their waste at the source that is at ward side, Operation Theater, laboratory or any other room in the hospital where waste is generated into three categories viz, sharps, hazardous and general. It needs to be some standard practices for all institutions and should be made mandatory.

(2) Waste collection:

Waste should be collected at least daily, but more often if necessary. Sanitary staff and sweepers shall wear protective clothing at all the times including face masking, industrial aprons, leg protectors, industrial boots and gloves. Collection must be in colour coded containers.

(3) Waste Transportation:

For in-site transportation, the waste collected trolley shall be free of sharp edges, easy to load, unload and clean.

- The trolley shall be cleaned regularly.
- Waste should be transported during low patients flow times.
- Yellow container and Green container general waste shall be collected on separate trolleys.
- The collected waste shall not be left even temporarily anywhere other than the designated central storage facility.
- All vehicles are decontaminated, cleaned after used.

(4) Waste Storage:

- Storage of infectious waste should be organized in specific restricted areas. It should be located within health care institution premises close to incinerator, if installed, but away from food storage or food preparation area.
- Easy accessible to collection vehicles.
- The maximum time of storing should not exceed 24h.
- Mark the storage areas with the biohazard symbol.

Exclusively allocated closed carts should be used to transport wastes.
Since medical waste poses a serious health threat to the community:

- Never store medical waste in open containers
- Never throw waste into an open pile.
- Waste should be stored in containers with lids to minimize the potential for insect, rodent, or other animal infestation, and to minimize the smell.

(5) Waste Treatment and Final Disposal:

Treatment

- Incineration
- Autoclaving
- Microwaving
- Encapsulation
- Inertization
- Needle Remover
- Chemical treatment

Final Disposal:

- Waste Burial
- Cemented Sharp pit
- Sanitary Landfilling

Treatment modifies the characteristics of the waste.

Treatment of wastes mainly aims

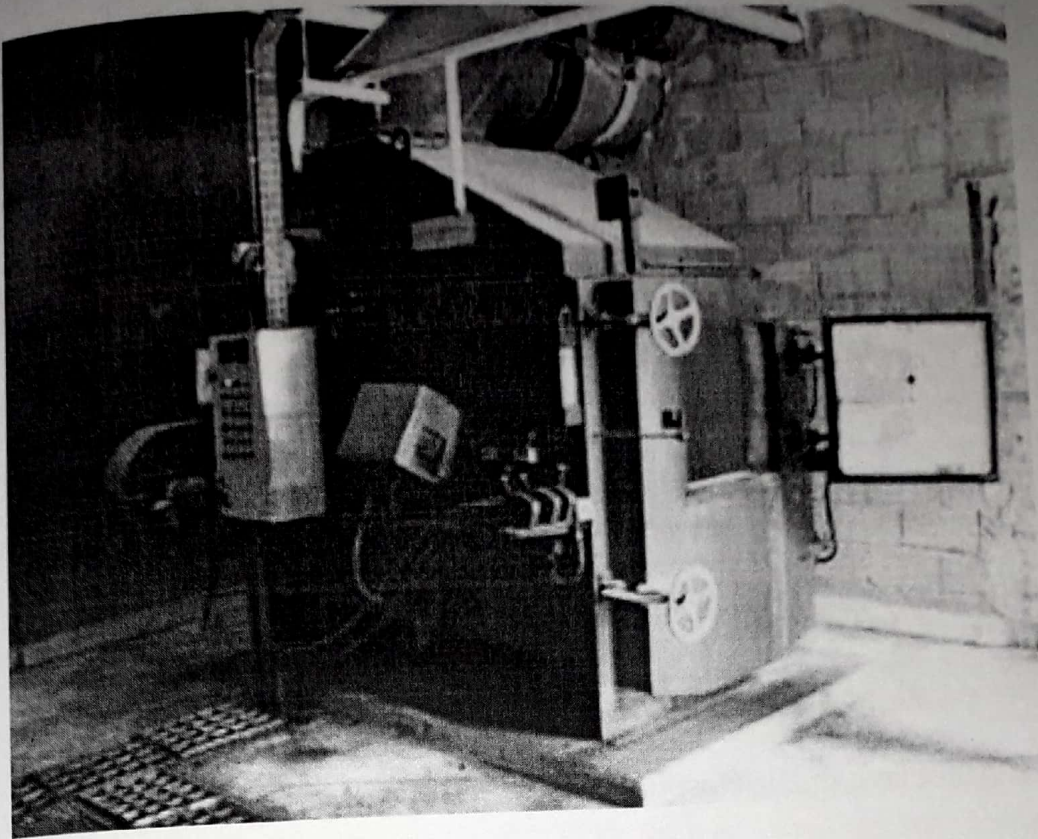
- at reducing direct exposure less dangerous to humans,
- at recovering recyclable materials, and
- at protecting the environment.

The main aim is

- to disinfect infectious waste
- to destroy disposable medical devices, in particular used syringe needles, which should not be reused, or at least to render them inaccessible.

(1) Incineration:

Incinerating is the best option for solid waste disposal, since the high temperature destroys microorganisms and reduces the amount of waste.



Do not incinerate

Do not incinerate the following:

- Plastics especially halogenated plastics (e.g. PVC)
- Pressurized gas containers
- Large amounts of reactive chemical waste
- Radioactive waste
- Silver salts or radiographic waste
- Mercury or cadmium
- heavy metals

(2) Autoclaving:

It is non-burn technology for hospital waste management. Waste is added to a large autoclave where a combination of heat and pressure sterilizes the waste. Various commercial models are available. In some countries locally made autoclaves are available. It sterilizes many types of waste such as used injection equipment.



Use of Autoclave in Bir Hospital (photo: Kishor Maharjan)

(3) Encapsulation:

It is a process in which full safety boxes or disinfected needles are placed within high-density plastic containers or metal drums. When the containers are full, an immobilizing material such as sand, cement and lime is added. Then containers are sealed and disposed of in landfill sites or waste burial pits.

(4) Inertization:

Mixing of waste with cement before disposal in order to minimize the risk of leakage of toxic substances contained in the waste is called inertization.

(5) Needle remover:

The used needle is inserted into a device which cuts or pulls the needle off from the syringe.

(6) Chemical disinfection:

Treatment of wastes with chemical disinfectants e.g. bleach (sodium hypochlorite 1% solution)

Waste Disposal:

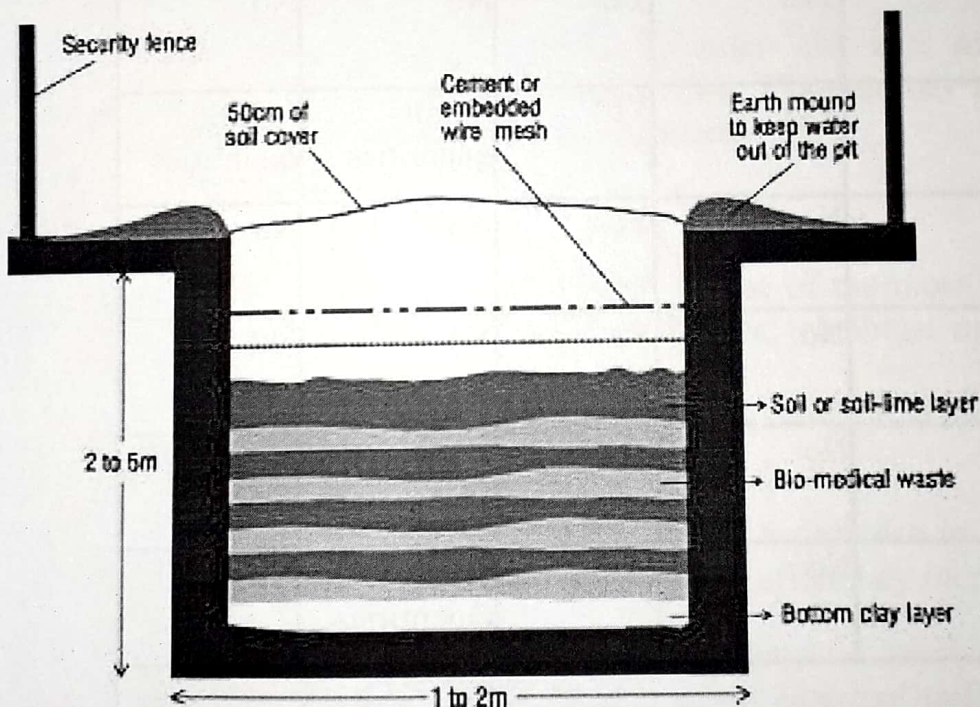
Disposal refers to the final placement of treated waste, using a sanitary landfill or any other environmentally acceptable method of final storage appropriate to the local conditions.

(1) Waste Burial

Pit sides covered with a low permeability material, covered and fenced. The pit should be sealed with cement once it is full or at least the last 50cm should be filled with compacted soil and the area identified.

Process of waste burial:

- Dig a pit 1 to 2 meters wide and 2 to 5 meters deep.
- Line the bottom of the pit with clay or low permeable material.
- Construct an earth mound round the mouth to prevent water from entering.
- Construct a fence around to prevent unauthorized entry.
- Alternatively place layers of waste inside and 10 cm of lime and soil.
- When the pit is within about 50 cm of the ground surface, cover the waste with soil and permanently seal it with cement or embedded wire mesh.



(2) Cemented Sharp Pit:

Pit well covered with a narrow access for sharps. It should be filled with cement once full.

- Needles: 1 million in 1m³
- Needle + syringes: 30,000 in 1m³

Overview of disposal and treatment methods suitable for different categories of health-care waste

Technical options	Non Plastic Infectious waste	Anatomical waste	Sharps	Pharmaceutical waste	Chemical waste
On Site					
Waste Burial	Yes	Yes	Yes	Small quantities	Small quantities
Sharp pit	No	No	Yes	Small Quantities	No
Encapsulation	No	No	Yes	Yes	Small quantities
Inertization	No	No	No	Yes	No
Low T° burning (<800°C)	Yes	Yes	No	No	No
Med T° burning (800 – 1000°C)	Yes	Yes	Yes	No	No
High T° burning (> 1000C°)	Yes	Yes	Yes	Small quantities	Small quantities
Steam autoclave	Yes	No	Yes	No	No
Microwave	Yes	No	Yes	No	No
Chemical (Bleach)	Yes	No	Yes	No	No
Discharge to sewers	No	No	No	Small Quantities	No
Offsite					
Sanitary landfill	Yes	No	No	Small quantities	No
Other methods				Return to supplier	Unused chemical to supplier

Unit 6: Noise pollution

Noise can be defined as an unwanted or undesired sound at a wrong time and a wrong place. Decibel (dB) is the standard unit for measurement of sound.

Causes of Noise Pollution

- Traffic noise is the main source of noise pollution caused in urban areas. With the ever-increasing number of vehicles on road, the sound caused by the cars and exhaust system of autos, trucks, buses and motorcycles is the chief reason for noise pollution.
- The construction of buildings, highways and city streets causes a lot of noise. Pneumatic hammers, air compressors, bulldozers, loaders, dump trucks and pavement breakers are the major sources of noise pollution in construction sites.
- Machinery, motors and compressors used in the industries create a lot of noise which adds to the already detrimental state of noise pollution.
- Plumbing, generators, air conditioners and fans create a lot of noise in the buildings and add to the prevailing noise pollution.
- Household equipments, such as vacuum cleaners, mixers and some kitchen appliances are noisemakers of the house. Though they do not cause too much of problem, their effect cannot be neglected.

Effects of Noise Pollution:

- Deafness, temporary or permanent, is one of the most prevalent effects of noise pollution. Mechanics, locomotive drivers, telephone operators etc all have their hearing impairment.
Auditory fatigue appears in the 90 dB and may be associated with the side effects as whistling and buzzing in ears.
- The first and foremost effect of noise is a decrease in the efficiency in working. Research has proved the fact that human efficiency increases with noise reduction.
- Too much of noise disturbs the rhythms of working, thereby affecting the concentration required for doing a work. Noise of traffic or the loud speakers or different types of horns divert the attention, thus causing harm in the working standard.
- Fatigue caused is another effect of noise. Due to lack of concentration, people need to devote more time to complete their task, which leads to tiredness and fatigue.
- Noise pollution increases the stress levels among people.

- Sometimes, being surrounded by too much of noise, people can be victims of certain diseases like blood pressure, mental illness, etc.
- Animals are susceptible to noise pollution as well. It damages the nervous system of the animals.
- Noise indirectly weakens the edifice of buildings, bridges and monuments. It creates waves, which can be very dangerous and harmful and put the building in danger condition.

Some of the important health hazards of Noise

Sno	Noise Intensity (dB)	Health Hazards
1	80	Annoyance
2	90	Hearing damage
3	95	Very Annoyance
4	120	Pain threshold
5	130-135	Nausea, Vomiting
6	140	Pain in ear
7	160	Rupture of Tympanic membrane

Safe/Permissible Noise level (WHO recommended)

Sno	Locality	Permissible Noise Level (dB)	
		Day	Night
1	Industrial Area	75	65
2	Commercial Area	65	55
3	Residential Area	55	45
4	Silence Zones for hospital, educational institutions	45	35

Prevention and control of Noise pollution:

- (1) Reduction of noise at the source of its origin
- (2) Application of sound proofing techniques
- (3) Protection of exposed persons (eg. ear plugs)
- (4) Vegetation covers (eg. Ashok, Neem etc)
- (5) Control of noise through law (Silence zones, Restrictions of unnecessary horns etc)
- (6) Careful planning of city
- (7) Education/Awareness

Unit 7: Pesticide Pollution and Human Health

Pesticide

EPA definition: "substances or mixtures of substances intended for preventing, destroying, repelling or mitigating any pest..."

Pesticides are chemicals that can kill or repel pests.

Major benefits of pesticide:

- Save human life (Malaria, Plague-rat fleas etc)
- Increase food supplies and lower food costs
- When used properly-insignificant health risks compared with their benefits

Types of Pesticide

Type	Examples	Persistence	Biologically magnified?
Insecticides			
Chlorinated Hydrocarbon	DDT, Aldrin, Dieldrin, Mirex, Toxaphene, Lindane, Chlordane	High (2-15 Years)	Yes
Organo-phosphate	Malathion, Parathion, Diazinon	Low to moderate (1-2 weeks, but some can last several years)	No
Carbamates	Aldicarb, Carbaryl (Sevin), Propoxur, Zineb, Maneb	Low (days to week)	No
Botanicals	Rotenone, Pyrethrum, and Camphor extracted from plants.	Low (days to week)	No
Micro botanicals	Various bacteria, fungi, Protozoa	Low (days to week)	No

Herbicides

Contact chemicals	Atrazine, Simazine, Paraquat	Low (days to week)	No
Systemic chemicals	Silvex, Diruon, 2,4-D	Mostly Low (days to week)	No
Soil sterilants	Tribualin, Dalapon, Butylate	Low (days)	No

Fungicides

Various chemicals	Captan, Carbon bisulfide Pentachlorophenol, Zaneb, Methyl bromide,	Most low (days)	No
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Fumigants

Various chemicals	Carbon tetrachloride, Ethylene dibromide, Methyl bromide.	Mostly High	Yes (for most)
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Use of Pesticides

Before 500 BC – well use of sulphur as insecticide

1400s – Toxic compound Arsenic, Lead, Mercury – crops

(abandoned due increasing no. of human poisoning -late 1920s)

1600s– Nicotine sulphate, extracted from tobacco leaves came into use as an insecticides

Mid 1800s – Two more natural pesticides were introduced i. Pyrethrum– obtained from chrysanthemum flowers

ii. Rotenone– from roots of various tropical forest legumes

These First generation pesticides were mainly natural substances chemical burrowed from plants that had been defending themselves from insects.

- ✓ A major pest control revolution began in 1939, When entomologist Paul Miller discovered DDT.

- ✓ DDT, the first of the so-called second generation pesticides soon became the world's most used pesticide and Miller received the NOBEL prize in 1948 for his discovery.
- ✓ Since 1945, chemists have developed hundreds of synthetic organic chemicals for use for pesticides
- ✓ World wide, about 2.3 million metric ton of second generation pesticides are used yearly.
- ✓ About 75% of these chemicals are used in developed countries but use in developing countries is rising.
- ✓ Though there were many episodes of poisoning caused by synthetic organic earlier, it was only in 1962 that publication of Rachel Carson's book entitled 'The Silent Spring' which brought the problem of pesticide contamination in the environment and raised many controversies

Pesticide Use in Nepal

- Most pesticides used in Nepal are imported from India & from China.
- Limited use of Pesticide
- Altogether 250 types of Pesticides were used and average use 0.142kg/ha in 1995 (Palikhe 1999)
- Presently the number of pesticides used has increased to 319 of which

213-Insecticides

71-Fungicides

23-Herbicides

8-Rodenticides

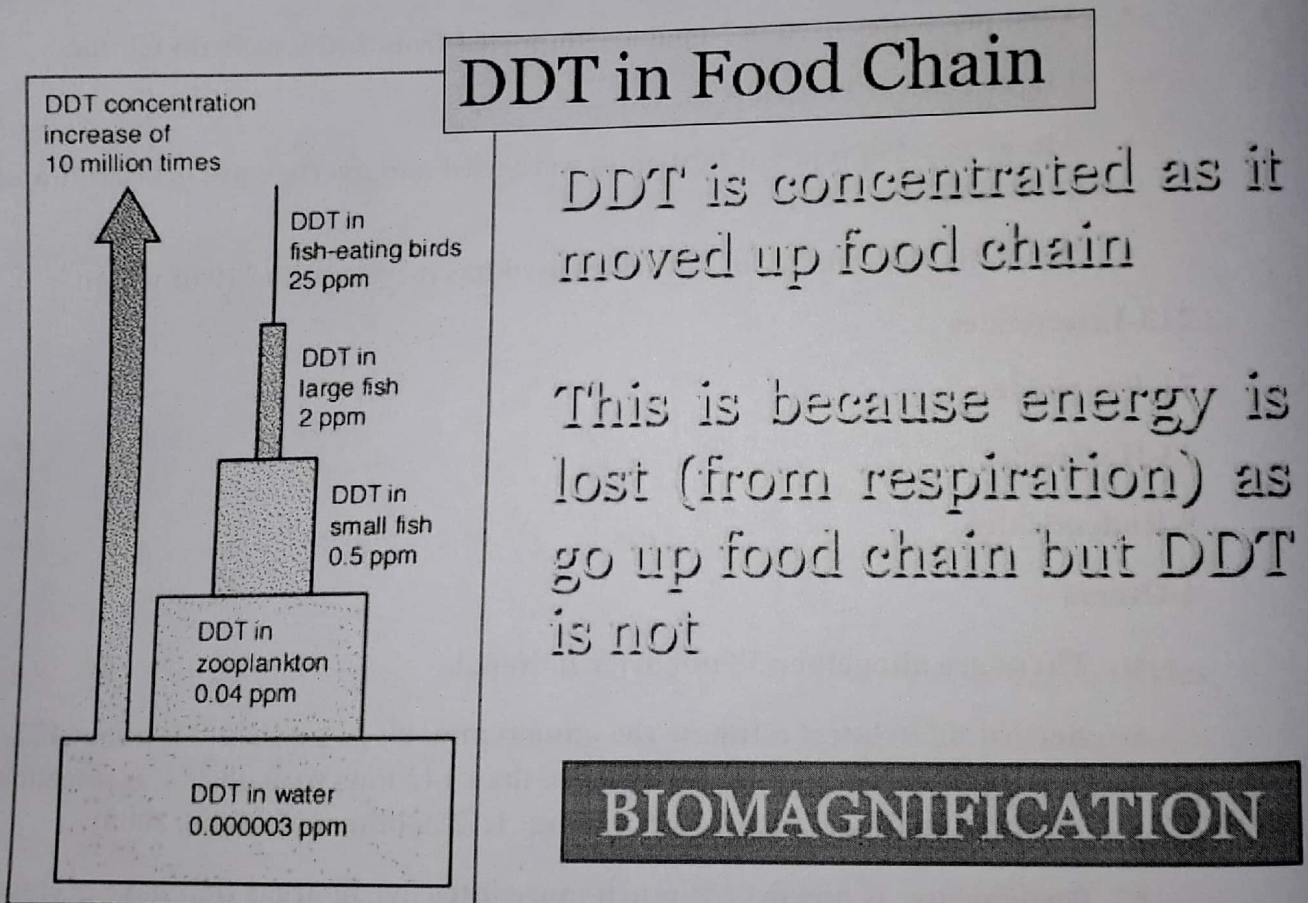
4-Others

- There are altogether 38 importer in Nepal.
- According to latest estimate the annual imports of pesticides is about 177 tons and current annual use is more than 142 tons with 48.3% as insecticide, 46.22% fungicides, 4.36% herbicides, 1.12% others (Palikhe, 2005)
- Pesticide use is however is much more intensive in areas that have greater access to market.
- The use is higher in areas with intensive commercial farming of vegetables, fruits, tea, rice and cotton.

- Under present scenario as reported by many researchers, systematic use of pesticides by Nepalese farmers is largely ignored.
- All types of pesticides are not only repeatedly used but also carelessly used

Problems associated with the use of Pesticides

- Persistence
- Bioaccumulation and Biomagnification
- Selective action of pesticide is never perfect
- Difficult to prevent circulation
- Pesticide resistance (Impossible to reduce rate of application)
- Ineffective prey-predator interactions



Ecological Effects

Remarkable influence on

- microbial community in an ecosystem.

- Earthworms
- Phytoplanktons
- Fish eating birds

Pregrine falcon suddenly decreased in 1940 , now totally unknown there (UK)

“Egg Breaking”

- Problem of lethal dose to non resistant predator

(prey-resistant fish sp. such as Mosquito fish, golden shiners and Black bull heads in areas of heavy use of pesticide)

Effect on Human Health

- Enter the target organ by oral, dermal, or respiratory routes.
- DDT- very high oral toxicity but low dermal toxicity
- Parathoin- higher dermal and respiratory toxicity
- Accumulate various parts of human body and cause
- Cancer
- Sterility
- Kidney damage
- Hypertension
- Leukemia
- Death at higher concentration
- Chlorinated Hydrocarbon affect mainly CNS, where as other may effect circulatory and reproductive system
- Presence of pesticide residue in human is universal
- Average Indian-25 ppm
- Average American-12 ppm (Organochlorine pesticide)
- (US Dept. of Health, Education and welfare, 1969)
- Significant Hazard for Agricultural workers- Organophosphate
- Estimated that Organophosphate - responsible for about 70% human pesticide poisonings and deaths,
- 3 million seriously poisoned yearly
- 180,000 deaths per year in developing countries
- 490 premature deaths per day (WHO/UNEP estimation)

Actual no. of pesticide related illness and deaths generally underestimated due to

- **Poor record**
- **Lack of doctors and diseases reporting in rural areas &**
- **Faulty diagnoses.**

- **Pesticide can cause**
- **Genetic mutation**
- **Birth defects**
- **Nervous system disorders**
- **Immune and Endocrine System**

Alternative Methods of Pest Control

1. Mechanical Control:

- Handpicking
- Capturing and killing insects and pest by hand nets
- Shaking the plants to dislodge the organisms
- Sieving to remove the insects in case of grains

2. Physical Control:

- Involves manipulation of physical factors like temperature, moisture, light etc to control the population of pest
- Feasible in case of food grains only.

3. Cultivation Practices:

- Crop Rotation- Changing the type of crop planted in a field each year
- Planting rows of hedges or trees around fields to hinder insect invasions & provide habitat for their natural enemies (with added benefit to reduce soil erosion)
- Growing crops in areas where their major pests donot exist.
- Planting Trap crops to lure pests away from the main crop
- Switching from vulnerable monoculture to intercropping, agroforestry and polyculture
- Plowing under or burning diseased or infected plants & stalks & other crop residues that harbor pests that remain in crop fields after harvesting.

4. Pheromonal Control:

(Use of Pheromene trap)

The group of chemicals secreted by insects to attract their mate during reproduction are termed as pheromones.

Used to control fruit flies.

5. Use of Botanical Pesticide:

Eg. Neem, Titepati, Bakaino etc

6. Biological Control

- Controlled by introduction of biological agencies which normally restrict a population within reasonable limits.

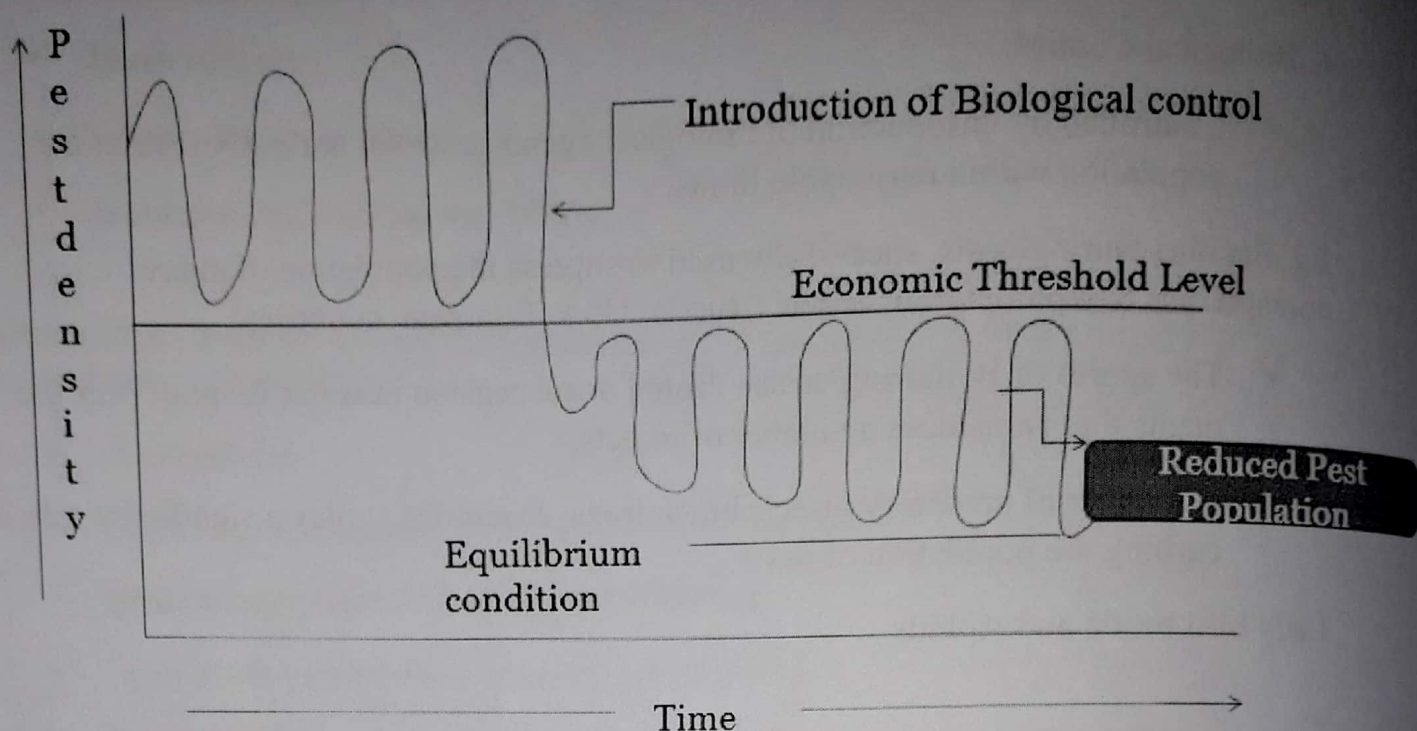
Eg. *Bacillus thuringiensis*, successfully used to suppress the population of many coleopterous & lepidopterous larvae (Russia, USA, European countries)

- The spores of *B. thuringiensis*— dusted or suspension in water is spray over the plants that parasitizes a number of insects.
- A number of predatory insects birds, frogs & reptiles play a significant role in curbing the population of pests

Lady bird beetle and Aphids

Integrated Pest Management (IPM)

- Best way to control crop pest if carefully designed.
- In this approach, each crop and its pest are evaluated as parts of an ecological system.
- The overall aim of IPM is not to eradicate pest population but to reduce crop damage to an economically tolerable level.
- Control program is developed that includes a mix of cultivation, biological and chemical methods applied in proper sequence & with the proper timing.
- Each pest management technique must be environmentally sound and compatible with producer objectives.



Advantages of IPM

IPM is an important form of pollution prevention that reduces risks to wildlife and human health

The experiences of various countries show that a well designed IPM program can

- Reduce pesticide use and pest control costs by 50-90%
- Improve crop yields
- Reduce the inputs of fertilizer
- Slow the development of genetic resistance

Disadvantages of IPM:

- Requires a higher degree of management
- More labor intensive
- Success can be weather dependent
- Requires expert knowledge about each pest situation
- Slow acting than conventional pesticides

- Nepal passed the first Pesticide Act in 1991 and Pesticide regulation in 1994.
- The purpose of Legislation is to enable the society to obtain the benefit from their use with minimal effects to humans and other non-target organisms.
- The act regulates import, manufacture, sales, distribution and use of pesticides within the country with a view of prevent risks of human beings and animals.
- The importers wishing to market and sell pesticides must submit an application dealing with the use of pesticides, toxicity and the corrective use of pesticide in agriculture.
- No pesticide may be imported into the country without the appropriate certificate of importation issued by registration Authority.
- Large persistent chemical pesticides have been banned for agriculture and public health from 9th April 2001 and also hazardous pesticides have been phased out from the use since 9th April 2001.
- The use of Quinalphos, Ethion, Monocrotophos and Phorate in the tea field have been prohibited because of their highly toxic effect.

List of Banned Pesticides:

- 1. Chordane
- 2. DDT
- 3. Dieldrin
- 4. Aldrin
- 5. Endrin
- 6. Heptachlor
- 7. Mirex
- 8. Toxaphene
- 9. BHC
- 10. Lindane
- 11. Phosphamidon
- 12. Organo Mercury
- The Pesticides to be imported, distributed, traded and used should be more friendly and less hazardous to health and environment.
- More emphasis have been given to use of organic pesticides an alternative of chemical pesticides to control crop pests.
- The present Pesticide Act and Regulation donot address the issue of chemical pesticide disposal.

- The problem of safe disposal of stockpiles of existing obsolete pesticides clearly indicates the absence of regulatory measure for collection and disposal