Ambo University Woliso Campus

School of informatics and technology, Department of Civil Engineering

Degree Program(s) B.Sc. in Civil engineering *Credit Hours: - 3, ECTS Credits: - 5*
Course Title: - **Environmental Engineering**
Academic year: - 2019/ 2020, Semester: II *Pre-requisites:-None*
Course Numbers: - CEng3221

Course Objectives

- Discuss environmental disturbances and their causes
- Discuss the importance of environmental considerations in all Engineering endeavors.
- Describe the key technologies used to reduce the impact of human activities on the water, air, and land environments
- Appreciate environmental impact assessment as a tool for sustainabledevelopment

Course Description

- Major environmental problems and their relation to human activity and development.
- Aspects of environmental policies and legislation.
- Sources and causes of water, land, food, and air pollution and their control.
- Urbanization and its impact on the environment.
- Issues and strategies of environmental protection.
- Quantities and composition of solid wastes.
- Methods of solid waste treatment (land filling, incineration, composting, etc.).
- Handling of hazardous waste.
- Aspects of solid waste management.
- Environmental impact assessment.

Literature

1. **Mackenzie L. Davis, Susan J. Masten. (2003). Principles of Environmental Engineering and Science. 1/e.**

Mode of Assessment:
Test/Quiz: - 20% ***Project: - 20%***
Assignment: - 20% ***Final Exam:- 40%***

1 Ecological concepts and natural resources

Environmental Engineering is the application of scientific and engineering principles to assess, manage and design sustainable environmental systems for the protection of human and ecological health. Environmental Engineering encompasses a range of specialties including:

- Environmental chemistry, microbiology, geology, and ecology
- Hydrology and water resources
- Water quality
- Water and wastewater treatment processes
- Solid and hazardous waste management and Remediation
- Air pollution and air quality control
- Mathematical modeling of environmental processes
- Environmental toxicology and risk assessment
- Environmental impact assessment
- Sustainable engineering systems
- Environmental engineering laboratory

1.1 Components of the environment

The natural environment consists of four segments- ***atmosphere, hydrosphere, lithosphere and biosphere.***

Atmosphere: The atmosphere is the protective blanket of gases surrounding the earth, which sustains life on earth and saves it from hostile environment of outer space. It filters out tissue-damaging ultraviolet radiation. The atmosphere plays a key role in maintaining the heat balance of the earth, through absorption of infrared radiation emitted by the sun and re-emitted from the earth. The atmosphere is the source of oxygen and carbon dioxide. It also supplies nitrogen which nitrogen-fixing bacteria and ammonia manufacturing plants utilize to yield chemically bound nitrogen essential for life. Furthermore, it is a vital carrier of water from oceans to land, as part of the hydrologic cycle.

Hydrosphere: The hydrosphere includes all types of water resources- oceans, seas, rivers, lakes, streams, reservoirs, polar ice caps and ground water. About 97 % of the earth's water supply is in the oceans, where the high salt content does not permit its use for human consumption. About 2 % of the water is locked in the polar ice caps and glaciers, while only 1 % is available as freshwater (rivers, lakes, streams, and ground water) for human consumption and other uses.

Lithosphere: This is the outer shell of the earth, comprising the crust and the uppermost layer of the mantle. It consists of minerals occurring in the earth's crust and the soil. The latter comprises a complex mixture of minerals, organic matter, air and water. The soil is the most important part of the lithosphere.

Biosphere: This denotes the realm of living organisms and their interactions with the environment, viz. atmosphere, hydrosphere and lithosphere. It comprises a number of specific ecosystems.

Ecosystem: is an ecological system that consists of interacting biotic and abiotic components. The biotic components include plants, animals and microbes. The abiotic component comprises physicochemical substances, i.e. basic inorganic elements and compounds such as oxygen, water, carbon dioxide, phosphates and gradients like temperature, wind, moisture, etc. The dynamic nature of the ecosystem due to the interactions between and interdependence of the various components is shown in Fig. 1.1. Ecosystems occur in space and exist in time- they have breadth, width and depth, plus a past as wells as a present and a future.

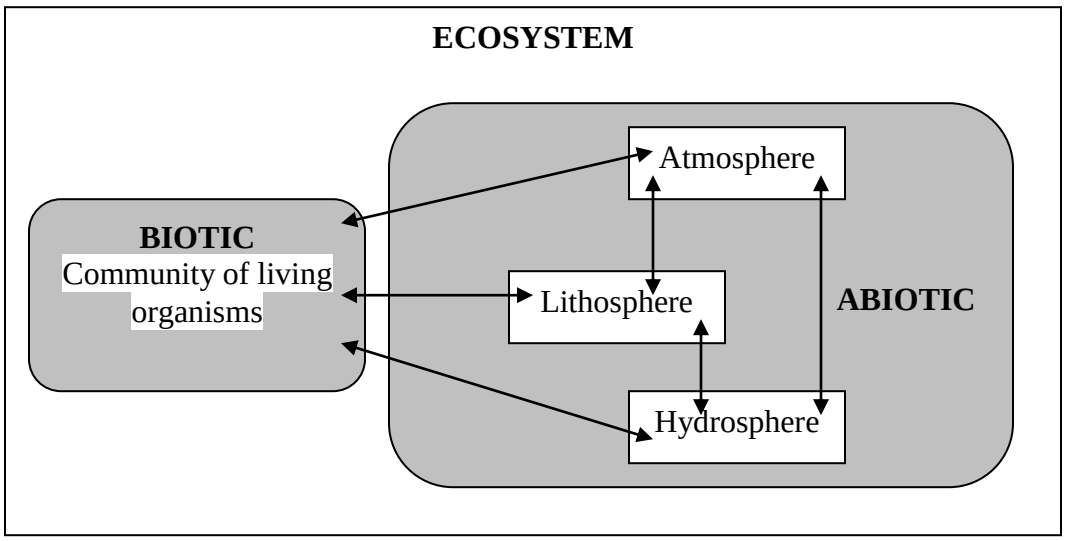


Fig 1.1 Ecosystem interactions

Ecological systems can broadly be classified into two classes: *Aquatic and Terrestrial* ecosystems.

Aquatic ecosystems. Three broad categories of aquatic ecosystems can be distinguished on the basis of major chemical difference- freshwater (river, lake and pond), marine (ocean and sea), and estuarine (coastal, bay, tidal).

Freshwater ecosystems: encompasses all inland bodies of flowing and still water. Flowing water or *lotic* habitats include the different parts of a river: the headwater streams and brooks, mid-valley streams with pools and riffles, the floodplain zone, and the estuaries where rivers flow into the sea. The amount, variability, and reliability of water flow in rivers has enormous significance for plants, animals, and people living along the course of the river. Rivers and their flood plains possess diverse and valuable ecosystems. Hence, great care must be exercised when altering this regime through basin

and river management, as careless handling or over-exploitation of water resources has catastrophic impacts on riparian ecosystems.

Still water or *lentic* habitats (ponds and freshwater lakes) comprise a shallow-water zone or wetlands along the shore; an upper open-water zone that extends to the depth at which light is insufficient for photosynthesis; a deep-water zone on which the warmer, less dense water floats; and a bottom zone of soft mud and silt, where decomposition takes place.

Wetlands are unique transient ecosystems, falling between true aquatic systems on one hand and terrestrial systems on the other. The water table is usually at or near surface, or the land is covered by shallow water. About 6% of the total surface area of the world is covered by wetlands. Wetlands are among the earth's most productive ecosystems.

Box 1.1 Aquatic ecosystems of Ethiopia

Lotic:

- 7000 km total river length
- 12 major river basins
- Total annual surface runoff 110 billions m3

Lentic:

- Lake Tana (3600 km2 area; 14 m max. depth)
- Rift valley lakes (Zeway, Langano, Abiyata, etc.)
- Impoundments (e.g. Koka)

Terrestrial ecosystems: are usually named after the dominant vegetation type of an area. Hence, there can be forest (different types), grassland, and desert ecosystems. Soil and climate are the major factors that determine the distribution of terrestrial ecosystems.

Box 1.2 Major terrestrial ecosystems of Ethiopia:

- Afroalpine and sub-Afroalpine ecosystem (found in > 3200 m.a.s.l)
- Mountain grassland ecosystem (1500 – 3000 m.a.s.l)
- Combertum-Terminalia woodland ecosystem (generally found on rocky sand soils; 500-1900 m.a.s.l)
- Mountain moist forest ecosystem (major forest area in the country; mainly south west)
- Acacia-commiphora woodland ecosystem (900-1900 m.a.s.l; 600-1600 mm annual rainfall (a.r.f); 18-27 ^{O}C temperature)
- Dry evergreen mountain ecosystem (1500-2700 m.a.s.l; 700-1100 mm a.r.f; 17-25 ^{O}C temperature)
- Lowland tropical forest ecosystem (well-drained sand soil; 1300-1800 mm a.r.f; 28-30 ^{O}C temperature; mainly in the lowlands of eastern Gambela)
- Desert and semi-desert scrub land ecosystem (very dry zone; 300-800 mm a.r.f; 1600-2100 mm annual evapotranspiration; 16-27 ^{O}C temperature)

1.2 Ecological processes and natural cycles

Ecological processes

Ecosystems function through two ecological processes- energy flowing in one direction from the Sun, and through nutrients, which are continuously recycled. These two processes are essential for the survival and maintenance of the biotic environment. Light energy is used by plants, which, by the process of photosynthesis, convert it to chemical energy in the form of carbohydrates and other carbon compounds. This energy is then transferred through the ecosystem by a series of steps called a food web. A simplified model for energy and nutrient movement is shown in Fig. 1.2.

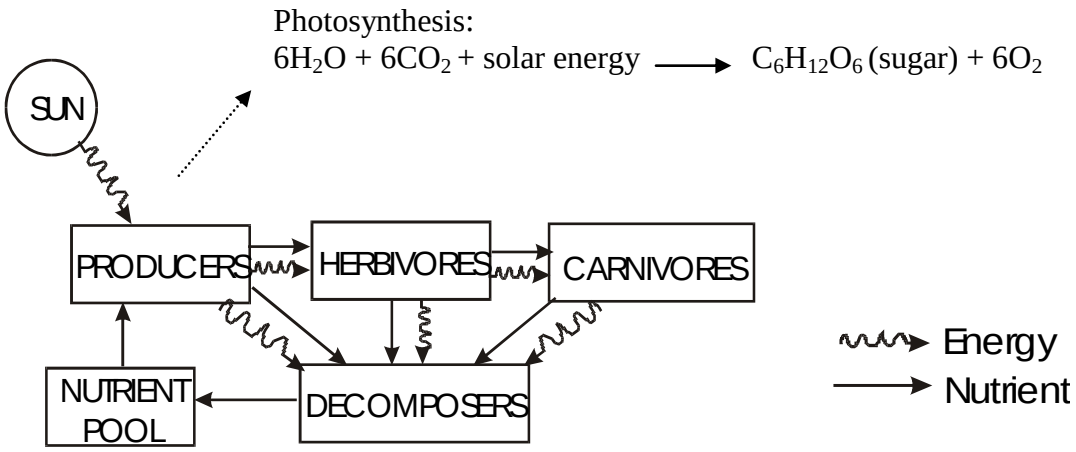


Fig. 1.2 The food web

Energy flow fuels the biogeochemical cycles, or nutrient cycles. The cycling of nutrients begins with their release from organic matter by weathering and decomposition in a form that can be picked up by plants. Plants incorporate nutrients available in soil and water and store them in their tissues. The nutrients are transferred from one trophic level to another through the food web. Because most plants and animals go uneaten, nutrients contained in their tissues, after passing through the decomposer food web, are ultimately released by bacterial and fungal decomposition, a process that reduces complex organic compounds into simple inorganic compounds available for re-use by plants.

Within an ecosystem nutrients are cycled internally. But there are leakages or outputs, and these must be balanced by inputs, or the ecosystem will fail to function. Nutrient inputs to the system come from weathering of rocks, from windblown dust, and from precipitation, which can carry material great distances. Varying quantities of nutrients are carried from terrestrial ecosystems by the movement of water and deposited in aquatic ecosystems and associated lowlands. Erosion and the harvesting of timber and crops remove considerable quantities of nutrients that must be replaced. The failure to do so

results in an impoverishment of the ecosystem. This is why agricultural lands must be fertilized.

Natural cycles of the environment

The natural cycles and ecosystems operate in a balanced manner which stabilizes the entire biosphere and sustains the life processes on earth. Some major natural cycles are discussed below.

The hydrologic cycle: is a continuous natural process which helps in exchange of water between the atmosphere, the land, the sea, living plants and animals (See Fig. 1.4). The solar radiation drives the hydrologic cycle.

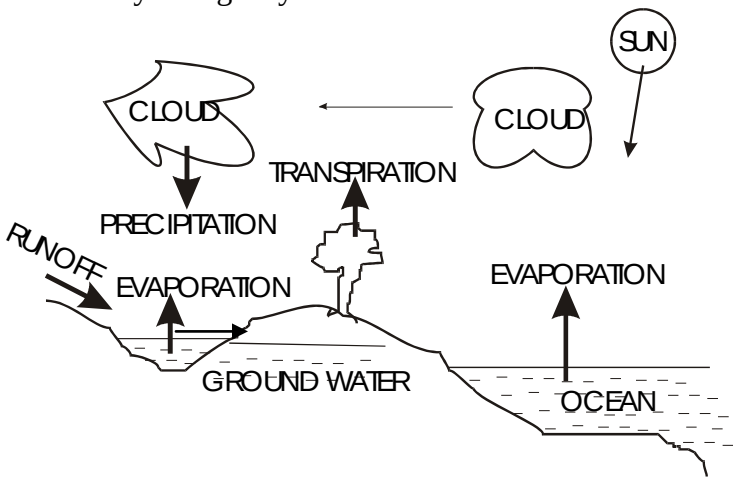


Fig. 1.4 The hydrologic cycle

The Nitrogen cycle: Nitrogen and its compounds are essential for the maintenance of life processes in the biosphere. There is a continuous exchange of nitrogen within ecosystems, operating the nitrogen cycle (See Fig. 1.5).

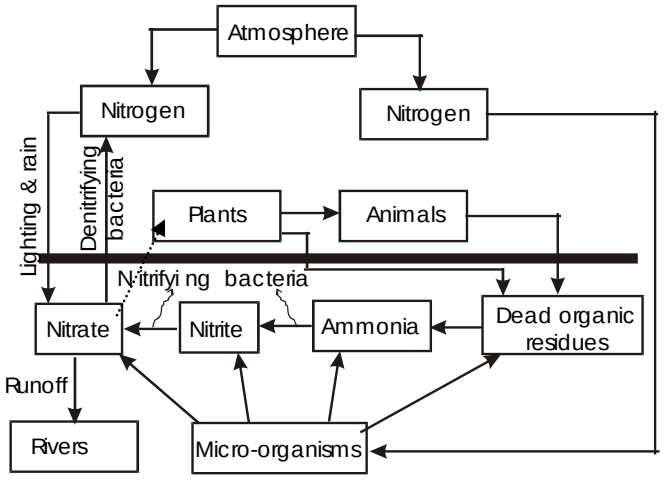


Fig. 1.5 The Nitrogen Cycle

The activities of humans have severely altered the nitrogen cycle. Some of the major processes involved in this alteration include:

- The application of nitrogen fertilizers to crops has caused increased rates of denitrification and leaching of nitrate into groundwater. The additional nitrogen entering the groundwater system eventually flows into streams, rivers, lakes, and estuaries. In these systems, the added nitrogen can lead to eutrophication.
- Increased deposition of nitrogen from atmospheric sources because of fossil fuel combustion and forest burning. Both of these processes release a variety of solid forms of nitrogen through combustion.
- Livestock ranching: Livestock release large amounts of ammonia into the environment from their wastes. This nitrogen enters the soil system and then the hydrologic system through leaching, groundwater flow, and runoff.
- Sewage waste and septic tank leaching.

The Phosphate cycle

Phosphates are important to metabolism in both plants and animals. Phosphorus cycle occurs both in terrestrial and aquatic ecosystems. The natural phosphorus cycle has been affected by pollution, mainly from agricultural runoff containing super-phosphate and also from domestic sewage containing phosphates derived from excreta and detergents. Phosphate pollution of rivers and lakes is the cause of algal bloom (eutophication), which reduces the dissolved oxygen in water and disrupts the natural food chain.

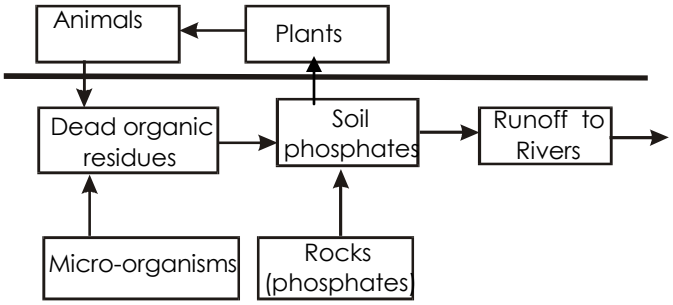


Fig. 1.6 The Phosphate cycle on land

The carbon cycle

Carbon, used by all living organisms, continuously circulates in the earth's ecosystem. In the atmosphere, it exists as the gas carbon dioxide, which is used by plants in the process of photosynthesis. Animals acquire the carbon stored in plant tissue when they eat and exhale carbon dioxide as a by-product of metabolism. Although some carbon is removed from circulation temporarily as fossil fuels and limestone deposits, respiration and photosynthesis balance to keep the amount of atmospheric carbon relatively stable. Industrialization, however, has contributed additional carbon dioxide to the environment.

Figure 1.7 depicts the natural carbon cycle and the increase in atmospheric CO_2 due to combustion of fossil fuel.

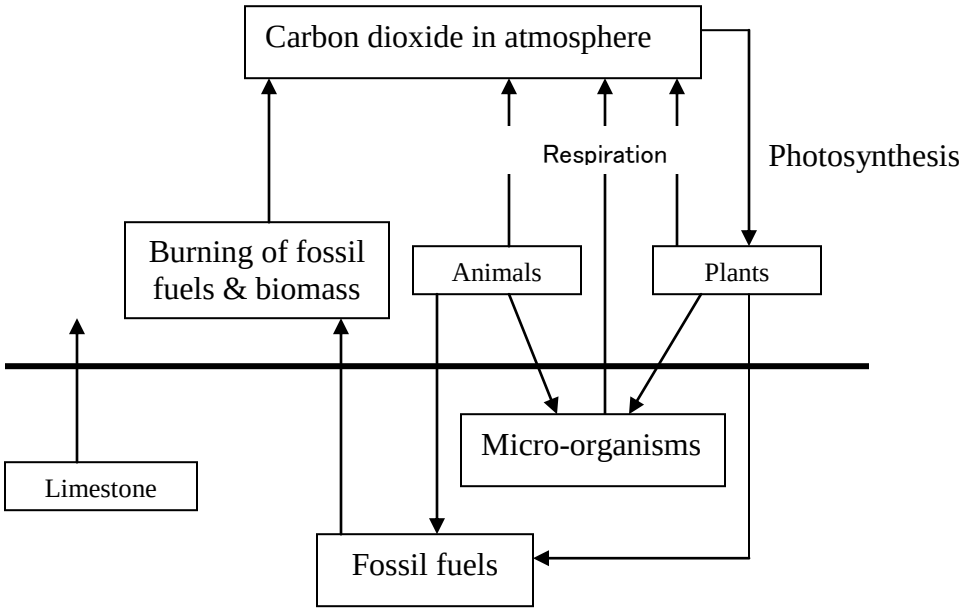


Fig. 1.7 The Carbon Cycle

1.3 The Value of the Environment

Environmental Functions

Many societies today have technological capabilities undreamed of in centuries past. Their citizens have such a global command of resources that even foods flown in fresh from all over the planet are taken for granted, and daily menus are decoupled from the limitations of regional growing seasons and soils. These developments have focused so much attention upon human-engineered and exotic sources of fulfillment that they divert attention from the local biological underpinnings that remain essential to economic prosperity and other aspects of our well-being.

These biological underpinnings are encompassed in the phrase ecosystem functions, which refer to a wide range of conditions and processes through which natural ecosystems, and the species that are part of them, help sustain and fulfill human life. Ecosystems provide human beings with different goods and life support services. Four categories of ecosystem functions can be identified.

Regulation function: this group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems which, in turn, contributes to the maintenance of a healthy environment by providing clean air, water, and soil. Major regulation functions of the natural environment are listed below.

- Protection against harmful cosmic influences
- Regulation of the local and global climate
- Regulation of the local and global energy balance
- Regulation of the chemical composition of the atmosphere
- Regulation of runoff and flood prevention
- Water catchment and ground water recharge
- Prevention of soil erosion and sediment control
- Formation of topsoil and maintenance of soil fertility
- Fixation of solar energy and biomass production
- Storage and recycling of organic matter
- Storage and recycling of nutrients
- Storage and recycling of human waste
- Regulation of biological control mechanisms
- Maintenance of migration and nursery habitats
- Maintenance of biological (and genetic) diversity

Carrier function: natural and semi-natural ecosystems provide space and suitable substrate or medium for many human activities such as habitation, cultivation and recreation. The major ones include:

- Human habitation and (indigenous) settlements
- Cultivation (crop growing, animal husbandry, aquaculture)
- Energy conversion
- Recreation and tourism
- Nature protection

Production function: nature provides many resources, ranging from food and raw materials for industrial use to energy resources and genetic material. They include

- Oxygen
- Water (for drinking, irrigation, industry, etc)
- Food
- Genetic resources
- Medicinal resources
- Raw materials for building, construction, and industrial use
- Biochemicals (other than fuels and medicines)
- Fuel and energy
- Fodder and fertilizer

Information function: natural ecosystems contribute to the maintenance of mental health by providing opportunities for reflection, spiritual enrichment, cognitive development, and aesthetic experience. Specific functions include

- Aesthetic information
- Spiritual and religious information
- Historic information
- Cultural and artistic inspiration
- Scientific and educational information

Valuing the Environment

Different socio-economic values could be attributed to the above environmental functions. These values can be categorized into three major types- Ecological, Social and Economic values.

Ecological values: this is often expressed in qualitative terms; quantification will usually only be possible in "natural" dimensions (e.g. number of species, amount of runoff prevented). Two kinds of ecological values can be distinguished- conservative and existence values.

Conservation value. Many environmental functions do not provide direct benefits but are, nevertheless, quite essential to human welfare. Conservation (non-use) values are mainly provided by the services of natural and semi-natural environments, such as the regulation and information functions. The regulation functions maintain and conserve the environmental conditions necessary for most of the other functions that provide more direct economic benefits. Because of the problems involved in quantifying the economic and monetary value of these non-use benefits, they are usually not reflected in national accounts.

Existence value. This type of value which, stemmed from feelings of stewardship on behalf of future generations and non-human populations, relates to the intangible, intrinsic, and ethical values attributed to nature. The responsibility people feel towards future generations is also called the *bequest value; e*ven if we do not benefit ourselves directly, we do have a responsibility to our children and grandchildren to conserve natural ecosystems and enhance the evolution of biological diversity as much as possible. .

Social values can be quantified by setting acceptable minimum limits for different functions (e.g. acceptable limits of water quality indicators). The values can be seen in two ways:

Health value. Many environmental functions contribute directly or indirectly, to human health. Oxygen, drinking water, and food are essential resources to maintain human life. Natural regulation processes contribute to the maintenance of clear air water and soils. Nature provides a large array of medicinal resources and contributes to mental health by providing a multitude of opportunities for recreation and cognitive development. The socioeconomic importance of this value is evident and the specific contribution of a given ecosystem or function may be expressed in terms of human lives "saved" or in monetary indicators, such as the costs of medical treatment required in the absence of a given function (or the actual loss of life and/or economic damage suffered after a given function is disturbed), for example, the disturbance of the protective function of the stratospheric ozone layer.

Option value. The option value of nature ecosystem and environmental function relates to the importance people place on a safe future (i.e., the future availability of a given amenity, good or service) either within their own lifetime, or for future generations. This

value is therefore sometimes also referred to as *bequest value*, or *serendipity value*. Since the future is uncertain, all types of option value can be seen as a value to risk aversion in the face of uncertainly. It is a type life insurance for access to future benefits from natural ecosystems.

Economic values can be measured by the economic benefits they render to human beings. Three such values can be identified:

Consumptive use value. The consumptive use value of environmental functions relates to the use of natural products, which are harvested directly from the natural ecosystem. This value, therefore, mainly relates to natural resources in the narrow sense, which are included in the category of production functions. Because these natural products are consumed directly, without passing through a market, consumptive use values seldom appear in national income accounts such as Gross National Product (GNP) or Gross domestic product (GDP), although their economic value is often considerable.

Productive use value. The most important part of the traditional economic value of a given good or service is probably still its contribution to the production process which consists of many different sectors, such as agriculture, energy conversion, transportation, and industry. Since this value can relatively easily be expressed in monetary units, the productive use value of natural resources is usually the only economic value of environmental functions, which is reflected in national income accounts.

Employment value. In many economic sectors, employment depends directly on environmental functions, such as peoples who are employed in the management of protected areas and the guiding of recreational activities in nature. In addition jobs held by fishermen and farmers depend on a healthy natural environment and many jobs in industry are in one way or another dependent on environmental functions.

Box 3.1 Some Values of Wetlands

Wetlands have immense values from ecological, economic, biological and aesthetic viewpoints.

- They support extensive freshwater and marine fisheries.
- They are natural sewage treatment plants. An 8-ha marsh or pond can clean 4.54 million liters of raw sewage every day.
- Wetland plants like water hyacinth act as pollution filters for some heavy metals.
- Wetlands serve as the breeding and feeding sites for resident and migrating water birds.
- Wetlands act as an efficient buffer against natural calamities in flood or cyclone-prone areas.
- Wetlands help maintain the water table by recharging ground water.

Monetary valuation of environmental functions

It is possible to calculate monetary values for many of the environmental functions and values, especially for those of direct economic importance. Some of the methods available for this purpose are shown in Table 1.1.

Table 1.1 Monetary valuation methods for environmental values

Value	**Monetary valuation method**						
	Market price	Shadow price					
		Cost of environmental damage	Maintenance costs	Mitigation costs	Willingness to pay /accept	Property pricing	Travel cost
Conservation		X	X	X	X		
Existence			X		X		
Health			X		X		
Option			X		X		
Consumptive	X						
Productive	X					X	X
Employment	X						

It should be stressed that socio-economic valuation of environmental functions does not necessarily mean that the importance of nature and its biological resources is entirely reduced to monetary values. It should be regarded as an addition, and not a replacement of, their many intrinsic and intangible values.

The function valuation system presented above can be helpful in many ways, notably in Environmental Impact Assessment and Cost Benefit analysis. An important application area is the use in providing ecological baseline information for development projects. Especially for drafting environmental profiles, country reviews and formulating carrying capacity limits, information on environmental functions and values is essential.

Information on environmental functions and values may also be used to provide more general guidelines for development assistance or national government policies. In order to obtain a clear insight into the environmental trade-offs involved in alternative development projects, environmental impact assessment studies should assess both the direct environmental effects of certain human activities or interventions in a given area, and the environmental functions and hazards affected by the activity.

1.4 Environmental problems

Environmental problems range from “Brown” to “Green” issues. The “Brown” issues include environmental health problems and pollution. They are primarily local and urban in nature. Issues related to resource depletion and degradation are termed as “Green” problems and can be global or transnational in spatial extent. Specific environmental problems include:

- Lack of access to environmental infrastructures such as water supply, wastewater and drainage systems, solid waste management, etc.)

- Pollution (water, indoor air, outdoor air, soil, noise, light)
- Resource depletion and degradation (deforestation, land degradation, soil erosion, over fishing, depletion of non-renewable resources, etc.)
- Conservation (biodiversity, habitat loss and fragmentation, endangered species, etc.)
- Climate change
- Natural hazards (flooding, earthquake, volcanic eruption, landslide, etc.)

Environmental problems may have adverse impacts on ecological, social and economic values. It is of great importance to assess/predict the magnitude of environmental impacts on these values. It is also necessary to identify the underlying causes and factors that are responsible for environmental problems. Table 1.2 represents diverse biophysical and socio-economic factors that result in ecosystem degradation.

Table 1.2 Major factors that involve in ecosystem degradation

Factor	Sub-factors	Specific factors
Biophysical	Climatic	Rainfall, temperature, wind direction, etc.
	Physiographic	Topography, altitude, slope
	Edaphic	Soil-water, soil types & conditions
	Landuse change	Settlement, agriculture, etc.
Socio-economic	Demographic	Population density, age/education structure, migration, settlement pattern
	Economic	Income level, occupational structure, tenure status, market/credit facilities
	Cultural	Beliefs, values, attitudes and perceptions, indigenous technologies
	Political	Decision-making system, developmental policy priorities, trade practices & policy

2 Introduction to Environmental Processes

Knowledge of various environmental physical, chemical, and biological processes is important to model the fate contaminants and to design pollution control systems.

2.1 Physical processes

The physical processes of relevance in environmental engineering include sedimentation, resuspension, filtration, volatilization, and transport processes that include advection and dispersion.

Sedimentation is a gravitational accumulation of particles (essentially solid particles) at the bottom of a fluid (air or water). Roles of sedimentation in environmental engineering include r*emoval of solids from drinking water, removal of solids from waste water, removal of solids from runoff water, removal of solids from air emissions.*

The rate of sedimentation in a fluid is influenced by the particle and fluid characteristics;

Particle characteristics: size, density, shape, charge
Fluid characteristics: density, viscosity, flow rate

Principal physical mechanisms that are responsible for the transport of pollutants in a fluid are:

Advection- transport due to the bulk movement of fluid
Dispersion- transport due to molecular or turbulent diffusion
Buoyancy- transport due to vertical temperature gradient

Advection is the dominant transport mechanism in river systems. Buoyancy is important in lentic aquatic systems like lakes, oceans, etc. diffusion is most significant in quiescent systems if the concentration gradient of the pollutant is significant.

2.2 Chemical processes

Various chemical processes of environmental significance take place in the water, air and soil environment. Examples include acid-base reactions, precipitation reactions, etc. The concentration of constituents that involve in the process can be expressed in two ways-

Mass/volume and *Mass/mass* methods.

Mass/volume: mass of a solute per unit volume of solution, mg/L = ppm (parts per million)

Mass/mass: mass of a solute in a given mass of solution, mg/kg

The mass of inputs and outputs in the process can conveniently be accounted by applying the concept of mass balance.

2.2.1 Mass balance

Mass balances are applied to rivers, lakes, or treatment basins, where the problem is to find the concentration of a substance at a location or its rate of change in a section. Material balances are useful as a check on measurements of all streams that may be difficult or impossible to measure directly. Mathematically, mass balance can be illustrated by three equations:

1. What comes in equals what goes out (Steady state)
   Input = Output

2. Material accumulates within the system

   Accumulation = Input – Output

3. Material is produced or consumed within the system

   Accumulation = Input – Output + Production – Consumption

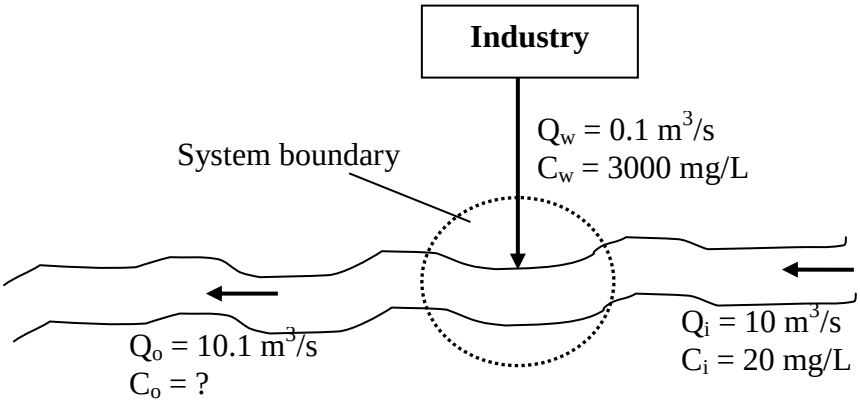
The following guidelines may be used for solving problems that involve mass balances.

1. Draw a diagram or flowchart of the process
2. Calculate all weights, flow rates, concentrations, and so on, which can be determined from the information provided without making balances
3. Show all known data (flow rates, concentrations, etc.) on the diagram
4. give appropriate symbols to any unknown quantities, and indicate each unknown by a question mark
5. Select a convenient basis on which to carry out all calculations, for example, a suitable time interval, such as a day or a second, or a fixed quantity of material such as 1 kg
6. Select the appropriate system boundaries for the material balance(s) to be made. Choose boundaries in such a way that calculations are kept as simple a possible
7. Write the material balances. These may include a balance on the total material and a balance for each of the component materials involved ion the problem.
8. Make, assumptions, if any are necessary, that make the problem simpler.

Example:

An industry discharges its liquid waste into a river that has a minimum flow rate of 10 m^3/s. The major pollutant in the waste is a conservative material called P. The waste stream has a flow rate of 0.1 m^3/s, and the concentration of P in the waste stream is 3000 mg/L. upstream pollution has cause a concentration of 20 mg/L P in the river upstream of the industrial discharge under the minimum flow rate conditions. The state regulatory agency has set a maximum limit of 100 mg/L P in the river. Assume that complete mixing occurs in the river. Will the industry be able to discharge the waste without treatment?

Solution



A material balance on P for an interval of 1 second is,

$$\text{Input} = \text{Output}$$

$$\text{Input}_{\text{u/s river}} + \text{Input}_{\text{waste}} = \text{Output}_{\text{d/s river}} \text{ or}$$
$$Q_iC_i + Q_wC_w = Q_oC_o$$

Substituting and solving for Co,

Co = 49.5 mg/L

Therefore, no treatment is needed.

2.2.2 Reaction kinetics and reactors

Many processes in environmental engineering that take place in tanks or natural systems undergo changes over time. The tank or the natural system in which the change takes

place is called a ***reactor***. The process of change is called ***reaction kinetics***. The original compounds prior to the reaction are called ***reactants*** and the compounds formed by the reaction are termed as ***products***. The speed at which the process takes place is known as ***reaction rate***. Knowledge of the rate and extent of reaction is important to size and cost the reactor. A process may be biological, biochemical, or chemical. Examples include:

- Biochemical growth/decay of biomass/organic material in activated sludge, in anaerobic digestion
- Chemical processes of disinfection of potable water by chlorination
- Gas-water transfer, e.g. removal of H_2S from groundwater
- Diffusion of effluents in rivers
- Chemical reactions of contaminants in the air environment
- Biochemical production of methane in a landfill site

Based on the relationship between the rate of reaction (k_i ; i = 0, 1, 2,…) and the concentration (C), different orders of reaction can be identified as shown in Table 2.1.

Zero-order is defined where the rate of reaction is independent of the concentration.

First-order is defined where the rate is directly proportional to the concentration.

Second-order is defined where the rate is proportional to the square of the concentration.

Table 2.1

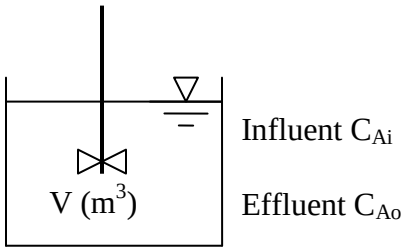
Order of reaction	**Equation**
Zero-order	$-\frac{dC}{dt} = k_0$ $C - C_0 = -k_0 t \quad ; \; C = C_0 \; at \; time \; t = 0$
First-order	$-\frac{dC}{dt} = k_1 C$ $\ln(\frac{C_0}{C}) = k_1 t$
Second-order	$-\frac{dC}{dt} = k_2 C^2$ $\frac{1}{C} - \frac{1}{C_0} = k_2 t$

Types of Reactors

There are three principal kinds of reactors: ***batch reactors, continuous stirred tank reactors and plug flow reactors***.

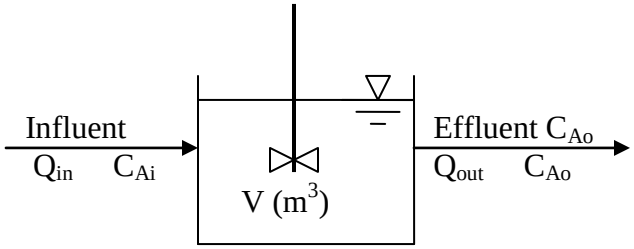
Batch Reactors (BR)

The reactants are input to the reactor at the desired conditions and the reaction takes place over a specified period of time. The contents are then discharged. The longer the reaction time, the more complete the conversion.



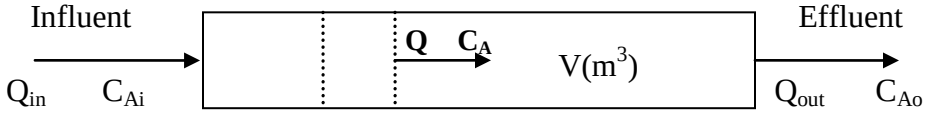
Continuous Flow Stirred Reactors (CSTR)

Reactants are continuously (may be once per day, per hour, etc.) are fed to the reactor and the products (including unused reactants) are continuously discharged from a well-mixed vessel. Being well-mixed, the contents are assumed uniform in concentration throughout with no concentration gradients and therefore equal to the effluent concentration. Increasing residence time in the tank increases the extent of conversion. This reactor is common in wastewater treatment and anaerobic processes.



Plug Flow Reactors (PFR)

The input is fed in at one end of a long reactor and products are discharged at the other end after spending a minimum retention time in the system. As the distance of travel along the length of the reactor is a function of time, the extent of conversion depends on the length. As such, the longer the reactor, the greater the conversion. This reactor is most common in activated wastewater treatment.



$$\mathbf{C_{Ao} > C_A > C_{Ai}}$$

Reactor performance analysis

Basic equation:

Input – Output + Generation = Accumulation

- Accumulation may be positive or negative
- Input may be through the system boundaries or by generation within the reactor due to reaction
- Output may be flow through the system boundaries or by consumption due to reaction.

The material balance for a material A may be written as

$$QC_{Ai} - QC_{AO} + r_A V = V\frac{dCA}{dt}$$

Where,

Q = the flow rate, m3/s
C_A = concentration of material A, mg/l
C_{Ai} = influent concentration, mg/l
C_{AO} = effluent concentration, mg/l
V = volume of fluid in the reactor, m3
r_A = rate of reaction of material, mg/L-s

Batch process

Substituting Q = 0 and V = constant in the basic equation

$$r_A = \frac{dCA}{dt}$$

Solutions:

Zero-order reaction: substituting $r_A = k_0$ in the above equation and integrating

$$C_{Ai} - C_{AO} = k_0 t$$

First-order reaction: substituting $r_A = -k_1 C_A$ and integrating,

$$\ln(\frac{C_{A0}}{C_{Ai}}) = -k_1 t$$

CSTR process

For steady state, accumulation = 0, and the general equation becomes:

$$QC_{Ai} - QC_{AO} + r_A V = V\frac{dCA}{dt} = 0$$

From which, $$-r_A = \frac{Q}{V}(C_{Ai} - C_{A0})$$

Solutions:

Zero-order reaction ($r_A = k_o$):

$$C_{Ai} - C_{AO} = k_o \frac{V}{Q} = k_o Ø$$

Where, $\frac{V}{Q}$ is termed as hydraulic retention time (Ø)

First-order reaction ($r_A = -k_1 C_{A0}$):

$$\frac{C_{Ai} - C_{AO}}{C_{A0}} = k_1 Ø$$

2.3 Biological processes

Biological processes that affect the movement and form of substances in the environment include uptake, biotransformation, bioaccumulation, and trophic transfer (passage of a contaminant through the food web).

2.3.1 Environmental Microbiology

Microbiology is the study of micro-organisms, which are distinct from all other matter by their small size, in the range of 10^{-5} to 10^{0} mm. Environmental microbiology is concerned with microorganisms found in water, wastewater, air and soil that may affect public health, decompose organic matter, or perform useful function.. An environmental engineer should understand the role of micro-organisms in the particular environment, so as to beneficially transform that environment. Some important roles of microorganisms include determination of chlorine dosage in water treatment, biological treatment of wastewater, remediation of contaminated soil and groundwater, closing biogeochemical cycles, etc. Microorganisms in the environment can be classified as presented in Table 2.1

Table 2.1 classification of the microbial world

Microbial kingdom	***Some microbes***
Animals	Worms, Helminths
Plants	Aquatic plants, Macrophytes, Seed plants, Ferns, Mosses
Higher protista	Fungi, Algae, Protozoa, Rotifiers, Crusacea
Lower protista	Bacteria, Blue-green algae
Viruses	Many

Bacteria

Bacteria are the dominant organisms in biological wastewater treatment systems, and in many ecological systems. The rate of growth of the bacteria population can be expressed mathematically as follows:

$$\boldsymbol{dN/dt = kN}$$

Where,

dN/dt = rate of growth
N = number of bacteria at time t
k = first-order growth rate constant

Based on the different growth factors bacteria can be classified as follows:

Carbon source	Inorganic (CO2) Organic	Autotrophs Heterotrophs
Energy source	Sunlight Oxidation reaction	Phototrophs Chemotrophs
Oxygen	Require oxygen Do not require oxygen Oxygen/No oxygen	Aerobic Anaerobic Facultative
Temperature	0-15^{o}C 15-45^{o}C >45^{o}C	Psychrophiles Mesophiles Thermophiles
Pressure	High pressure	Barophiles
pH	Strong acids	Acidophiles
Salt concentration	High	Halophiles

Most bacterial processes found in environmental engineering applications are either aerobic or anaerobic. The general models for these processes are represented below:

Aerobic

AEROBIC

Organic Matter + O_2 $\xrightarrow{\text{aerobes}}$ New Biomass + $CO_2 + H_2O + NH_4 + NO_3^- + NO_2^-$

ANAEROBIC

Organic Matter + H_2O + Nutrients $\xrightarrow{\text{anaerobes}}$ New Biomass + $CO_2 + CH_4 + NH_3 + H_2S$ +heat

Bacteria of special interest in environmental engineering are indicated in Table 2.2.

Table 2.2 Bacteria of special interest in environmental engineering

Group of bacteria	Some Genus	Environmental significance
Pathogenic bacteria	*Salmonella* *Shigella* *Mycobacterium*	Cause typhoid fever Cause dysentery Cause tuberculosis
Indicator bacteria	*Escherichia,* *Enterobacte* *Streptococcus* *Clostridium*	Faecal pollution Faecal pollution Faecal pollution Faecal pollution
Decay bacteria	Pseudomonas Zooglea Micrococcus Methanococcus	Degrade organics Form floc in activated sludge plants Produce fatty acids from organics in anaerobic digester Produce methane gas from acids in anaerobic digester
Nitrifying bacteria	Nitrobacter	Oxidize inorganic nitrogen compounds

	Nitrosomonas	Oxidize inorganic nitrogen compounds
Denitrifying bacteria	*Bacillus* *Pseudomonas*	Reduce nitrate or nitrite to nitrogen gas or nitrous oxide Reduce nitrate or nitrite to nitrogen gas or nitrous oxide
Nitrogen-fixing bacteria	*Azotobacter* *Beijerinckia*	Capable of fixing atmospheric nitrogen to NH_3 Capable of fixing atmospheric nitrogen to NH_3
Sulphur bacteria	*Thiobacillus* *Desulfovibrio*	Oxidize sulphur and iron Involved in corrosion of iron pipes
Photosynthetic bacteria	Chlorobium Chromatium	Reduce sulphides to elemental sulphur Reduce sulphides to elemental sulphur
Phosphorus bacteria	*Acinetobacter*	Responsible for phosphorus removal in wastewater
Iron bacteria Filamentous Iron oxidizing	 *Sphaerotilius* *Leptothrix*	 Responsible for sludge bulking in activated sludge plants Oxidize ferrous iron

Pathogens

A pathogen is an agent that causes infection in a living host. It acts as a parasite within a host or host cells and disrupts normal physiological activities. Pathogenic organisms that can cause diseases in humans include some species of bacteria, viruses, algae, and fungi as well as protozoa and helminthic (parasitic worm) organisms. Diseases of great interest in environmental field include waterborne (e.g. cholera, giardiasis), airborne (pulmonary tuberculosis, influenza), and insect- and rodent-borne (e.g. malaria) diseases.

Table 2.3 Typical Pathogens Excreted In Human Feces

Pathogen Group and Name	Associated Diseases
Virus	
Adenoviruses	Respiratory, eye infections
Enteroviruses	
Polioviruses	Aseptic meningitis, poliomyelitis
Echoviruses	Aseptic meningitis, diarrhea, respiratory infections
Coxsackie viruses	Aseptic meningitis, herpangina, myocarditis
Hepatitis A virus	Infectious hepatitis
Reoviruses	Not well known
Other viruses	Gastroenteritis, diarrhea
Bacterium	
Salmonella typhi	Typhoid fever
Salmonella paratyphi	Paratyphoid fever
Other salmonellae	Gastroenteritis
Shigella species	Bacillary dysentery
Vibrio cholerae	Cholera
Other vibrios	Diarrhea
Yersinia enterocolitica	Gastroenteritis

Protozoan	
Entamoeba histolytica	Amoebic dysentery
Giardia lamblia	Diarrhea
Cryptosporidium species	Diarrhea
Helminth	
Ancylostoma duodenale (hookworm)	Hookworm
Ascaris lumbricoides (roundworm)	Ascariasis
Hymenolepis nana (dwarf tapeworm)	Hymenolepiasis
Necator americanus (hookworm)	Hookworm
Strongyloides stercoralis (threadworm)	Strongyloidiasis
Trichuris trichiura (whipworm)	Trichuriasis

Source: Hammer and Hammer, 1996.

Waterborne-related diseases

Water related diseases can be of waterborne, water-washed, water-based, and water-related insect vectors. The first three are most clearly associated with lack of improved domestic water supply.

Table 2.4 Classification Of Infectious Diseases Associated With Water

Transmission mechanism	Description	Examples of diseases
Waterborne	Oral ingestion of pathogens in water contaminated by urine or feces	Cholera, typhoid, bacillary dysentery, infectious hepatitis
Water-washed	Disease spread enhanced by scarcity of water making cleanliness difficult	Trachoma, scabia, dysentery, louseborne fever
Water-based	Water provides the habitat for intermediate host organisms, transmission to humans through water contact	Schistosomiasis (bilharziasis), dracunculiasis (guinea worm)
Water-related	Insect vectors (e.g., mosquitoes) rely on water for habitat, but human water contact not needed	Malaria, filariasis, yellow fever onchocerciasis (river blindness), dengue

3 Water Quality Engineering

Water quality is a term that implies some value judgment of the water with respect to a particular use. There are a variety of uses for water each requiring their own set of specific quality requirements. These can be categorized into simple groups, such as:

1. those requiring water of highest quality and free of pathogens; uses include: drinking water supply, salmonid fishery, swimming and certain industrial processes such as food processing;
2. those requiring water of lesser quality but still free from toxins and pathogens; uses include: amenity and recreation such as boating, irrigation and certain industries;
3. where quality is unimportant; use include: cooling water and navigation.

Water quality degradation interferes with vital and legitimate water uses at scales from local to regional to international levels. Water quality parameters and standards are therefore necessary to ensure that the appropriate quality of resource is available to a particular use.

3.1 Water quality parameters and standards

Parameters that define a water quality may be classified into three broad categories: physical, chemical, and biological parameters (Table 3.1).

Table 3.1(a) Physical parameters

Parameter	Significance
Temperature	Temperature of water is a very important factor for aquatic life. It controls the rate of metabolic and reproductive activities, and determines which fish species can survive. Temperature also affects the concentration of dissolved oxygen and can influence the activity of bacteria and toxic chemicals in water.
Conductivity	Conductivity is a measure of how well water can conduct an electrical current. Therefore, conductivity is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron, and can be used as an indicator of water pollution.
Total Suspended Solids (sand, silt, clay, in colloidal suspension)	Total Suspended Solids (TSS) are solids in water that can be trapped by a filter. High concentrations of suspended solids can cause many problems for stream health and aquatic life. TSS may destroy fish habitat through blanketing of fish spawning and feeding areas and elimination of certain food organisms; directly affect fish through gill abrasion and fin rot; reduces sunlight penetration, thereby impairing photosynthesis of aquatic plants. Suspended sediment decreases recreational values, reduces fish habitat, adds to the mechanical wear of water supply pumps and distribution systems, and adds treatment costs for water supplies. Nutrients and toxic substance attached to sediment particles are transported to water bodies and may enter aquatic food chains, cause fish toxicity problems, impair recreational uses, or degrade the water as a drinking water source.
Total dissolved solids	Total Dissolved Solids (TDS) are solids in water that can pass through a filter (usually with a pore size of 0.45 micrometers). TDS is a measure of the amount of material dissolved in water. This material can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. If TDS concentrations are too high or too low, the growth of many aquatic lives can be limited, and death may occur. TDS is used to estimate the quality of drinking water, because it represents the amount of ions in the water. Water with high TDS often has a bad taste and/or high water hardness, and could result in a laxative effect.
Turbidity	Turbidity is a measure of the cloudiness of water. Turbidity in water is caused by suspended matter such as clay, silt, and organic matter and by plankton and other microscopic organisms that interfere with the passage of light through the water. Turbidity is closely related to total suspended solids (TSS), but also includes plankton and other organisms. Turbidity itself is not a major health concern, but high turbidity can interfere with disinfection and provide a medium for microbial growth. It also may indicate the presence of microbes.

Table 3.1(b) Chemical parameters

Dissolved Oxygen (DO)	Dissolved Oxygen (DO) is found in microscopic bubbles of oxygen that are mixed in the water and occur between water molecules. DO is a very important indicator of a water body's ability to support aquatic life.
Oxygen demanding organics: BOD, COD, TOC, etc.	Organic materials may enter surface waters dissolved or suspended in runoff; natural decomposition of these materials may deplete dissolved oxygen supplies in the surface waters. Dissolved oxygen may be reduced to below the threshold necessary to maintain aquatic life, harming or killing fish and other aquatic plants and animals.
Nutrients (phosphorus and nitrogen- Total nitrogen, Kjeldahl N)	Nutrient enrichment of surface waters may cause excessive algae and aquatic plant growth, chocking open waters consuming oxygen (mainly through plant die-off); fish and aquatic organisms, fishing and boating, and the use of the resources of water supply are thereby affected. Nitrogen contaminants in drinking water significantly above the drinking water standard may cause methoglobinemia (a blood disease) in infants, and have forced closure of several water supplies.
Principal inorganic cations and anions: Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Fe^{+}, Mn^{2+}, $HCO3^{-}$, CO_3^{2-}, Cl^{-}, SO_4^{2-}, NO_3^{-}, PO_4^{3-}, F^{-}	See next page
Toxic substances: e.g. Arsenic, Asbestos, Lead, Zinc, Mercury, synthetic organics like cyanide, phenols, pesticides, etc.	These substances become toxic in excess. Toxic chemicals may enter surface waters either dissolved in runoff or attached to sediment or organic materials, and may enter groundwater through soil infiltration. The principal concerns in surface water are their entry into the food chain, bioaccumulation, toxic effects on fish, wildlife, and micro-organisms, habitat degradation, and potential degradation of public water supply sources; the groundwater impacts are primarily related to water supply sources.
pH	pH represents the effective concentration of hydrogen ions (H^{+}) in water. The pH of most mineral waters is 6 to 9. Most ecological life is sensitive to pH changes. It is also important to maintain appropriate pH level in water and wastewater treatment processes.
Hardness	Hardness is measure of polyvalent cations (ions with a charge greater than +1) in water. Hardness generally represents the concentration of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions, because these are the most common polyvalent cations. Other ions, such as iron (Fe^{2+}) and manganese (Mn^{2+}), may also contribute to the hardness of water, but are generally present in much lower concentrations. Waters with high hardness values are referred to as "hard," while those with low hardness values are "soft". Hardness affects the amount of soap that is needed to produce foam or lather. Hard water requires more soap, because the calcium and magnesium ions form complexes with soap, preventing the soap from sudsing. Hard water can also leave a film on hair, fabrics, and glassware. Hardness of the water is very important in industrial uses, because it forms scale in heat exchange equipment, boilers, and pipe lines. Some hardness is needed in plumbing systems to prevent corrosion of pipes. Hardness mitigates metals toxicity, because Ca^{2+} and Mg^{2+} help keep fish from absorbing metals such as lead, arsenic, and cadmium into their bloodstream through their gills. The greater the hardness, the harder it is for toxic metals to be absorbed through the gills.
Alkalinity	Alkalinity is a measure of the buffering capacity of water, or the capacity of bases to neutralize acids. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater. Alkalinity does not refer to pH, but instead refers to the ability of water to resist change in pH. The presence of buffering materials helps neutralize acids as they are added to the water. These buffering materials are primarily the bases bicarbonate (HCO_3^{-}), and carbonate (CO_3^{2-}), and occasionally hydroxide (OH^{-}), borates, silicates, phosphates, ammonium, sulfides, and organic ligands. Waters with low alkalinity are very susceptible to changes in pH. Waters with high alkalinity are able to resist major shifts in pH. Alkalinity not only helps regulate the pH of a water body, but also the metal content. Bicarbonate and carbonate ions in water can remove toxic metals (such as lead, arsenic, and cadmium) by precipitating the metals out of solution.

Table 3.1(c) Biological parameters

Indicator microorganisms (Coliforms): Fecal coliform (E.coli), Fecal streptococci, total coliforms, etc	Used to determine the presence of pathogenic organisms in natural and treated water.
Aquatic plants and animals	Presence/absence of certain species may reveal the health of the aquatic ecosystem

Water quality standards are developed as rules by which to measure the quality of water. They normally state the amount of a particular pollutant which is viewed as not likely to cause some kind of harm to users. They can be used for several purposes. First, they are used as a basis for assessing water quality data. If the degree of pollution is at or below the standard, it is good, and if it above the standard, it is bad. Second, they are used as a regulatory or educational tool. They can be used as a "trigger" for initiating some kind of action, or as an "end point" for terminating action. This allows them to be viewed by different people in totally different ways. As a trigger, they in effect set an upper limit on the degree of pollution which will be allowed by society before something must be done to control it. As an end point they, in effect set a lower limit on the degree of pollution which is not acceptable by the society. Control measures which get the pollution level down to the standard are considered adequate, and further efforts to control the pollution are not required. Thus environmentalists see standards as preventing further water quality improvement, and economists see standards as requiring costly control measures.

Types of water quality standards include *ambient water quality standard (*e.g. surface water quality standard*), water abstraction standard* (e.g. drinking water quality standard, irrigation water standard) and *effluent standard* (Fig. 3.1).

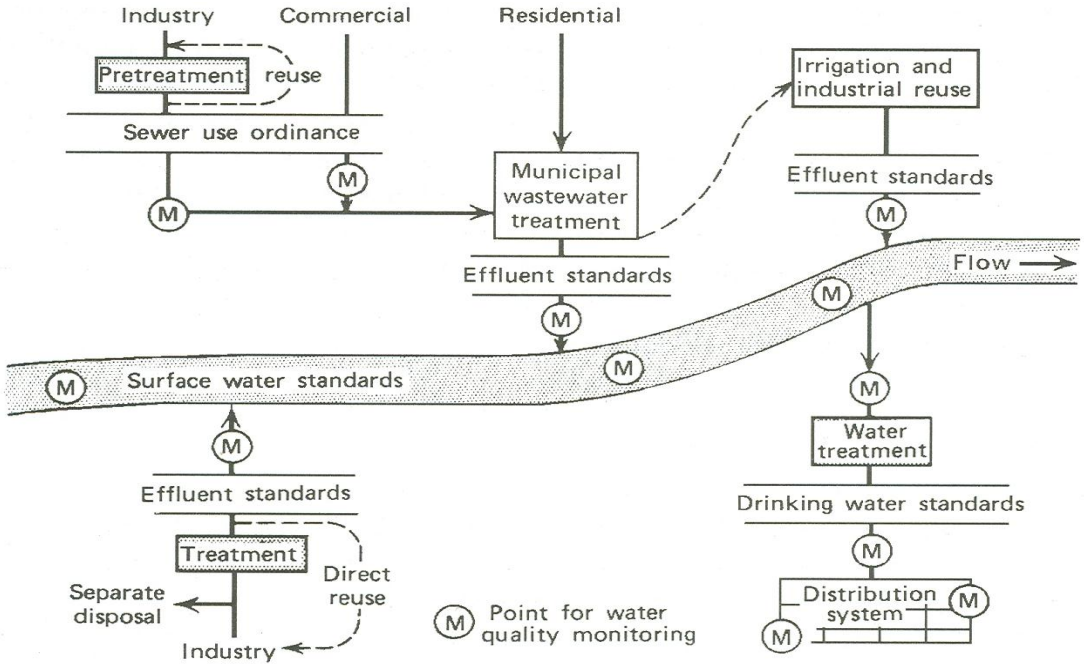


Fig. 3.1 Types of water quality standards

Water quality assessment

Water quality assessment is critical for pollution control and protection of the surface and ground waters. The selection of parameters for water quality assessment is dependent on the type of receiving water, the nature of the discharges into the receiving water, water use and any legal designation relating to the system. Some of the key parameters of to be used for water quality assessment may include the following:

- River: BOD, DO, Temperature, NH3, Cl, PO_4, NO_3, etc.
- Lake: DO, Temperature, PO_4, NO_3, SiO_2, Fe, Mn, Na, K, etc.
- Drinking water: Coliforms, Fe, Mn, Toxic metals, Pesticides, etc.
- Biodegradable effluents: BOD, COD, TSS, NH_3, PO_4, etc.
- Toxic effluents: BOD, COD, TSS, NH_3, Metals and/or other toxic compounds
- Water source quality appraisal: hardness, alkalinity, pH, Color, Conductivity, Iron, Chloride, Na, K, Silica, SO_4, Temperature, etc.

Water quality assessment requires a number of specific activities that include definition of objectives, sample collection, laboratory analysis, data analysis and interpretation Fig. 3.2)

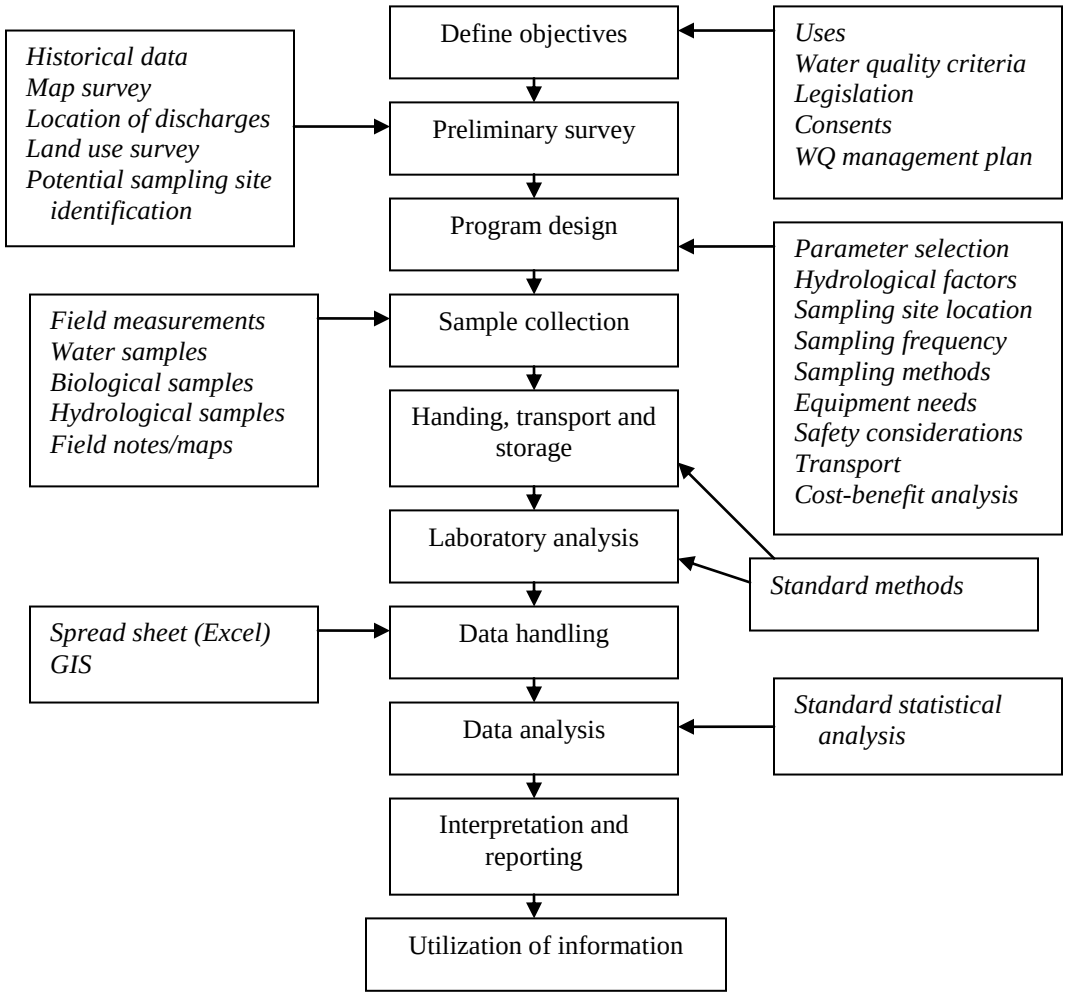


Fig. 3.2 Main components of a water quality assessment program

3.2 Water pollution and control

Water pollution

Water pollution may be defined as man-made or man-induced alteration of the chemical, physical, biological, or radiological integrity of water. Pollution of water may adversely affect human and ecological health as well as impair the use of water for other activities. The sources of water pollution can be point or nonpoint sources (Fig. 3.3).

Point sources of pollution include municipal and industrial wastewaters for which specific points of entry to a receiving water body can be identified. Key characteristics of point sources of pollution include:

- Single or multi-point location
- Discharge contains pollutants
- Volume of discharge generally unaffected by weather
- National Pollution Discharge Elimination System (NPDES) permit required to discharge; EPA authorizes state agency (e.g., WV DEP) to issue permits
- Controls required (usually through water treatment)

Nonpoint sources of pollution include general land runoff from urban and agricultural areas and other diffuse sources that do not have specific discharge points. The major charcatreistics of nonpoint source pollution are:

- Diffuse, source not easily located
- Highly variable in time and correlated with weather
- Prevention more effective (more difficult to treat)
- Largely unregulated, hence, voluntary

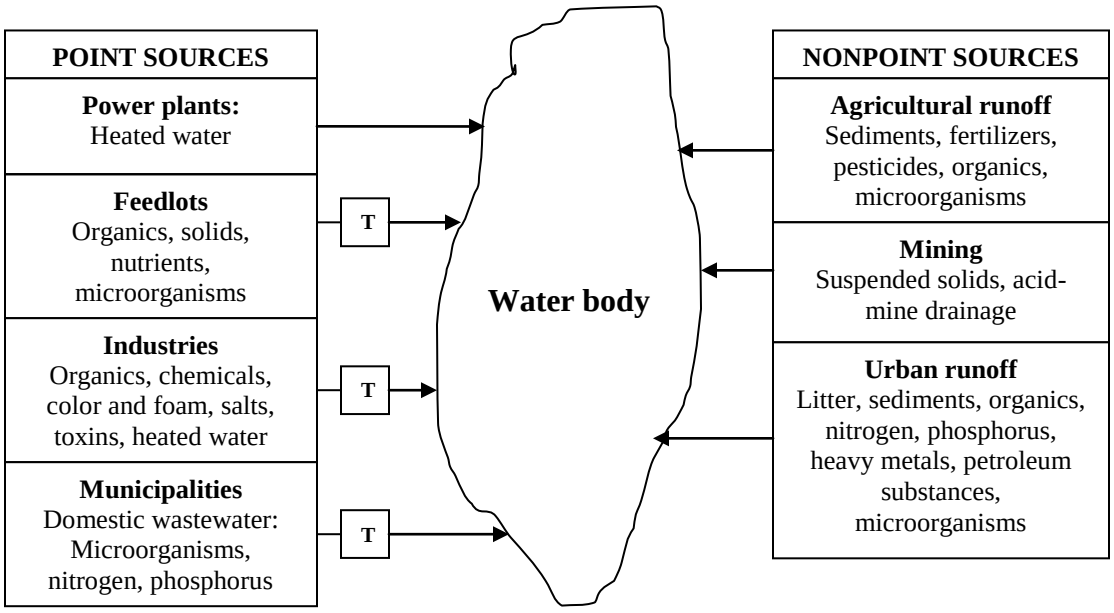


Fig. 3.3 Major sources of water pollution

Major types of water pollution

- Pathogenic organisms which have a direct health impact on human beings (e.g. Typhoid, Cholera, etc.). This type of pollution is expressed in terms of the number of coliform bacteria per 100 ml of water sample (MPN/100 ml).
- *Organic pollution*. Biodegradation of oxygen demanding wastes deplete the dissolved oxygen content of the water body. The decrease in the DO content has in turn an adverse effect on the various aquatic species such as fish. The strength of the oxygen demanding waste is often expressed by BOD (Biochemical Oxygen Demand).
- *Eutrophication (Cultural).* This is due to the enrichment of water bodies by nutrients (Nitrogen and Phosphorus). Eutrophication results in abundant plant growth which in turn accelerates ageing of aquatic bodies. This problem occurs mainly in lakes, reservoirs and in slow-flowing rivers. Based on the level of nutrient level lakes can be classified into different types as shown Table 3.2. Phosphorus is typically the limiting nutrient in lakes, and algae growth is linked to phosphorus inputs. Nitrogen is often the limiting nutrient in ocean waters and some streams

Table 3.2 Lake classification

Lake Classification		Chlorophyll *a* Concentration ($\mu g \cdot L^{-1}$)	Secchi Depth (m)	Total Phosphorus Concentration ($\mu g \cdot L^{-1}$)
Oligotrophic	Average	1.7	9.9	8
	Range	0.3–4.5	5.4–28.3	3.0–17.7
Mesotrophic	Average	4.7	4.2	26.7
	Range	3–11	1.5–8.1	10.9–95.6
Eutrophic	Average	14.3	2.5	84.4
	Range	3–78	0.8–7.0	15–386
Hypereutrophic		> 50	< 0.5	Often >100

- *Toxic and hazardous substances.* The pollutants of concern are heavy metals (e.g. lead, mercury, zinc, etc.) and non-metallic salts (e.g., arsenic, selenium), synthetic organics (e.g. pesticides), etc. These pollutants are harmful even at lower concentrations.
- *Sediments* Runoff from urban construction sites is the major source of sediments. Loading water bodies with excessive sediment reduces their volume. This disrupts the normal functions of such systems as hydro-electric power plants, water supply systems, etc.
- *Thermal pollution* Runoff from heated urban surfaces and industrial cooling water are the major sources of thermal pollution. The increase in temperature of the natural water body can adversely affect different aquatic species.

Water quality modeling

Water quality modeling is used to analyze and predict the level of specific constituents- conservative or non-conservative constituents. It may also be used to compare various water quality management alternatives.

Commonly used non-conservative (those that change or react) substances include:

- Biochemical oxygen demand (BOD)
- Dissolved oxygen (DO)
- Temperature
- Algae as chlorophyll-a
- Organic nitrogen
- Ammonia nitrogen (NH_3-N)
- Nitrite nitrogen (NO_2-N)
- Nitrate nitrogen (NO_3-N)
- Organic phosphorus
- Dissolved phosphorus
- Coliforms

Conservative constituents of main interest include:

- Sediment
- Dissolved solids or salts
- Metals (Pb, Cu, Hg, Cr, Cd)

A simple modeling process is indicated in Fig. 3.4.

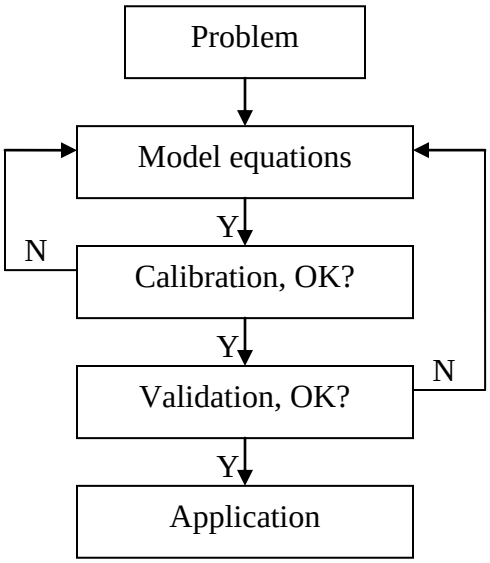


Fig. 3.4

BOD and DO modeling in rivers

The variations of the BOD and the D.O. concentration along the flow direction downstream of a certain waste discharging point are given in Fig. 3.5.

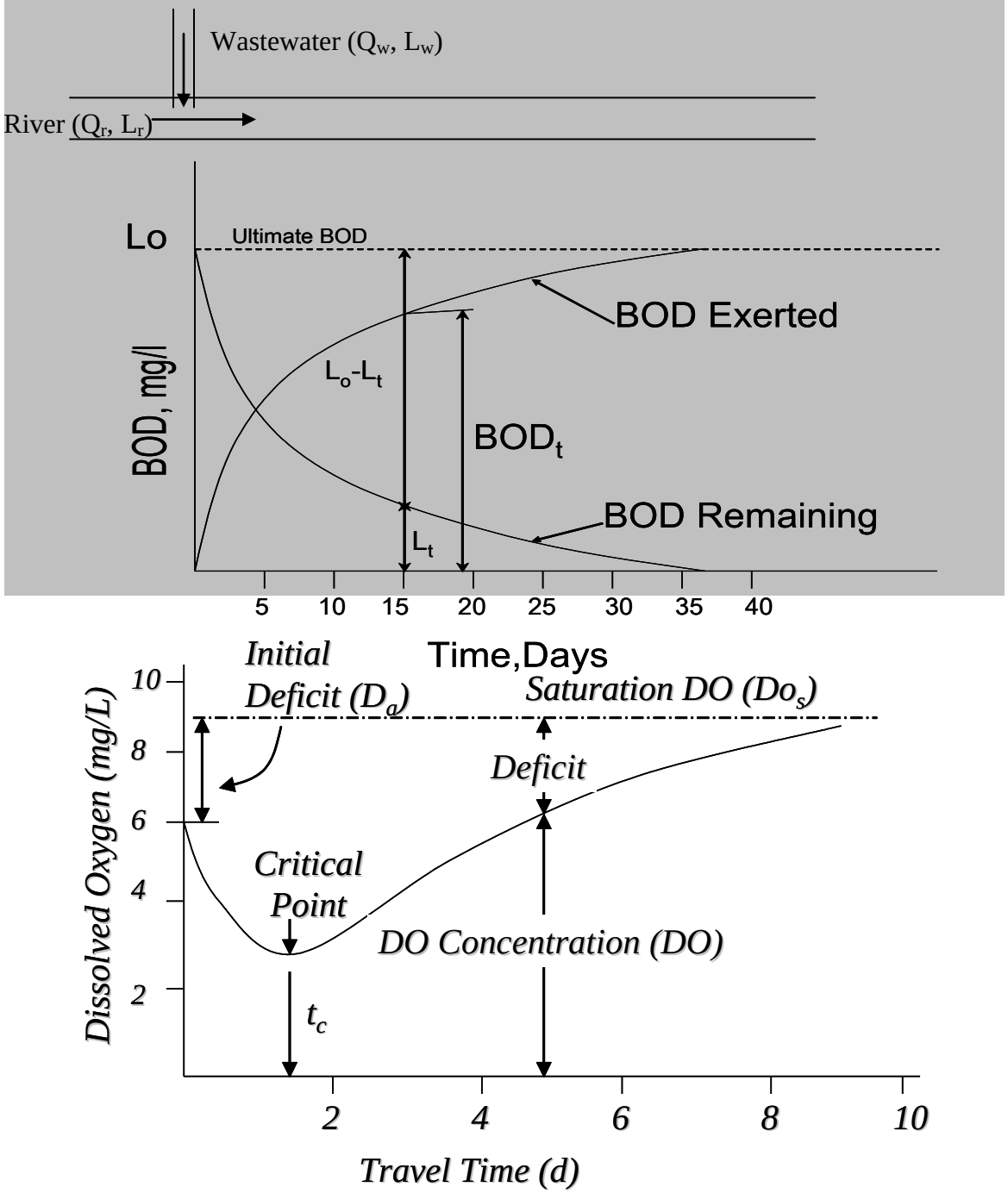


Fig. 3.5 BOD and DO variation along a river

Mathematically these processes are expressed as (assuming first order reaction)

Biochemical Oxygen Demand (BOD):

$$L_t = L_o e^{-k_d t}$$

V = Mean flow velocity, m/s

L_t = BOD at any time, t or distance, X (t = X/V), mg/l

Lo = initial BOD, mg/l

K_d = Biodegradation (deoxygenation) rate at 20^0C, day^{-1}

The rate constant K_d can be determined from laboratory BOD test results. Typical k_d values at 20^oC are given in Table 3.3.

Table 3.3 Typical K_d values

Environment	*K_d, day^{-1} (to base e)*
Untreated wastewater	0.35-0.70
Treated wastewater	0.10-0.25
Polluted river	0.10-0.25

For temperatures other than 20^oC, K_d can be computed as follows:

$$K_{d,T} = K_{d,20}\theta^{(T-20)}$$

$K_{d,T}$ = the rate at temperature T(^{o}C)
$K_{d,20}$ = the rate at 20^oC
Θ = coefficient: 1.047 for 20-30^{o}C; 1.135 for 4-20^{o}C

The BOD just discussed is synonymous to oxygen demand exerted on carbonaceous wastes (CBOD). There can also be oxygen demand for biodegradation of nitrogenous compounds (NBOD) which takes place after 5 days (Fig.3.6). NBOD is exerted in the process of nitrification as shown below.

Nitrification (2 step process)

$$2\ NH_3 + 3O_2 \rightarrow 2\ NO_2^- + 2H^+ + 2H_2O$$

$$2\ NO_2^- + O_2 \rightarrow 2\ NO_3^-$$

Overall reaction:

$$NH_3 + 2O_2 \rightarrow NO_3^- + H^+ + H_2O$$

If the concentration of nitrogen as organic and ammonia nitrogen is known then it is possible to directly determine the NBOD as

$$NBOD = TKN \times \frac{2 \times 32}{14}$$

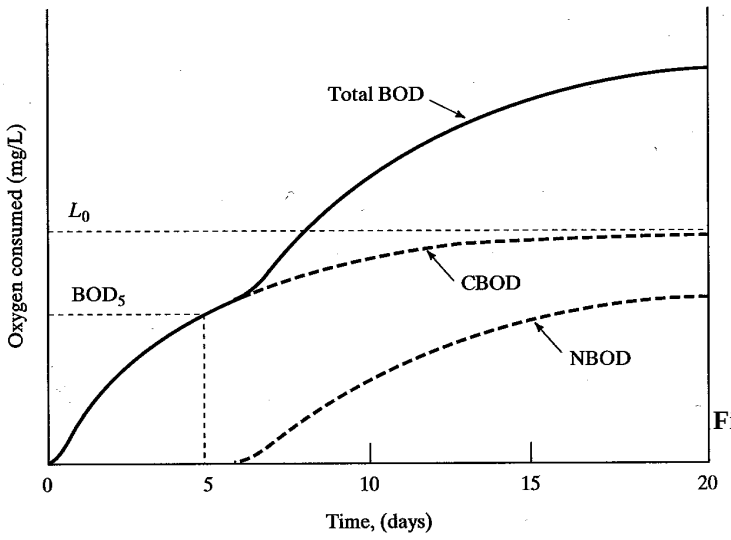


Fig. 3.6 Relation b/n CBOD and NBOD

Dissolved Oxygen (DO):

$$\frac{dDO}{dt} = K_d L_t - K_r DO = K_d L_0 e^{-K_d t} - K_r DO$$

Integrating,

$$DO(t) = \frac{K_d L_0}{K_r - K_d}(L_0 e^{-K_d t} - e^{-K_r t}) + DO_0 e^{-K_2 t}$$

DO(t) = DO saturation deficit at any time, t, mg/l
DO_0 = Initial DO deficit, mg/l
K_d = deoxygenation rate at 20^0C, day^{-1}
K_r = Reaeration rate at 20^0C, day^{-1}
L_0 = initial BOD, mg/l

$$L_0 = \frac{Q_w L_w + Q_r L_r}{Q_w - Q_r}$$

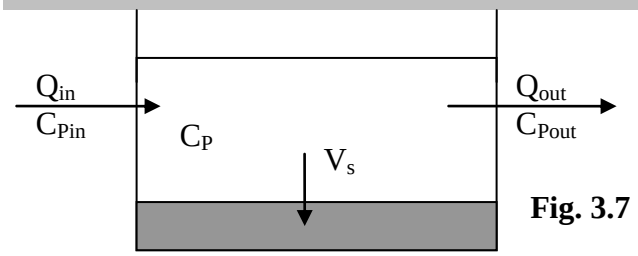
The time (t_c)of the occurrence of the minimum DO or the maximum DO deficit (DO_c) can be determined as follows:

$$t_c = \frac{1}{K_r - K_d} \ln\left\{\frac{K_r}{K_d}\left[1 - \frac{DO_0(K_r - K_d)}{K_d L_0}\right]\right\}$$

$$DOc = \frac{K_d}{K_r} L_o e^{-K_d t}$$

Phosphorus balance model in a lake

A simple phosphorus balance in a lake (Fig. 3.7):



C_P = Lake P concentration
V_s = P settling velocity

Fig. 3.7

Applying mass balance equation,

Accumulation = Mass rate in – Mass rate out – Mass of P settling in the lake+ P generation

Assuming steady state condition ($Q_{in} = Q_{out} = Q$; accumulation = 0) and no P generation

$$0 = Q_{in}C_{Pin} - Q_{out}C_{Pout} - V_sA_sC_P$$

If the lake is well-mixed, $C_P = C_{Pout}$; Solving for the lake P concentration, C_P,

$$C_P = \frac{QC_{Pin}}{Q + V_sA_s}$$

Simple model for nonpoint source pollution load

A simple method for estimating long-term pollutant load is the constant concentration method. The method requires knowledge of average pollutant's concentration in the runoff and the average annual/seasonal runoff volume. Pollutant load is then estimated as the product of the runoff volume and the corresponding constant concentration. Mathematically, the method is given as

$$\boxed{L = 10^{-3} \times V \times EMC}$$

Where
L = Annual/seasonal pollutant load (kg)
V = Annual/seasonal runoff volume (m^3)
EMC = average annual event mean concentration (mg/l)
10^{-3} = unit conversion factor

Runoff volume could be obtained from flow records or estimated from hydrologic simulation. Event Mean Concentration (EMC) is defined as:

$$EMC = \frac{\sum V_i C_i}{\sum V_i}$$

Where
EMC = Event Mean Concentration (mg/l)
Q_i = discrete flow volume corresponding to C_i (m^3)
C_i = discrete concentration of a pollutant (mg/l)

Water quality control

The ultimate goal of water quality control is to maintain quality characteristics that protect specified beneficial uses of an aquatic system. Policy instruments for implementing water pollution control measures can be of two types:

- Regulatory instruments (Command and control), examples include
    - Effluent standards
    - Land use controls
    - Permits and licenses
- Economic instruments- examples include
    - Effluent charges
    - Incentives

There different approaches and methods that can be used for water quality control as indicated in Table 3.4.

Table 3.4 Methods to control surface water pollution

Approach	Method
Pollution prevention	Source reduction: input changes, processes changes, product changes Recycling/reuse, water conservation Minimizing illicit wastewater discharge Improving solid waste management, etc.
Reducing waste after generation	Waste treatment • Conventional • Alternative treatment methods (e.g. septic tank, land treatment, constructed wetlands)
Increasing assimilative capacity of a watercourse	Low flow augmentation by using river control structures such as reservoirs. Artificial reaeration using aerators or weirs constructed across the water course
Making better use of the assimilative capacity of a watercourse	Regulated discharge, i.e., to temporarily store water during low flow period and to release it later when flow is high. To collect individual effluents to a common treatment plant and discharge it at a point where impact on quality is minimized.
Land use planning	Zoning Restrictions on population density and settlement on sensitive areas Erosion control Reducing impervious surfaces Reducing directly connected impervious surfaces Low impact land development

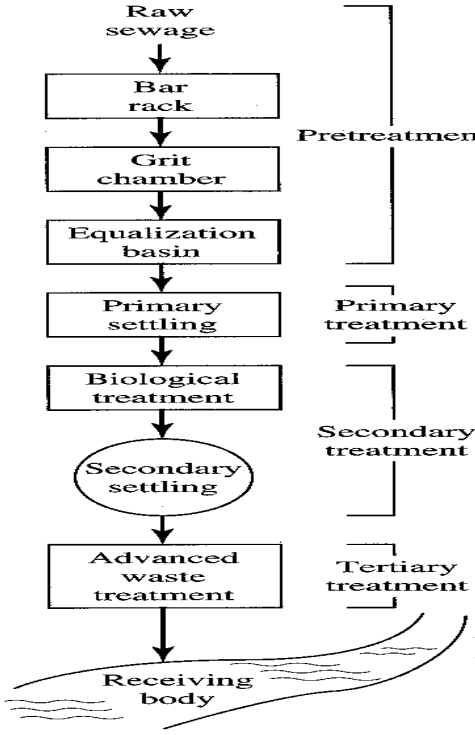
Wastewater treatment

Parameters that commonly characterize untreated domestic wastewater are presented in Table 3.5.

Table 3.5 Typical characteristics of domestic wastewater

Constituent	*Weak* (all mg/L except settleable solids)	*Medium*	*Strong*
Alkalinity (as $CaCO_3$)	50	100	200
BOD_5	100	200	300
Chloride	30	50	100
COD (as O_2)	250	500	1000
Suspended Solids	100	200	350
Settleable solids	5	10	20
Total Dissolved Solids	200	500	1000
Total Kjeldahl nitrogen (as N)	20	40	80
Total organic carbon (as C)	75	50	300
Total phosphorus (as P)	5	10	20

The methods of sewage treatment include conventional treatment, waste stabilization ponds, onsite treatment methods and advanced treatment technologies. The processes that are involved in wastewater treatment are physical and biological processes. The common physical processes are screening, and removal of grit and suspended organic solids. Biological processes involve the agency of bacteria and algae and constitute by far the most important methods of sewage treatment, particularly in hot climates. Conventional wastewater treatment unit processes (Fig. 3.7)



- Pretreatment – removes materials that can cause operational problems, equalization optional
- Primary treatment – remove ~60% of solids and ~35% of BOD
- Secondary treatment – remove ~85% of BOD and solids
- Advanced treatment – varies: 95+ % of BOD and solids, N, P

Fig. 3.7 Wastewater treatment unit processes

Biological treatment systems can broadly be classified into three groups as

- *Suspended growth:* aerobic processes that achieve a high microorganism concentration through the recycle of biological solids (e.g. activated sludge unit).
- *Attached growth (fixed film reactors):* allow a microbial layer to grow on the surface of a media (stone, plastic) while exposed to the atmosphere for oxygen supply (e.g. trickling filters).
- *Dual biological treatment*: uses two stage arrangements of attached growth and suspended growth processes to achieve a high quality effluent.

There are a number of alternative treatment processes under each of the above groups as indicated in Fig. 3.8.

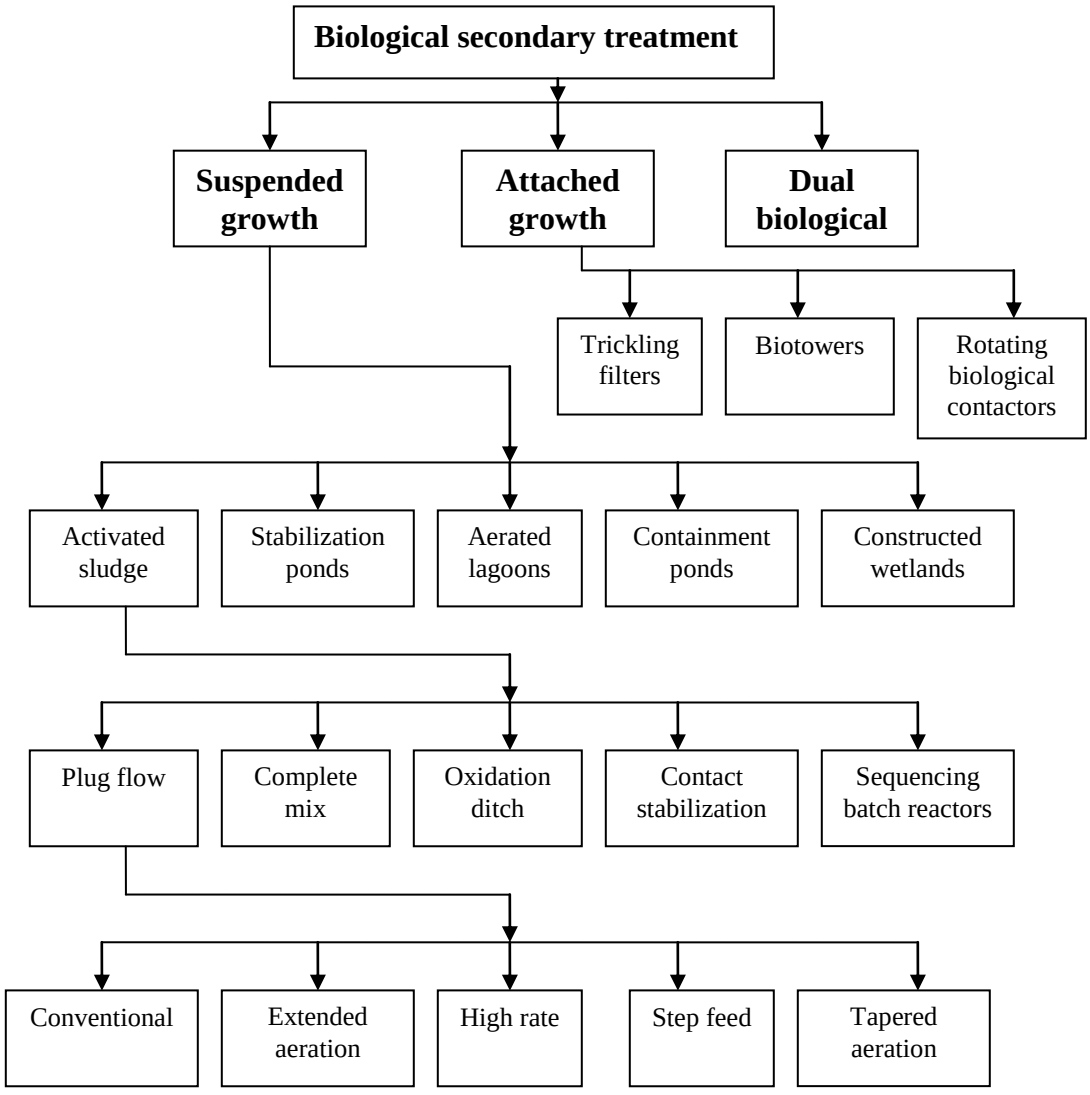


Fig. 3.8 Biological treatment systems

Biological nutrient removal systems

Nitrogen removal

Biological nitrogen removal is a two-step process

- Nitrification in aerobic environment

$$\text{Organic matter} + O_2 \rightarrow NH_3 + CO_2 + \text{microorganisms}$$
$$NH_3 + 2O_2 \rightarrow NO_3^- + H^+ + H_2O + \text{microorganisms}$$

- Denitrification in an anoxic environment (no free oxygen)

$$\text{Organic matter} + NO_3^- \rightarrow N_2 + \text{microorganisms}$$

There can be different arrangement that allow the nitrification-denitrification processes to take place (Fig. 3.9).

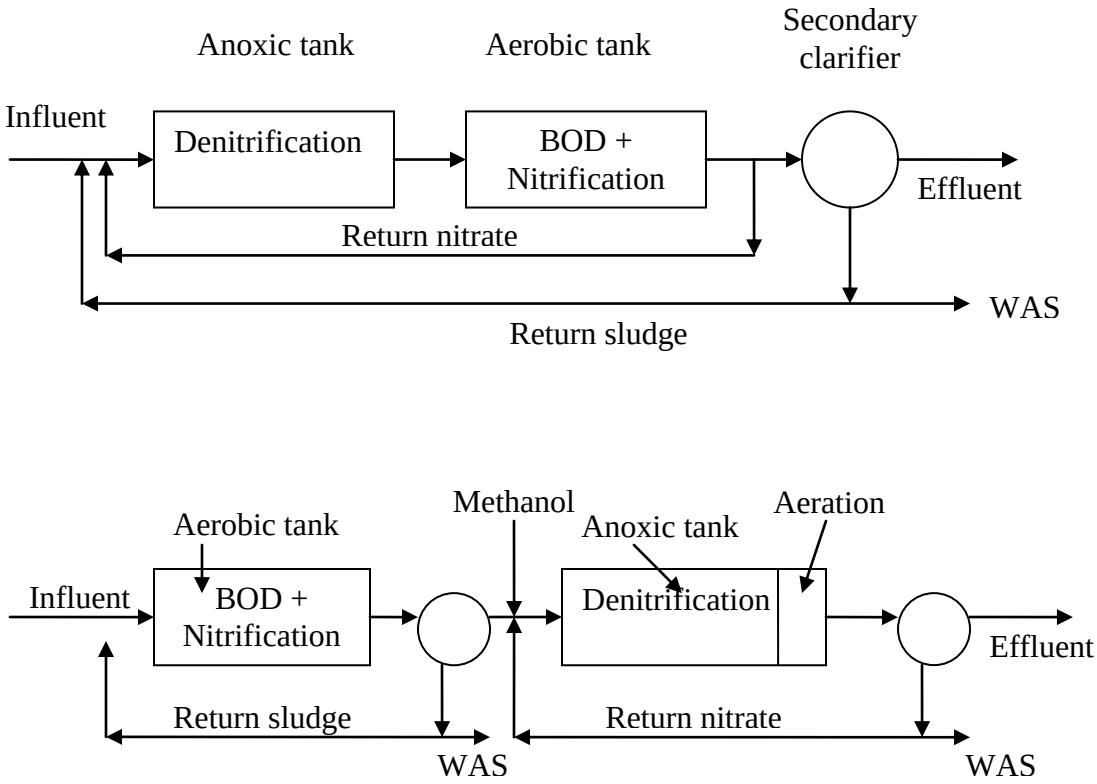


Fig. 3.9 Biological nitrogen removal

Phosphorus removal

Biological phosphorus removal is based on the idea of forcing the microorganisms to accumulate more phosphorus than is required for cell growth. This can be achieved by a system with anaerobic zone followed by an aerobic zone (Fig 3.10). The mechanism of

phosphorus removal is via the bacteria *Acinobacter sp*. in the anaerobic tank where the phosphorus in the wastewater is released as soluble phosphates and then taken up by the biomass in the aerobic zone. This arrangement can reduce the level of phosphorus by 70-80%.

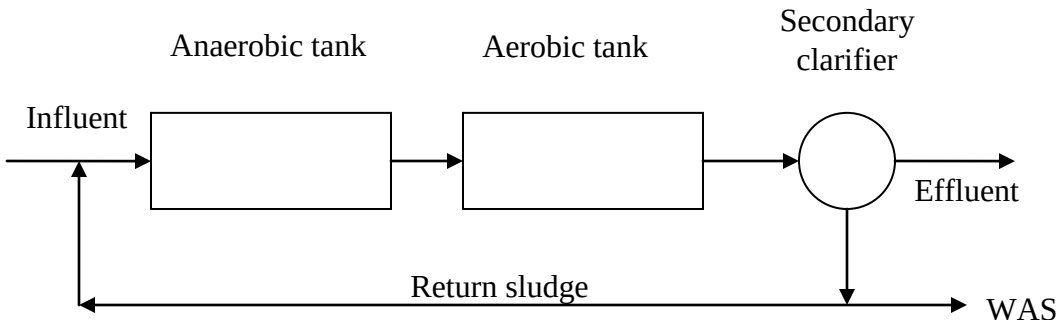


Fig. 3.10 Two-stage biological P removal

Waste stabilization ponds

Waste stabilization ponds (WSP) are shallow man-made basins into which wastewater flows and from which, after a retention time of several days a well-treated effluent is discharged. WSP systems comprise a series of ponds – ***anaerobic, facultative*** and several ***maturation ponds***. WSP are the most important method of sewage treatment in hot climates where sufficient land is normally available and where temperature is most favourable for their operation. Advantages of WSP include:

- They can achieve any required degree of treatment at the lowest cost and with minimum of maintenance by unskilled operators
- The removal of pathogens is considerably greater than that in other methods of sewage treatment
- They are well able to withstand both organic and hydraulic shock loads
- They can effectively treat a wide variety of industrial and agricultural wastes
- They can easily be designed so that the degree of treatment is readily altered
- The method of construction is such that, should at some future time the land be required for some other purpose, it I easily reclaimed
- The algae produced in the pond are potential sources of high-protein food which can be conveniently exploited by fish farming

Anaerobic ponds

These units are the smallest of the series. Commonly they are 2-4 m deep and receive high organic loads equivalent to100 g BOD_5/m^3-d. These high organic loads produce strict anaerobic conditions throughout the pond. In general terms, anaerobic ponds function much like open septic tanks and work extremely well in warm climates. The optimum retention time is 5 days with a BOD_5 reduction of 70%.

Successful operation of anaerobic ponds require temerature > 15^0C and pH > 6. under these circumstances sludge accumulation is minimal resulting in a desludging frequency of once in 3-5 years.

Facultative ponds

Facultative ponds are the most common form of wastewater stabilization ponds. They are usually 1 to 1.5 meters in depth, with an aerobic layer which overlies an anaerobic layer that usually contains sludge deposits. Desludging is required rarely, only once every 10-15 years. These ponds require large land areas to maintain suitable BOD loadings. If structural failure occurs, a large area of an aquifer and soil are at risk of being contaminated.

Facultative ponds are designed for BOD_5 removal on the basis of a low organic surface load to permit the development of an active algal population. This way, algae generate the oxygen needed to remove soluble BOD_5. Wind has an important effect on the behavior of facultative ponds, as it induces vertical mixing of the pond liquid. Good mixing within the upper aerobic layer ensures a more uniform distribution of BOD, dissolved oxygen, bacteria and algae and hence a better degree of waste stabilization. The depth to which wind-induced mixing is felt is largely determined by the distance the wind is in contact with the water; an unobstructed contact length of about 100 m is required for maximum mixing by wind action.

There exists a *mutualistic* relationship between the pond algae and the pond bacteria: the algae provide the bacteria with oxygen and the bacteria provide the algae with carbon dioxide (Figure 3.11). Some oxygen and carbon dioxide comes from the atmosphere by mass transfer, but the bulk is supplied by algal-bacterial mutualism.

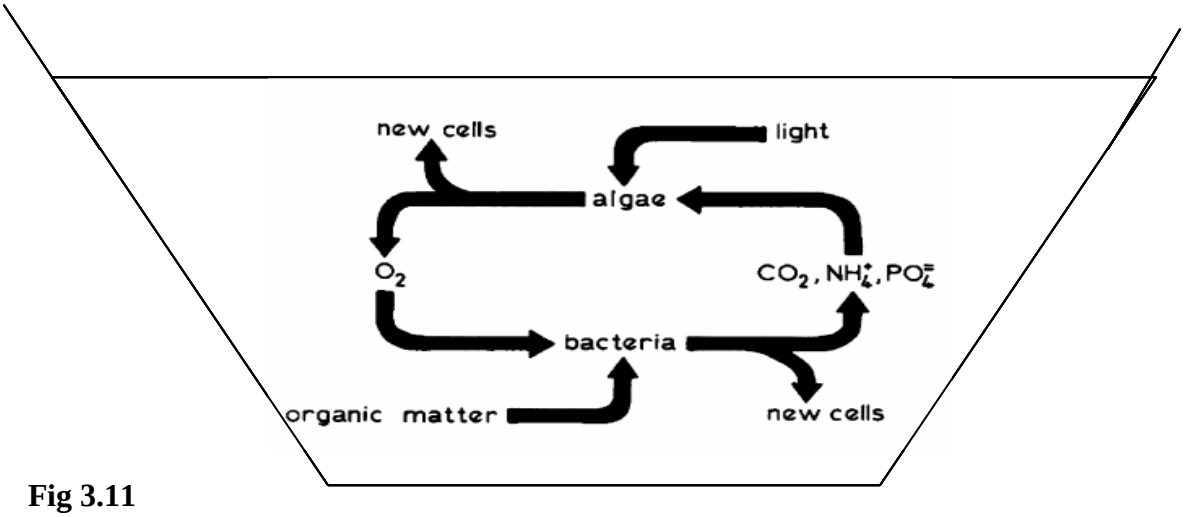


Fig 3.11

Maturation ponds

These ponds receive the effluent from a facultative pond and their size and number depend on the required bacteriological quality of the final effluent. Maturation ponds are shallow (1.0-1.5 m) and show less vertical stratification, and their entire volume is well oxygenated throughout the day. Maturation ponds only achieve a small removal of BOD_5, but their contribution to nitrogen and phosphorus removal is more significant.

The primary function of maturation ponds is the removal of faecal coliforms, and this is extremely efficient in a properly designed series of ponds. With proper design removals > 99.99 per cent can be achieved.

Pond layout

In hot climates two pond layouts are acceptable as shown in Fig. 3.12. A multi-pond system comprising anaerobic, a facultative and three or more maturations ponds, each with a retention time of 5d is recommended as a minimum treatment if the final effluent is to be used for unrestricted irrigation.

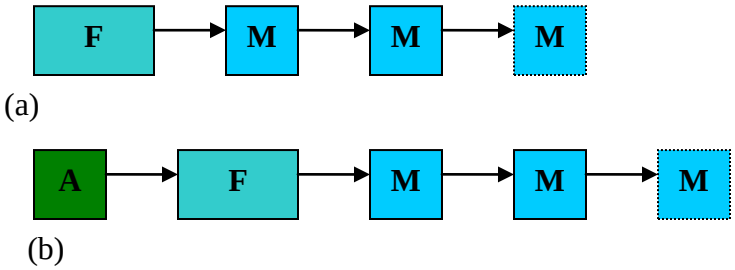


Fig.3.12 Pond layouts (a) Weak-medium strength wastes
(b) Strong wastes
A: Anaerobic pond F: Facultative pond M: Maturation pond

Onsite treatment methods

Septic systems: consist of (Fig. 3.13):

- a septic tank, where the sewage collects and is treated by anaerobic action,
- a vent-pipe, through which gases escape from the septic tank,
- a distribution box, where the supernatant collects,
- Septic or drain field (with perforated drainlines), where the supernatant is evenly distributed into the ground.

The first step in installing a septic system is to test the permeability of the soil. Then the relevant authority issues a permit. The septic tank is chosen and installed, then the septic field is put in place

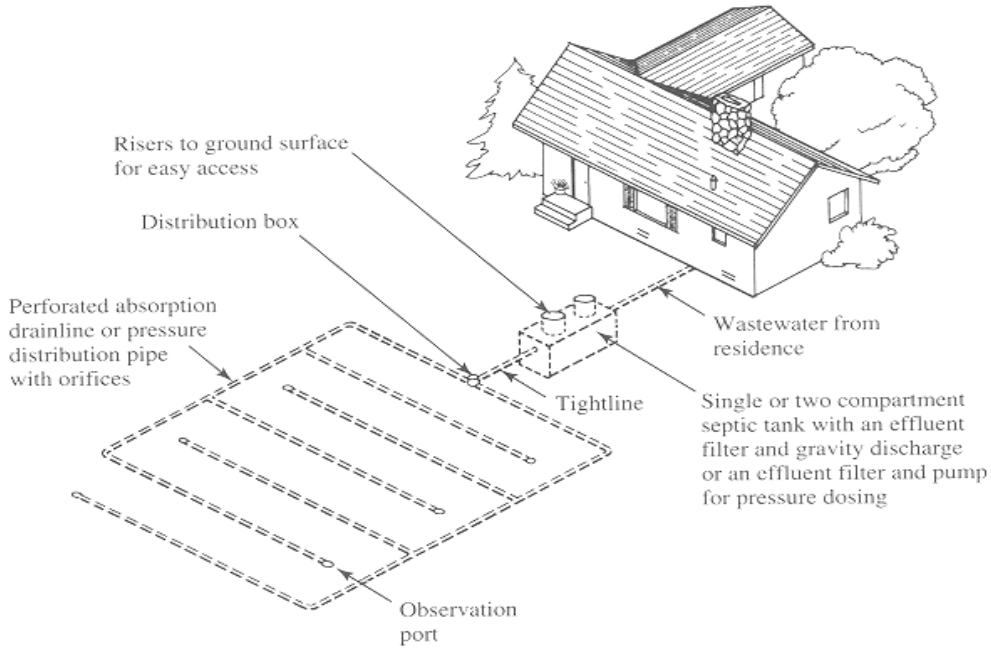


Fig. 3.13 Septic system

Septic tank (Fig. 3.14)

Untreated wastewater from a property flows into the septic tank, where the solids separate from the liquids. Some solids, such as soap scum or fat, will float to the top of the tank to form a scum layer. Heavier solids, such as human and kitchen wastes, settle to the bottom of the tank as sludge. Self forming bacteria in the tank help the system "digest" these solids or sludge. The remaining liquids flow out of the tank to a drain field. Baffles built into the tank hold back the floating scum from moving past the outlet of the tank. The effluent from a septic tank, still contains about **70%** of the polluted matter in the sewage, and hence there is a need for further treatment of the liquid from the tank.

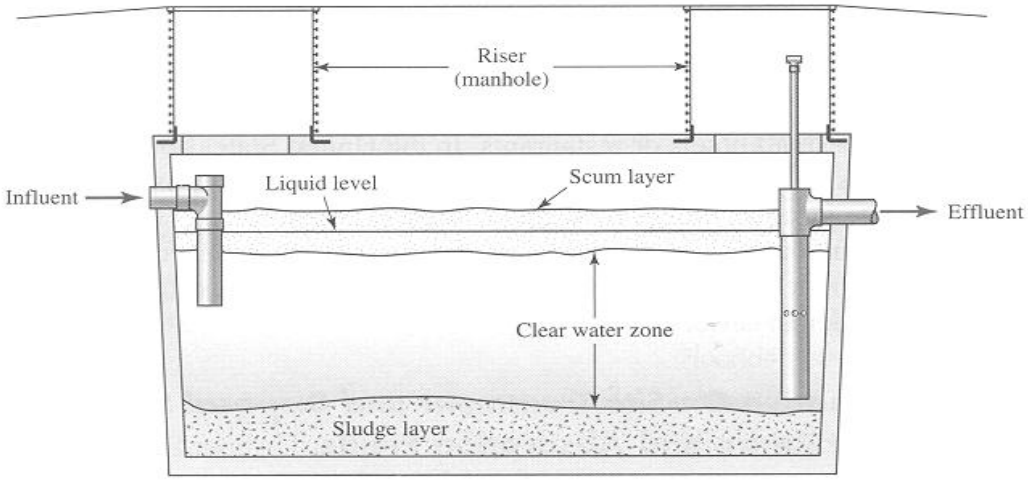


Fig. 3.14

Septic or Drain field (Fig. 3.15)
This part is perhaps the most important part of the septic system. The drain field is an underground soil treatment system, and it receives partially treated sewage from the septic tank. The soil on a site must be suitable for a drain field to work properly.
Percolation tests are required on the ground strata to ascertain the suitability of the soil for drain fields.
Connected to the septic tank by an underground pipe, the drain field may consist of trenches or a seepage bed. The bottom of the trench's of the drain field should generally be 900mm above the seasonally high water table, or bedrock. In a land drain or drainfield, wastewater moves from the septic tank into perforated pipes, bedded on and surrounded in, gravel-filled trenches. These pipes should be laid fairly flat, at a gradient of about 1 in 200, so that the effluent is dispersed along the whole length of the pipe run. The perforations in the pipe should preferably be larger than 6mm to avoid the effluent forming a biomass, which will soon result in blocking the holes. From the pipeline the pathogens, nutrients, and organic material are dispersed into the gravel where they are removed or neutralized as the liquid moves through into the soil.

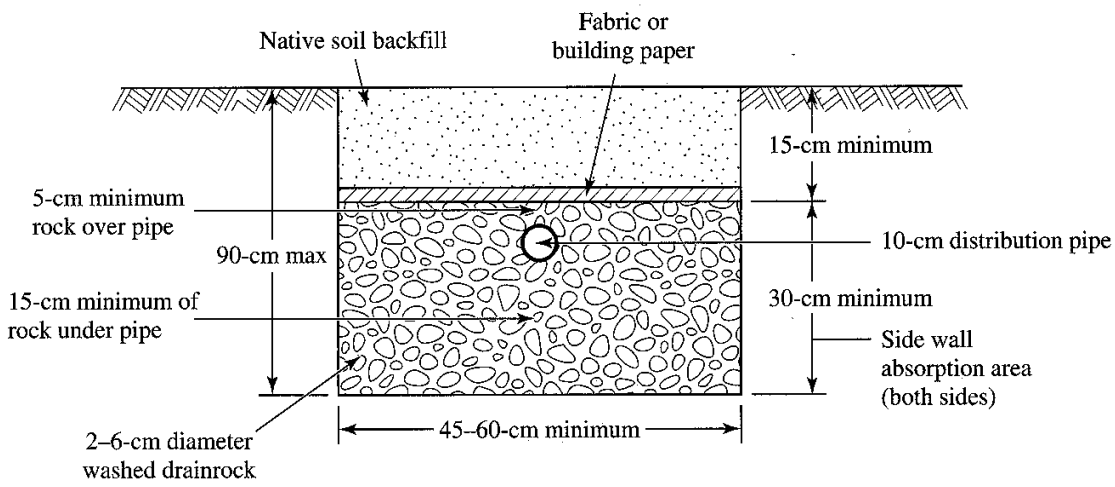


Fig. 3.15

Disadvantages of septic systems include:

- Maintenance-intensive- sludge must be pupmed out every 1-2 years
- Leach field is vulnerable to clogging with oil and grease
- BOD and nitrates are not treated effctively
- Can cause groundwater contamination

Land treatment of wastewater

Land treatment of wastewater is a viable option when land availability is not a problem. This system regards wastewater as a resource rather than as a problem to be rectified.

Three types of land application systems can be identified: Slow rate (SR), Rapid infiltration (RI) and Overland flow (OF) systems.

Slow rate systems rely on plants and soil percolation to provide tretament. These systems have also been referred to as irrrigation systems.

In RI systems wastewater is applied to relatively permeable soil within a basin at a much higher rate than in the slow-rate system. Plants may be present in the basin, but play only a minor role in wastewater renovation. Treatment is accomplished by natural processes in the soil. It requires much smaller land areas and recharges groundwater table.

The overland flow treatment is used when surface soil permeabilities are low. Vegetation is used in OF systems and the effluent is collected as runoff and conveyed to the receiving water. Treatment is provided by the plants and the microbial biomass at the soil surface as the wastewater flows down a sloping field.

Table. 3.6 Characteristics of land treatment systems

Feature	Slow-rate irrigation	Rapid infiltration	Overland flow
Hydraulic loading rate (cm/d)	0.2-1.5	1.5-3.0	0.6-3.6
Land required for 1000 m3/d (1000 x m^2)	63.4-396	3.2-63.4	26.4-159
Soil type	Loamy sand to clay	Sand	Clay to clay loam
Soil permeability	Moderately slow to moderately rapid	Rapid	slow

Wetlands for wastewater treatment

Wetlands are natural/artificial wet ecosystems with diverse and complex roles in nature. Wetlands may support aquatic plants (emergent or floating plants). Wetlands are designed to remove conventional pollutants like BOD, SS, and nutrients. Heavy metals can also be removed to a great extent. The artificial wetland systems are called constructed wetlands.

Wetlands incorporate physical, biological, and chemical processes to treat wastewater. The water flows in and slows down as it spreads across the wetland surface. This slowing of the flow allows soil and sediment particles to filter or physically settle out. This process also removes nutrients such as phosphorous and chemicals that are attached to the sediments. Biological and chemical treatment processes transform materials rather than just physically remove them.

Constructed wetlands treatment systems are engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist in treating wastewater. Constructed wetlands treatment systems generally fall into one of two general categories: **Subsurface Flow Systems** and **Free Water Surface Systems**. Subsurface Flow Systems are designed to create subsurface flow through a permeable medium, keeping the water being treated below the surface, thereby helping to avoid the development of odors and other nuisance problems. Such systems have also been referred to as "root-zone systems," "rock-reed-filters," and "vegetated submerged bed systems." The media used (typically soil, sand, gravel or crushed rock) greatly affect the hydraulics of the

system. Free Water Surface Systems, on the other hand, are designed to simulate natural wetlands, with the water flowing over the soil surface at shallow depths. Both types of wetlands treatment systems typically are constructed in basins or channels with a natural or constructed subsurface barrier to limit seepage. Tretament is generally better in subsurface flow systems and these systems do not have mosquito problems.

Constructed wetlands maximize treatment by ensuring slow flow rates, and plants provide lots of surface area. Plant stems and roots provide surface areas that support communities of microorganisms, which use some of the nutrients and organic matter carried in the runoff water. For example, microbe communities on plant stems convert organic nitrogen to the inorganic ammonium nitrogen form. Other biological treatments involve plant uptake of nutrients such as nitrates and phosphates. Chemical treatment occurs when incoming compounds react with oxygen or soil minerals in the wetland. The rate and extent of these reactions is influenced by the wetland acidity and other environmental factors.

Constructed wetlands are usually provided after primary or secondary treatment systems (Fig. 3.16). The purpose of the wetland after the secondary treatment is to polish the effluent and achieve a superior quality.

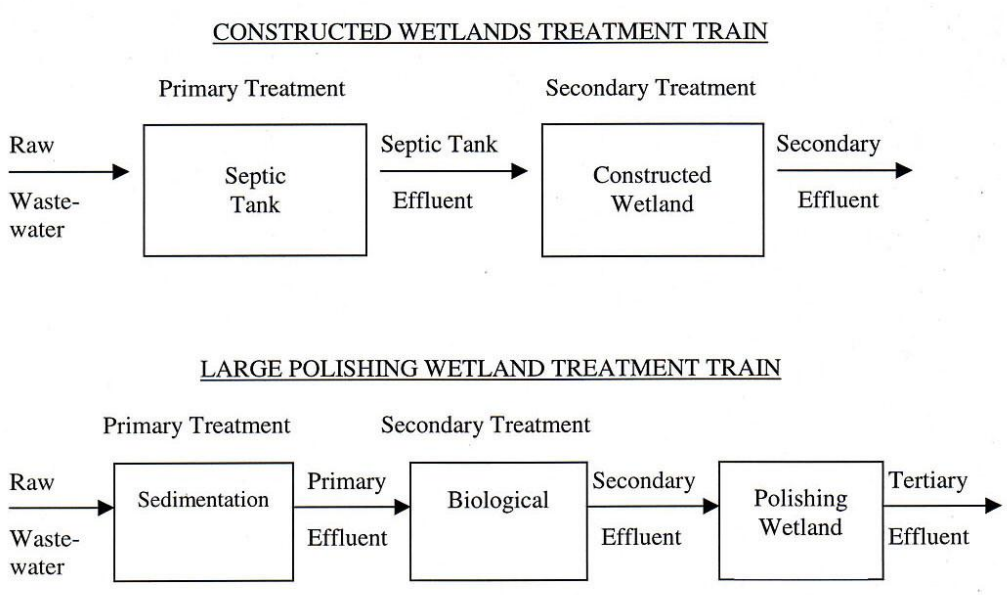


Fig. 3.16

4 Air Quality Engineering

Air pollution may be defined as the presence in air of any abnormal material or property that reduces the usefulness of the air resource. A typical comparison of clean and polluted air is represented in Table 4.1.

Table 3.1 Comparison of Clean and Polluted Air

Component	Clean air	Polluted air
SO_2	0.01-0.01 ppm	0.02-2 ppm
CO_2	310-330 ppm	350-700 ppm
CO	< 1 ppm	5-200 ppm
NOx	0.01-0.01 ppm	0.01-0.5 ppm
Hydrocarbons	0.01-0.02 1 ppm	1-20 ppm
Particulate matter	0.01-0.03 10-20 mg/m^3	70-700 mg/m^3

4.1 Sources and types of air pollutants

The sources of air pollutants can be natural or anthropogenic.

- Natural
  - Primarily, anaerobic oxidation of methane (CH_4)
- Anthropogenic combustion
  - motor vehicles
  - burning fossil fuels
  - solid waste disposal
  - industrial processes
  - burning leaves, brush, etc.

Air pollutants of major concern are divided into two groups: primary pollutants and secondary pollutants. Primary pollutants are those emitted by an identifiable source. The list includes CO, NOx, Sox, particulates (PM-10), hydrocarbons, and lead. Secondary pollutants are those formed in the atmosphere by chemical reactions and include: O_3, other photochemical oxidants (peroxyacetyl nitrate), and oxidized hydrocarbons.

Carbon monoxide (CO)

- Most abundant air pollutant
- Produced by incomplete combustion (insufficient O_2, low temperature, short residence time, poor mixing)
- Major source (~ 77%) is motor vehicle exhaust
- Colorless and odorless
- When inhaled, binds to hemoglobin in blood to form carboxyhemoglobin, reducing the oxygen carrying capacity
- brain function reduced, heart rate increased at lower levels
- asphyxiation occurs at higher levels

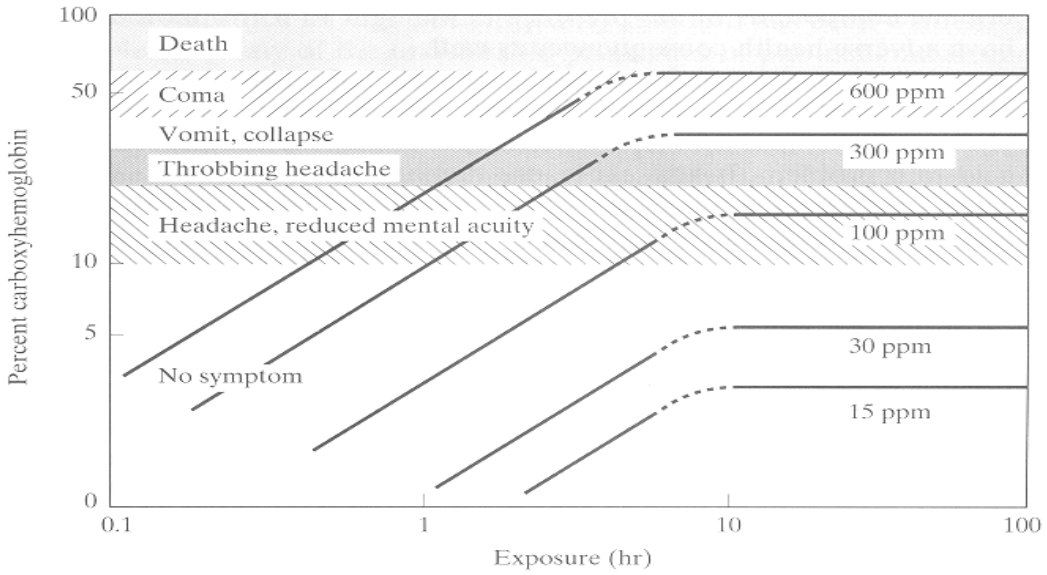


Fig. 4.1 Health effects of CO

Oxides of Nitrogen (NO_x)

- Primarily NO and NO_2
- NO_3, N_2O, N_2O_5 are also known to occur
- Thermal NOx created by oxidation of atmospheric N2 when T > 1000 K
- Fuel NOx from oxidation of N in fuel
- NO has few health effects, but is oxidized to NO_2
- NO_2 irritates lungs and promotes respiratory infections
- NO_2 reacts with hydrocarbons in presence of sunlight to produce smog
- NO_2 reacts with hydroxyl radicals to produce nitric acid – acid precipitation
- Acids of nitrogen: HNO_2 and H NO_3

Sulfur Oxides (SO_x)

- Source
  - As *primary pollutants* (SO_2 or SO_3): from power plants, industry, volcanoes
  - As *secondary pollutants:* from industrial and biological processes emitting H_2S
- Fate
  - Converted to sulfate or sulfuric acid and settle or wash out
  - Major contributor to acid rain

- Health effects of sulfur dioxide:
  - High concentrations of SO_2 can result in temporary breathing impairment.

- Longer-term exposures to high concentrations of SO_2, in conjunction with high levels of PM, include respiratory illness, alterations in the lungs' defenses, and aggravation of existing cardiovascular disease
- Short-term exposures of asthmatic individuals to elevated SO_2 levels may result in reduced lung function.

- Environmental effects of sulfur dioxide:

  - Acid rain
  - Decreased visibility

Particulate Matter

- Solid or liquid particles with sizes from 0.005 – 100 μm and are termed as ***aerosols.***
- Primary sources are
  - Natural: Sea salt, soil dust, volcanoes, smoke from forest fires
  - Anthropogenic : Fossil fuel burning and industrial processes
- Secondary sources: When H_2S, SO_2, NO_x, etc. converted to particulates
- Fate - settle out or are washed out

- Health effects of particulate matter:
  - Impact depends on particle size, shape and composition
  - Large particles trapped in nose
  - Particles >10 μm removed in tracheobronchial system
  - Particles <0.5 μm reach lungs but are exhaled with air
  - Particles 2 – 4 μm most effectively deposited in lungs
  - Inhalable PM includes both fine and coarse particles.
  - Coarse particles
    - Aggravation of respiratory conditions, such as asthma.
  - Fine particles
    - increased hospital admissions and emergency room visits for heart and lung disease
    - increased respiratory symptoms and disease
    - decreased lung function
    - premature death

- Environmental effects of particulate matters:

  - Decreased visibility
  - Damage to paints and building materials

Lead

- Sources
  - Natural: Volcanic activity and airborne soil
  - Anthropogenic
    - Smelters and refineries

- Incineration of lead-containing wastes
- Leaded gasoline - no longer used in many countries

- Fate: Pb particles attach to other particles and settle out or wash out

- Health effects of lead:
  - Accumulates in the blood, bones, and soft tissues.
  - Adversely affects the kidneys, liver, nervous system, and other organs.
  - Excessive exposure to Pb may cause neurological impairments, such as seizures, mental retardation, and behavioral disorders.
  - May be a factor in high blood pressure and subsequent heart disease.

Volatile organic compounds (VOC)

Comprise hydrocarbons and other substances (Hydrocarbons: CH_4, ethylene, and benzene; others: formaldehyde, phenol, phosgene, carbon tetrachloride, CFCs and PCBs)

- Sources are mainly anthropogenic:
  - Road transport, landfilling, mining, oil refineries, solvent evaporation, etc.
- Many of the VOCs are precursors for photochemical oxidants
- Health effects: Irritate eye, throat and lung; suspected carcinogens
- Environmental effects: Global warming, Damage ozone layer, Inhibit plant growth

Photochemical Smog

- Primary oxidants produced:
  - Ozone (O_3)
  - Formaldehyde
  - Peroxyacetyl nitrate (PAN)

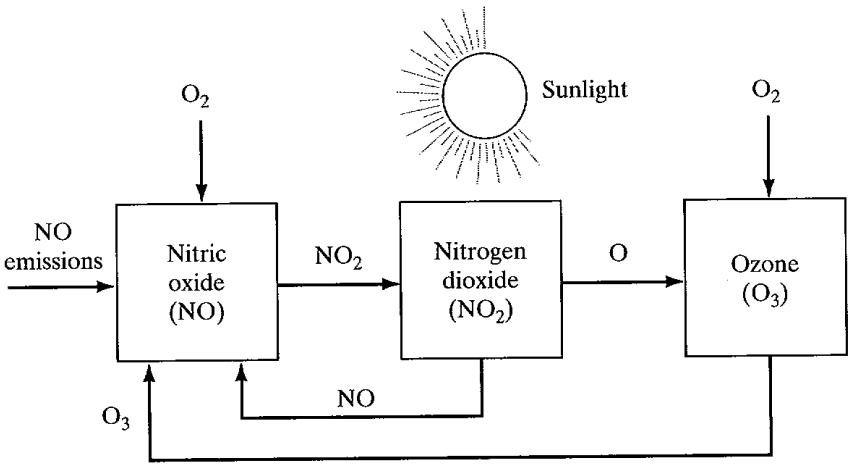


Fig. 4.2 Photochemical smog formation

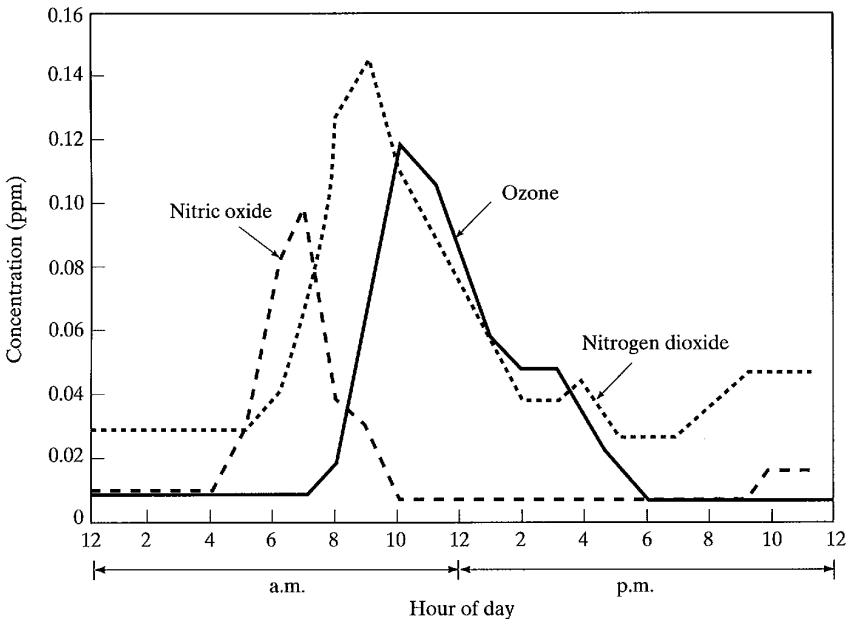


Fig. 4.3 Photochemical smog variation in a day

Health effects of ozone:

- Increased incidents of respiratory distress.
- Repeated exposures to ozone:
    - Increased susceptibility to respiratory infection
    - Lung inflammation
    - Aggravation of pre-existing respiratory diseases such as asthma.
    - Decreases in lung function and increased respiratory symptoms such as chest pain and cough.

- Environmental effects of ozone:

    - reductions in agricultural and commercial forest yields
    - Reduced growth and survivability of tree seedlings
    - Increased plant susceptibility to diseases, pests, and other environmental stresses (e.g., harsh weather).

Summaries of the health and environmental effects of air pollutants are given in Tables 4.2 and 4.3.

Table 4.2 Effects on human health

Pollutant	**Warning levels**	**Emergency levels**	**Significant harm levels**
Photochemical oxidant	800 mg/m3, 1-hr av	1200 mg/m3, 1-hr av	800 mg/m3, 4-hr av 1200 mg/m3, 2-hr av 1400 mg/m3, 1-hr av
Carbon monoxide	34mg/m3, 8-hr av	46 mg/m3, 8-hr av	57.5 mg/m3, 8-hr av 86.3 mg/m3, 4-hr av 144 mg/m3, 1-hr av
Nitrogen dioxide	2260 mg/m3, 1-hr av 565 mg/m3,24-hr av	740 mg/m3, 24-hr av	3750 mg/m3, 1-hr av 938 mg/m3, 24-hr av
Sulfur dioxide (SO2)	1600 mg/m3, 24-hr av	2100 mg/m3, 24-hr av	2620 mg/m3, 24-hr av
Particulate matter	625 mg/m3, 24-hr av	875 mg/m3, 24-hr av	1000 mg/m3, 24-hr av
SO2 and particulate matter combined	Product of mg/m3 for both is equal to261x103 , 24-hr av	Product of mg/m3 for both is equal to 393x103 24-hr av	Product of mg/m3 for both is equal to 490x103, 24-hr av

Table 4.3 Effects on vegetation

Pollutant	**Symptom**	**ppm**	**Sustained exposure time**
Ozone (O3)	Fleck, bleaching, bleached spotting, growth suppression. Tips of conifer needles become brown and necrotic.	0.03	4 hr
SO2	Bleached spots, bleached areas between veins, chlorosis, growth suppression, reduction in yield.	0.03	8 hr
Peroxyacetyl nitrate (PAN)	Glazing, silvering or bronzing on lower surface of leaves.	0.01	6 hr
HF	Tip and margin burn, chlorosis, dwarfing leaf abscission, lower yield.	0.0001	5 weeks
C12	Bleaching between veins, tip and leaf abscission.	0.10	2 hr
Ethylene(C2H4)	Withering, leaf abnormalities, flower dropping, and failure of flower to open.	0.05	6 hr

Global air pollution problems

Serious global air pollution problems include *acid rain, ozone layer depletion* and *global warming.*

Acid rain

Processes that cause acid rain are represented in Fig. 4.4. Major sources include vehicular emission and emission from factories.

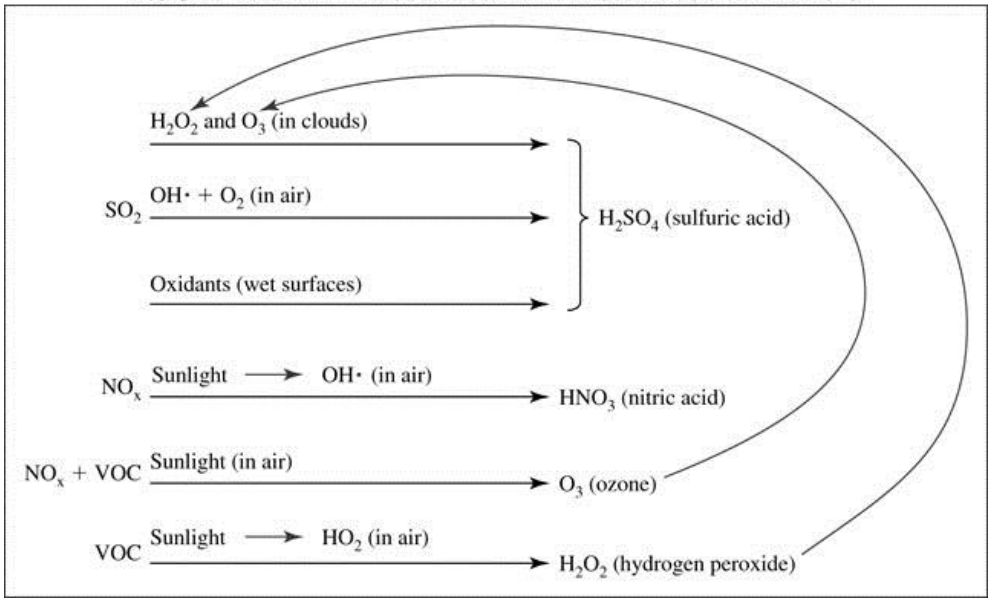


Fig 4.4 Atmospheric processes that cause acid rain

- Effects of acid rain
    - Affects fish
        - lower pH affects reproductive cycle
        - releases otherwise insoluble Al which is toxic to fish
    - has effects on vegetation
    - depletes soil nutrients
    - Degrades buildings & monuments

Ozone layer depletion

- Ozone in stratosphere is barrier to UV rays
- Chlorine in chlorofluorocarbons (CF_2Cl_2 & $CFCl_3$) reacts with ozone.
    - Chlorine recycles and continues to destroy ozone
    - Some CFCs have 110-year lifetime in atmosphere
    - Removed after Cl reacts with CH_4

- Source of the CFCs was aerosol propellant & refrigerants
- A 5% reduction in the ozone layer means 10% increase in skin cancer

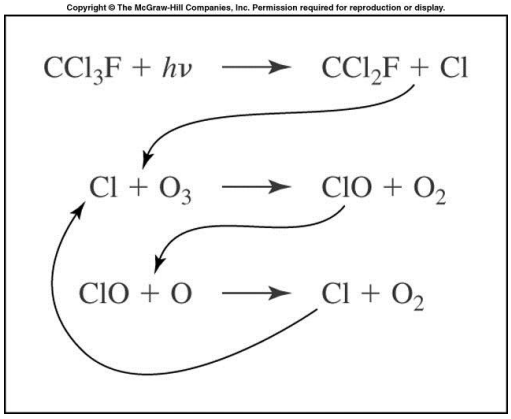


Fig. 4.5 Processes that deplete ozone

Conferences on Ozone Depletion

1987 Montreal Protocol
- freezes CFC production
- signers agree to reduce CFC production to 50% by 1998

1989 Helsinki Declaration
- phase out CFC production by 2000
- Phase out other chemicals (contain Br or Cl) as soon as feasible

1990 & 1992 - Strengthen Montreal Protocol
- ban production of CFCs, CCl4, and methyl chloroform by January 1996

Global warming

It is caused by atmospheric buildup of greenhouse gases such as carbon dioxide, methane, water vapor, CFCs, etc. The major contributor to global warming is CO_2. It is an artificial disturbance in the environment resulting from:
- Burning of Fossil Fuels
- Cutting of Forests

This disturbance likely results in a warming of the earth's climate. The mechanisms for this phenomenon to occur are:

- CO2 emits and absorbs radiation at wavelengths typical of the earth and the atmosphere.
- As the CO2 concentration increases, the atmosphere has increased resistance to the necessary escape of radiation to space.
- Incoming solar radiation is not greatly affected by the change in CO2 concentration.

Sources

- Fossil fuel combustion
- Burning forests
- Decreasing CO2 sinks by burning forests
  - growing rain forest 1-2 kg C/m2/yr
  - crops 0.2 - 0.4 kg C/m2/yr
- Other gasses contribute - methane, nitrous oxide and CFCs

4.2 Air pollution control

The driving forces for air pollution control include

- Environmental protection
- Occupational health consideration in workplace
- Social considerations
- Legal limitation imposed by government

The existence of air pollution problem can be identified by checking the ambient air quality or investigating the effects on receptors like humans, buildings, etc. Air pollution control strategies can focus on emission minimization and source control technologies.

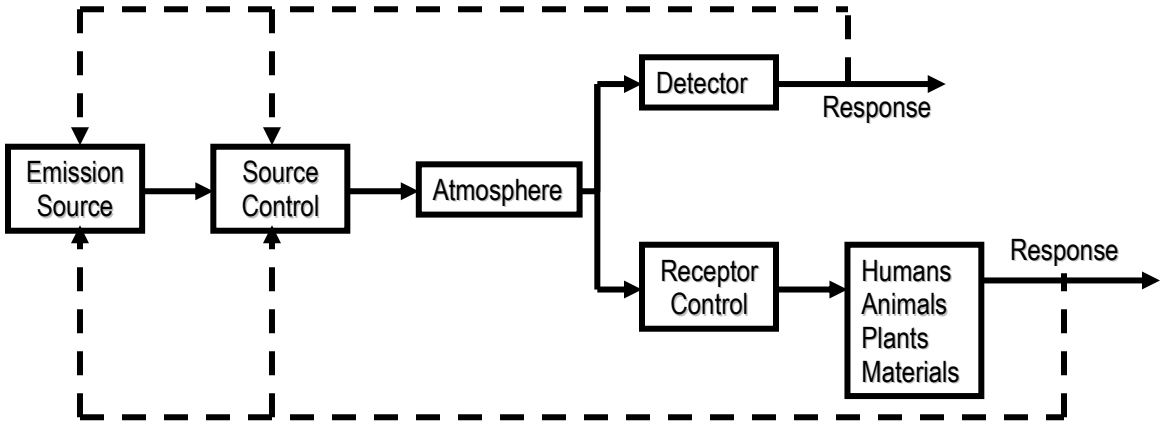


Fig. 4.6 Air pollution control system

The strategies may comprise long-term and short-term pollution control options (Fig. 4.7).

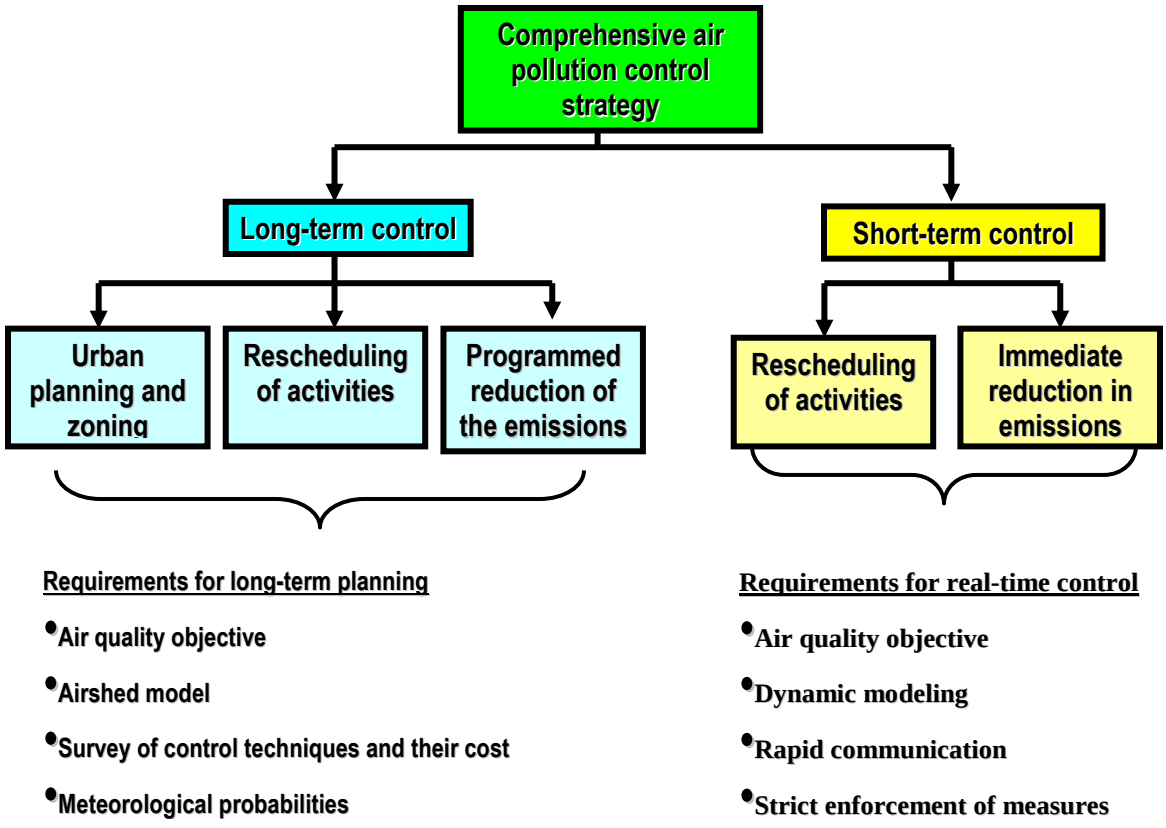


Fig. 4.7 Air pollution control options

Costs of air pollution may be expressed in terms of mitigation (control) costs or the damage costs (costs for medical treatment, costs to maintain degraded buildings, etc). Decision on pollution control investment should ensure a minimum total cost (Fig 4.8).

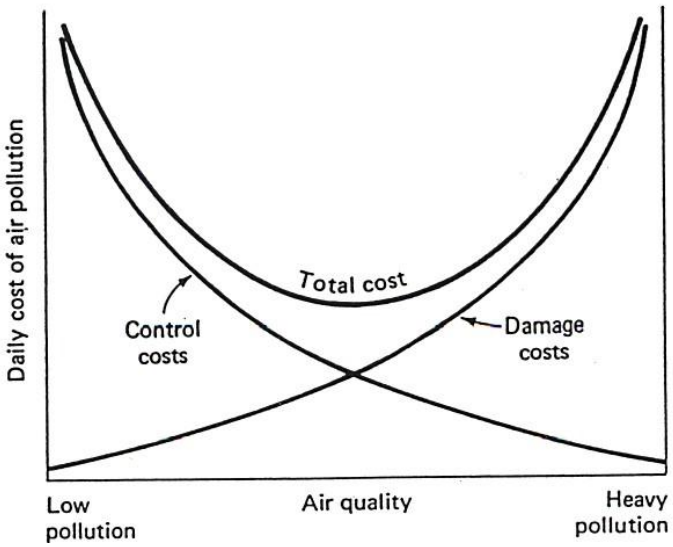


Fig. 4.8

Air pollution minimization strategies may include the following:

- Use clean fuels by vehicles (electric, fuel cell, ethanol, methanol, biodiesel, hydrogen, LPG, LNG, and CNG)
- Promoting the use of public transport by making it efficient, accessible, and cost effective
- Encouraging bicycling and walking by providing separate and attractive lanes
- Developing mixed land-use settlements that minimize the need for travel
- Discouraging private automobile dependence through fiscal measures
- Conducting timely and proper maintenance of roads
- Banning the use of leaded gasoline
- Good maintenance of vehicles
- Good driving practice (e.g. stop engine while waiting, avoid abrupt acceleration & deceleration

Source control of air pollution

The technologies for source control include:

- Control of Particulate Emission
  - Settling
  - Cyclone separation
  - Wet scrubbing
  - Baghouse filtration
  - Electrostatic precipitation
- Control of Vapor-phase Emissions
  - Wet scrubbing
  - Activated carbon adsorption
  - Incineration

The particlulate emission control technologies' performance depends on the size of particles as indicated in Fig. (4.9).

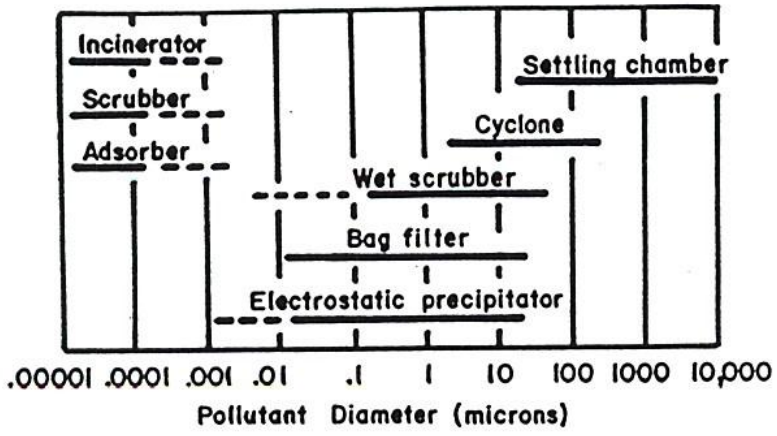


Fig. 4.9

4.3 Indoor air pollution

Major indoor air pollutants include:

- Organic gases: CO, CO_2
- Inorganic gases: NOx, O_3
- Volatile Organic Compounds (VOCs)
- Formaldehyde (HCHO)
- Respirable suspended particulates (RSP)
- Micro-organisms
- Radon (Rn)

Two approaches can be followed to control indoor air pollution:

- Source control
  - Use better materials
  - Cleaning and filtration
- Ventilation control
  - Local ventilation
  - General ventilation

5 Solid waste Management

Introduction

- **Municipal Solid Waste (MSW)–** Non-Hazardous and Non-Nuclear Waste
- ***Refuse* –** Fraction of MSW Produced by a Household
  - **Garbage:** Food Waste Exclusively
  - **Rubbish:** Paper, Cans Bottles, Glass etc.
  - **Ash:** residue from wood/coal burning
  - **Trash:** Tree Limbs, Leaves, Old Appliances (i.e., anything which is not normally deposited in garbage cans)

- ***Solid waste management*** is the discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid waste in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations and that is also responsive to public attitudes

Poor solid waste management can adversely affect public health, the environment, and social and urban development. Therefore, integrated solid waste management strategies that protect public and ecosystem health should be followed. The hierarchy of waste management options is shown in Figure 5.1.

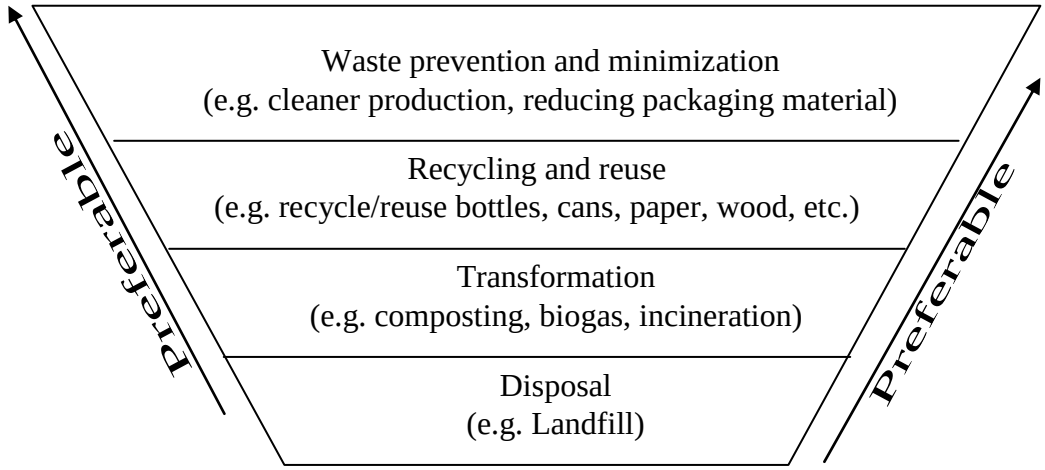


Fig. 5.1 The hierarchy of integrated waste management

5.1 Solid waste characterization

Solid waste characterization involves determination of source, composition, and generation rates as well as their properties of wastes.

Four methods for estimating waste quantities and composition can be identified: direct sampling (also referred to as waste stream analysis and waste audits), material flow, surveying waste generators, and literature sources.

Direct sampling. Direct sampling involves sampling, sorting, and weighing materials from the waste stream of a specific generator. This method has been used to estimate the composition of municipal waste streams. Representative sampling methods must be employed to achieve accurate results. When using the direct sampling method, the following questions must be addressed: How will representative samples of waste be obtained; how large should each sample be; and how many samples should be selected to achieve the desired level of accuracy in the results? The responses to these questions will influence the cost of conducting the study as well as the usefulness of the data.

Waste stream analysis. Waste stream analysis is another method used for characterizing the waste stream of a specific operation for a designated time period. Waste stream analysis is defined as a method for collecting, sorting, and measuring the amount and type of wastes generated by an operation. Results of a waste stream analysis provide data about the amount and type of wastes/residues in the waste stream. Data should be collected for a minimum of one week; the length of time depends on how the data are to be used and the accuracy required. The results are averaged to estimate the amount of wastes that the facility generates for a period of time. The ten steps in conducting a waste stream analysis are:

Waste audit. The basic objectives of a waste audit are similar to a waste stream analysis. A waste audit involves a more detailed assessment of wastes. The waste audit assesses not only the output (waste), but also the input, such as food products, packaging materials, office supplies, mail, or any process that results in materials that must be discarded. The detailed and complicated analysis of material flow through an institution will enable the facility to find the amount purchased, used, recycled, and disposed of for different materials. A waste audit can involve all materials or focus on a specific material, such as cardboard or office paper that is generated by a facility or department.

Material flow. The material flow method applies the concept of conservation of mass to track quantities of materials as they move through a defined system or region. The material flow methodology in this instance is based on the production weight data for materials and products. Generation data are the result of making specific adjustments for imports, exports, and diversions to the production data by each material and product category. The method also considers the useful life of products. One of the problems with the material flow approach is that it is difficult to quantify product residues, such as food left in the container and detergent remaining in the package.

Surveying waste. Surveying industrial generators, such as food processors, can provide useful data in quantifying waste generation. More accurate data can be obtained if the wastes/residues are measured at the disposal site.

Literature sources. Data on wastes/residues quantities and composition are available from a variety of sources including public agency documents, engineering reports, trade publications, and professional journals. These data may be helpful in assisting managers in identifying the type of residues/wastes generated by a specific industry or activity. However, caution should be used when making operational decisions on data reported in

the above sources. For example, specific conditions are not described, such as types of waste reduction strategies or diversion programs. Waste characterization studies are recommended rather than relying on published data since each industry site or foodservice operation is unique.

Source, composition, and generation of wastes

Identifying the source and composition of waste helps to devise appropriate handling, collection, treatment, and disposal mechanisms. Sources and types of solid wastes are presented in Table 5.1.

Table 5.1 Sources of solid wastes within a community

Source	Typical facilities, activities or locations	Types of solid wastes
Residential	**homes, flats, apartment blocks etc**	**food wastes, paper, cardboard, plastics, textiles, yard wastes, wood, glass, metals, special wastes (eg bulky items such as white goods, batteries, oil tyres), household hazardous wastes**
Commercial	**Shops, restaurants, markets, office buildings, hotels, motels, print shops, service stations, auto repair shops etc**	**Paper, cardboard, plastics, wood, metals, food wastes, glass, special wastes (as above), hazardous wastes**
Institutional	**Schools, hospitals, universities, prisons, government centers etc**	**As above in commercial**
Construction and demolition	**New construction sites, road repairs, building demolition**	**Wood, steel, concrete, dirt etc**
Municipal services (excluding treatment works)	**Street cleaning, landscaping, parks and beaches, creek bed cleaning, litter bins**	**Special wastes, rubbish, litter, sweepings, debris, general wastes**
Treatment plant sites	**Water, wastewater, industrial treatment processes etc**	**Effluent plus residual sludges**
Municipal solid waste (MSW)	**All of the above**	**All of the above**
Industrial	**Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power stations, demolition etc**	**Industrial process wastes, scrap materials etc. Non-industrial wastes including food wastes, rubbish, ashes, demolition and construction wastes, special wastes, hazardous wastes**
Agricultural	**Crops, orchards, dairies, feedlots, piggeries, farms etc**	**Spoiled food wastes, agricultural wastes, rubbish, hazardous wastes**

Source: Tchobanoglous (1993)

Sources and types of wastes in some urban centers of Ethiopia are indicated in Table 5.2

Table 5.2 Source and types of wastes in major urban centers of Ethiopia

Town	Source of waste	Types of waste
Awassa	Domestic, factories, institutions, animals	Organic waste, plastic (festal), metal scraps and animal manure.
Nazareth	Industries, institutions, commercial, domestic, street sweepings and construction derbies	Paper, food leftover, fruits and vegetables, plastic, fine (dust) pieces of woods and animal dung.
Dire Dawa	Commercial, domestic, hospital, street sweeping	Paper, leaves, dust, festal hospital waste, broken glasses and metals
Harar	Domestic, factories, commercial	Food leftover, dust, leaves festal, plastic
Bahirdar	Domestic, commercial, agriculture	Food leftover, plastic, fertilizers, chemical residues, street sweepings, fine.
Addis Ababa	Industries, institutions, commercial, domestic, street sweepings and construction derbies	Bone Vegetable, Paper Wood Glass Rubber Plastics Textile Fine scrap metal, street sweepings

Proportion of different types of wastes for some countries and cities are presented in Tables 5.3.

Table 5.3 Composition of municipal solid waste

Composition (% of wet weight)	Countries		
	Low income	Middle income	Industrialized
Vegetables and other putrescible materials	40-85	20-65	20-50
Paper and cardboard	1-10	15-40	15-40
Plastics	1-5	2-6	2-10
Metals	1-5	1-5	3-13
Glass	1-10	1-10	4-10
Rubber and leather	1-5	1-5	2-10
Inert material (ash, soil, and sand)	1-40	1-30	1-20

Waste generation rates are affected by degree of industrialization, climate and socio economic development. As economic prosperity increases, the amount of solid waste produced consists mostly of luxury waste such as paper, cardboard, plastic and heavier organic materials. In cities of developing countries, on the other hand, waste densities and moisture contents are much higher. Generally the greater the economic prosperity and higher percentage of urban population, the greater the amount of solid waste produced.

Knowledge of the amount of solid waste generation is necessary to design management strategies to effectively handle (reduce, reuse, recycle etc) those wastes.

Table 5.4 Typical generation rate of municipal solid waste

Country	Generation rate (kg/capita/day)
Industrial countries (UK, USA)	0.8-1.4
Middle income countries (Egypt, Nigeria, Singapore, Tunisia)	0.6- 0.8
Low income countries (Bangladesh, India, Indonesia, Pakistan, Thailand, Tanzania)	0.3-0.5

The per capita waste generation rates for Addis Ababa, Mekele and Bahirdar are estimated to be 0.252 kg/day, 0.203 kg/day and 0.223 kg/day, respectively.

Physical, chemical and biological properties of wastes

Knowledge of the various physical, chemical and biological properties of wastes is important for assessment of recycling impact, calculation of physical properties, investigation of combustion characteristics, and landfill requirements. Waste characterization study needs to be performed seasonally to define equipment needs, management programs, and trends for future planning.

Physical properties

The important physical properties of MSW include *density* (sometimes referred to as specific weight), *moisture content, particle size and distribution, field capacity, and porosity*.

Density

This is the weight per unit volume and is expressed as kg/m^3. Density varies because of the large variety of waste constituents, the degree of compaction, the state of decomposition, and in landfills because of the amount of daily cover and the total depth of waste. Inert wastes such as construction and demolition materials may have higher densities, and density can change as in landfills where the formation of landfill gas and decomposition may bring about significant mass loss. Density is important because it is needed to assess the total mass and volume of waste which must be managed.

The density of MSW is often referred to as loose, as found in containers, uncompacted, compacted etc. so it is important to specify what sort of waste is being referred to. Density varies not only because of the type of treatment it gets (collection vs compaction etc) but also because of geographic location, season, and length of time in storage. Some typical density values are presented in the Table 5.5.

Table 5.5 Typical solid waste densities of different countries

Country	Waste density (kg/m^3)
Industrial countries	

UK	150
USA	100
Middle income countries	
Egypt	330
Nigeria	250
Singapore	175
Tunisia	175
Low income countries	
Bangladesh	600
India	400-570
Indonesia	400
Pakistan	500
Thailand	250
Tanzania	330

For Addis Ababa the solid waste density is assumed to vary from 205 to 370 kg/m^3, with the average being 333 kg/m^3.

Moisture Content

The most commonly used method of expressing moisture content is as a percentage of the wet weight of material. Moisture content is important in regards to density, compaction, the role moisture plays in decomposition processes, the flushing of inorganic components, and the use of MSW in incinerators. Pre-treatment of waste to ensure uniform moisture content can be carried out prior to landfill disposal. The wet weight moisture content can be determined using the following equation:

$$M = \left(\frac{w - d}{w} \right) 100$$

Where M = moisture content (%)
w = initial weight of sample (kg)
d = weight of sample after drying at 105°C (kg)

Some typical moisture contents are shown in Table 5.6.

Table 5.6: Typical Moisture Contents of Wastes

Type of Waste	Moisture Content Range (%)	Moisture Content Typical (%)
RESIDENTIAL		
Food wastes (mixed)	**50 - 80**	**70**
Paper	**4 - 10**	**6**

Plastics	**1 - 4**	**2**
Yard Wastes	**30 - 80**	**60**
Glass	**1 - 4**	**2**
COMMERCIAL		
Food wastes	**50 - 80**	**70**
Rubbish (mixed)	**10 - 25**	**15**
CONSTRUCTION & DEMOLITION		
Mixed demolition combustibles	**4 - 15**	**8**
Mixed construction combustibles	**4 - 15**	**8**
INDUSTRIAL		
Chemical sludge (wet)	**75 - 99**	**80**
Sawdust	**10 - 40**	**20**
Wood (mixed)	**30 - 60**	**35**
AGRICULTURAL		
Mixed Agricultural waste	**40 - 80**	**50**
Manure (wet)	**75 - 96**	**94**

Source: Tchobanoglous et al. (1993)

Particle Size and Distribution

The size and distribution of the components of wastes are important for the recovery of materials, especially when mechanical means are used, such as trommel screens and magnetic separators. For example, ferrous items which are of a large size may be to heavy to be separated by a magnetic belt or drum system. The size of the waste component can be computed using length, height, or width

Field Capacity

The field capacity of MSW is the total amount of moisture which can be retained in a waste sample subject to gravitational pull. It is a critical measure because water in excess of field capacity will form leachate, and leachate can be a major problem in landfills. Field capacity varies with the degree of applied pressure and the state of decomposition of the wastes, but typical values for uncompacted-comingled wastes from residential and commercial sources are in the range of 50 - 60%.

Permeability of compacted wastes

The hydraulic conductivity of compacted wastes is an important physical property because it governs the movement of liquids and gases in a landfill. Permeability depends on the other properties of the solid material include pore size distribution, surface area and porosity.

Chemical properties of waste

Knowledge of the chemical composition of waste is important to help evaluate alternative processing and recovery options. This is especially important where wastes are burned for energy recovery, in which case the most important properties are proximate analysis,

elemental analysis, and energy content. Elemental analysis is also important in determining nutrient availability.

Proximate Analysis

Proximate analysis includes four tests - loss of moisture when heated to 105°C for 1 hour; volatile combustible matter (loss on ignition); fixed carbon; and ash (weight of residue after combustion). Some typical values are shown in Table 3.

Table 5.7: Typical Proximate Analysis Values (% by weight)

TYPE OF WASTE	MOISTURE	VOLATILES	CARBON	ASH
Mixed food	70.0	21.4	3.6	5.0
Mixed paper	10.2	75.9	8.4	5.4
Mixed plastics	0.2	95.8	2.0	2.0
Yard wastes	60.0	30.0	9.5	0.5
Glass	2.0	-	-	96-99
Residential MSW	21.0	52.0	7.0	20.0

Source: Tchobanoglous et al. (1993)

Elemental Analysis

This is also known as ultimate analysis and involves the determination of carbon, hydrogen, oxygen, nitrogen, sulphur, and ash. Because of concern about halogens these are also often determined as well. The results of this analysis are used to characterize the composition of the organic matter in wastes. This is important for C/N ratios for biological decomposition. Typical values are shown in Table 3.4.

Table5.8: Typical data in Elemental Analysis (% by weight)

TYPE	C	H	O	N	S	ASH
Mixed food	73.0	11.5	14.8	0.4	0.1	0.2
Mixed paper	43.3	5.8	44.3	0.3	0.2	6.0
Mixed plastic	60.0	7.2	22.8	-	-	10.0
Yard waste	46.0	6.0	38.0	3.4	0.3	6.3
Refuse Derived Fuel	44.7	6.2	38.4	0.7	<0.1	9.9

Source: Tchobanoglous et al. (1993)

Energy Content

The energy content of the components of waste can be determined using a boiler system, laboratory bomb calorimeter, or by calculation using elemental composition. The SI unit of measurement is kJ/kg. The nomenclatures for energy contents are as follows:

H_u = lower heat value, i.e. from waste as collected
H_{wf} = normal heat value, i.e. from water-free waste (dry)
H_{awf} = higher heat value, i.e. from ash- and water-free waste

$$H_u = H_{awf} \times B - 2.445 \times W \qquad [MJ/kg]$$

Where, B = flammable fraction (volatile matter + fixed carbon)
W = moisture content fraction by weight

Empirical equations for estimating energy content include

- Dulong formula
  $$\mathbf{H_u = 337C + 1419(H_2 - 0.125O_2) + 93S + 23N}$$ [J/kg]

Where C, H, O, S, and N = percent by weight of each component

- Khan's equation (works well if there is little or no yard or garden waste)
  E = 0.051[F + 3.6(CP)] + 0.352(PLR)

Where: E = energy content, MJ/kg
F = % of food by weight
CP = % of cardboard and paper by weight
PLR = % of plastic and rubber by weight

Table 5.9 Typical proximate analysis and energy content in MSW

Proximate analysis (% by weight)					*Energy content (MJ/kg)*		
Waste type	Moisture	Volatiles	Fixed carbon	Non-combustible (ash)	As collected lower heat value, H_u	Dry normal, water free H_{wf}	Dry ash and water-free higher heat value H_{awf}
Food mixed	70	21	3.6	5.0	4.2	13.9	16.7
Fats	2	95	2.5	0.2	37.4	38.2	39.1
Fruit	79	16	4.0	0.7	4.0	18.6	19.2
Meat	39	56	1.8	3.1	17.6	28.9	30.4
Paper mixed	10.2	76	8.4	5.4	15.7	17.6	18.7
Newspaper	6	81	11.5	1.4	18.5	19.7	20.0
Cardboard	5.2	77	12.3	5.0	26.2	27.1	27.4
Plastics mixed	0.2	96	2	2	32.7	33.4	37.1
Polyethylene	0.2	98	<0.1	1.2	43.4	43.4	43.9
Polystyrene	0.2	99	0.7	0.5	38.0	38.1	38.1
Polyurethane	0.2	87	8.3	4.4	26.0	26.0	27.1
PVC	0.2	87	10.8	2.1	22.5	22.5	22.7
Textiles	10	66	17.5	6.5	18.3	20.4	22.7
Yard wastes	60	30	9.5	0.5	6.0	15.1	15.1
Wood mixed	20	68	11.3	0.6	15.4	19.3	19.3
Glass	2			96-99	0.2	0.2	0.15
Metals	2.5			94-99	0.7	0.7	0.7
Domestic MSW	15-40	40-60	4-15	10-30	11.6	14.5	19.3
Commercial MSW	10-30				12.8	15.0	
MSW	10-30				10.7	13.4	

Adapted from Tchobanoglous et al., 1993; Robinson, 1986; Mortensen, 1993

Examples

1. If H_{awf} = 20 MJ/kg, compute the lower heating value of MSW if:

   W, water content = 21%
   B, flammable = 59%
   A, Ash = 20%.

   Solution

   Hu = Hawf * B – 2.445 * W
   = 20.0*0.59-2.445*0.21
   = 11.29 MJ/kg

2. Compute the lower heat value (Hu) of the domestic MSW shown below, using each waste component and its associated MJ/kg

Component	*% by weight*	*Component weight (tonnes)*	*Lower heat value, Hu (MJ/kg)*	*Total energy (GJ)*
Food waste	46	5129	4.2	21541
Paper and cardboard	11	1226	16.5	20229
Plastics	9	1003	32.7	32798
Glass	7	780	0.2	156
Metals	5	558	0.7	390
Clothing/textiles	1	111	18.3	2031
Ashes, dust	19	2118	6.9	14614
Unclassified	2	223	-	-
Total	100	11150		**91759**

Solution

Total lower heat value (H_u) = 91759 GJ = **<u>8.23 MJ/kg</u>**

3. Using Khan's equation, compute the energy value of the waste in the above example.

Solution

$$E = 0.051[F + 3.6(CP)] + 0.352(PLR)$$

F = 46%
P = 11%
PLR = 9%

Therefore,

$$E = 0.051[46 + 3.6(57)] + 0.352(9)$$
$$= \mathbf{7.53\ MJ/kg}$$

<u>Biological properties of waste</u>

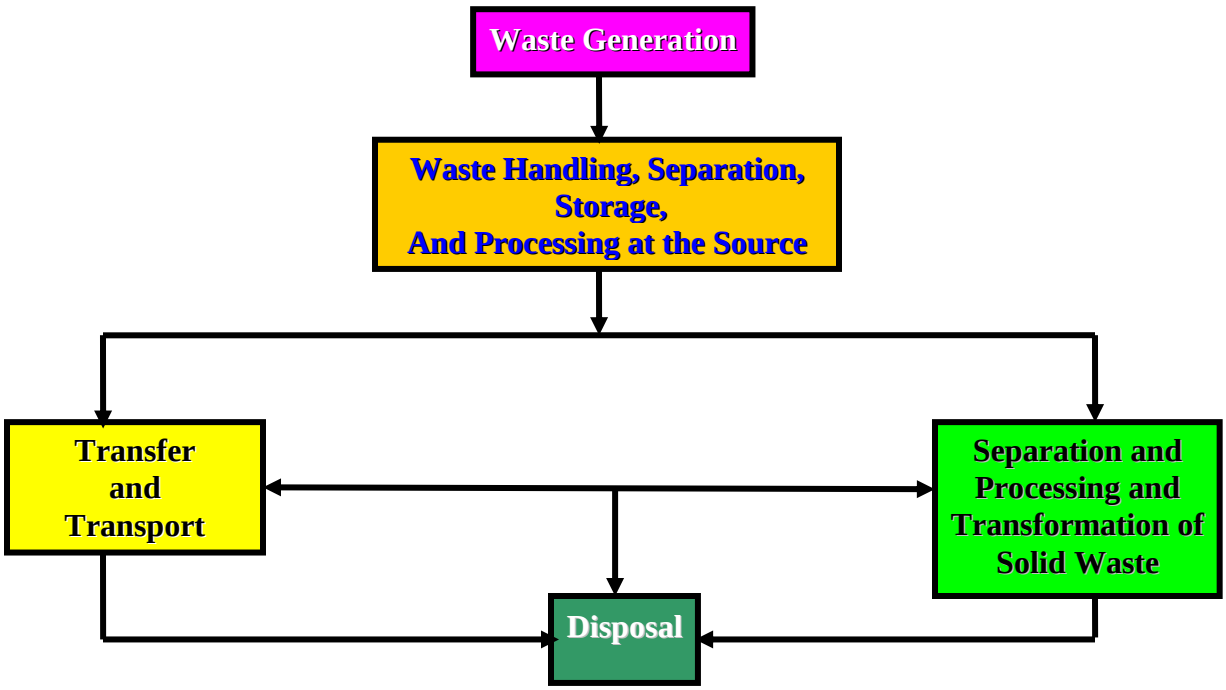
Biological properties of MSW are relevant because of the technology of aerobic/anaerobic digestion to transform waste into energy and beneficial end products. Biodegradation can be aerobic or anaerobic. Some organic MSW components are undesirable for biological conversion that is plastic, rubber, leather, and wood. The relevant fractions for biological transformation include

- Cellulose - a product of 6-carbon sugar glucose
- Fats, oils and waxes - esters of alcohols and long-chain fatty acids
- Lignin - present in some paper products
- Lignocellulose - combination of lignin and cellulose
- Proteins - amino acid chains

These organic components of MSW can be converted biologically to gases and relatively inert organic and inorganic solids. The production of odors and the generation of flies are also related to the putrescible nature of the organic materials.

5.2 Elements of solid waste management

Functional elements of a solid waste management system are shown in Fig. 5.2.



Separation

Separation solid waste into its different components is essential to realize environmentally sound solid waste management options. Waste separation can be either at source where it is generated, or at the transfer station or at final destination. Municipal solid wastes may be separated as follows:

- Food wastes
- Paper and cardboard
- Plastic
- Metals ferrous

Household source separation

- Metals non-ferrous- community recycling at drop-off centers
- Glass- community recycling at drop-off centers, household source separation
- Bulky waste (furniture, tyres, etc)
- Yard waste
- Hazardous household waste

Public drop-off centers

For source separation to work, drop-off centers for accepting recyclable wastes and public awareness raising efforts are required.

Storage

The size of premises, nature (type) and generation rate of solid waste determines the type of storage to be used. Storage facilities must be animal and insect proof washable and robust enough to meet the exigencies if normal use. There is a limit to the duration that solid waste can be stored at source (in the premises) based on the type and source of solid waste.

Solid waste should be collected and disposed of from temporary stores to final disposal site before breeding various disease carrying vectors. Uncovered container of waste ate exposed to human and animal scavengers that litter waste around and create community health problems.

Collection

Collection refers to the art of removing accumulated waste, be it containerized or not, from generating sources. Collection may occur at a centralized location where generators deliver their solid waste or by going from individual generator to another, which increases the expense of collection. Transfer or transportation, as the name indicates, refers to the transportation or/and haul of solid waste from a central point to one or more distant final management facility.

Methods of collection include communal collection, block collection, and door-to-door collection.

Transformation processes

Transformations of waste can occur through the intervention of people or by natural phenomena. Solid wastes can be transformed by physical, chemical and biological means as shown in Table 5.10. Typically waste transformations are used:

- to improve the efficiency of solid waste management systems
- to recover reusable and recyclable materials
- to recover conversion products and energy

Table 5.10: Transformation processes in solid waste management

Process	Method	Principal conversion products
Physical		
separation	manual and/or mechanical	individual components found in commingled MSW
volume reduction	Force or pressure	original waste reduced in volume
size reduction	Shredding, grinding, or milling	altered in form and reduced in size
Chemical		
combustion	thermal oxidation	CO_2, SO_2, oxidation products, ash
pyrolysis	destructive distillation	a variety of gases, tar and/or oil
gasification	starved air combustion	gases and inerts
Biological		
aerobic compost	aerobic biological conversion	compost
anaerobic digestion	anaerobic biological conversion	methane, CO_2, trace gases, humus
anaerobic composting (in landfills)	anaerobic biological conversion	methane, CO_2, digested waste

Source: Tchobanoglous et al. (1993)

Disposal

A sanitary landfill is an engineered facility that requires detailed planning and specifications, careful construction, and efficient operation. In a landfill, solid wastes are disposed of by spreading in thin layers, compacting to smallest practical volume, and covering each day, or periodically, with soil or suitable substitute material in a way that minimises environmental problems. Care must be exercised to ensure that an environmental problem does not develop during operation or after closure. Careful design, construction, and operation can minimise the potential for problems arising at a landfill.

The three common configurations of sanitary landfills are the trench (excavated cell) method, the area method, and the canyon or depression method.

The excavated cell/trench method of land filling is ideally suited to areas where an adequate depth of cover material is available at the site and where the water table is not near the surface. Typically, cells are excavated to depths of 1 to 3 m, with side slope of 2:1 or 3:1 (3 horizontal). Trenches vary from 60 to 300m in length, 1 to 3m in depth, and 3 to 15m in width. (See Fig. 5.3)

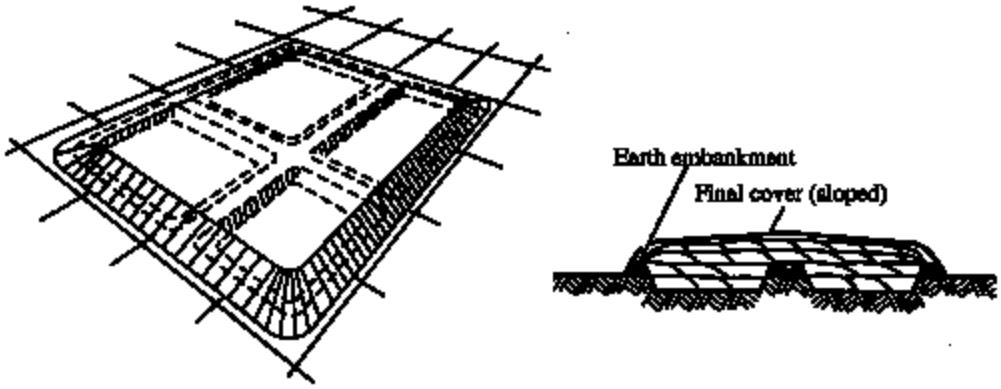


Fig. 5.3 The Trench Method of Landfill

The area method shown in Fig. 5.4 is used when the terrain is unsuitable for the excavation of cells or trenches in which to place the solid wastes. High groundwater conditions, necessitates the use of area-type landfills. Site preparations include the installation of a liner and leachate control system. Cover material must be hauled in by truck or earthmoving equipment from adjacent land or from borrow pit areas.

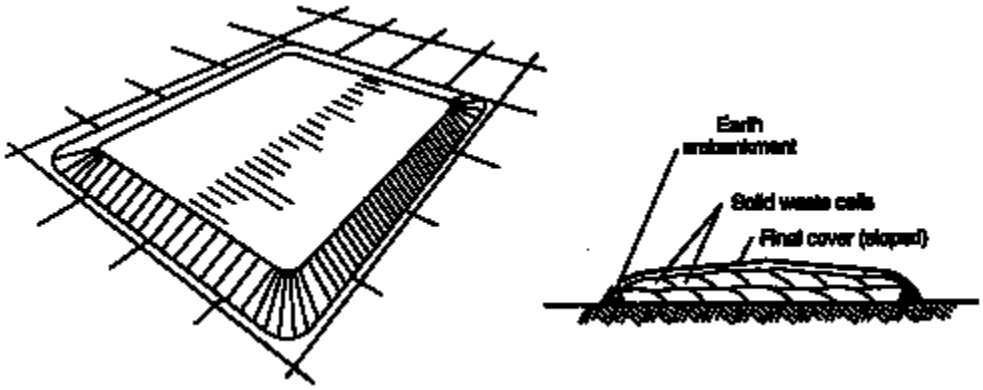


Fig. 5.4 The Area Method of Landfill

The canyon method is similar to the trench method except natural depressions or canyons are used rather than digging trenches. Canyons, ravines, dry borrow pits and quarries have been used for landfills. The techniques to place and compact solid wastes in canyon/depression landfills vary with the geometry of the site, the characteristics of the available cover material, the hydrology and geology of the site, the type of leachate and gas control facilities to be used and the access to the site. (See Fig. 5.5)

Control of surface drainage often is a critical factor in development of canyon/depression sites. Typically, filling for each lift starts at the head end of the canyon and ends at the mouth, so as to prevent the accumulation of water behind the landfill canyon/depression sites; and the method of operation is essentially the same as the area method.

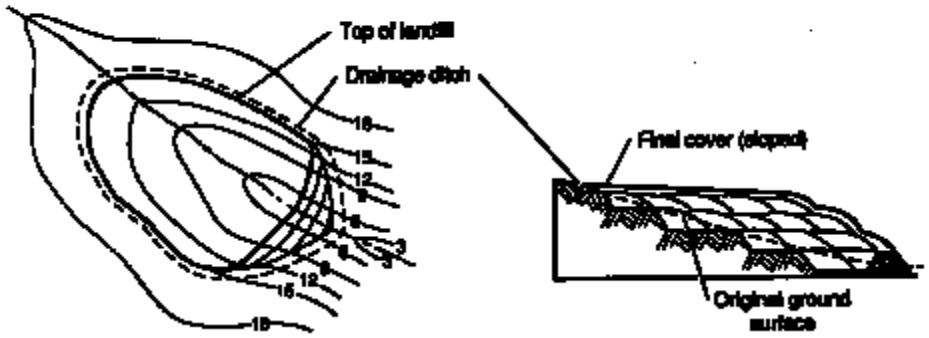


Fig. 5.5 The Canyon Method of Landfill

Landfill operations and processes may include the following:

- Landfill design
  - Foundation design
  - Liner design
  - Leachate collection and gas collection
  - Drainage design
  - Filling design
  - Runoff collection
  - Closure design
- Landfill operations
  - Waste inventory
  - Cell layout
  - Cells for hazardous waste
  - Cells for non-hazardous waste
- Leachate management
  - Collection
  - Treatment
  - Monitoring
  - Reuse
- Landfill gas management
  - Monitoring
  - Collection
  - Flaring or using
  - Quantity and quality
- Environmental monitoring
  - Air quality and odor monitoring
  - CH_4, H_2S, VOCs, etc
  - Groundwater monitoring
  - Pests and litter
  - Traffic
- Biochemical reactions in a landfill
  - Biological decay rates
  - Slowly biodegradable
  - Rapidly biodegradable
  - Non-biodegradable

Design of landfills should incorporate the following:

- Location of the landfill should consider
  - Ecological and biological conditions
  - Geological and hydrogeological conditions
  - Existing and potential water supply sources
    - Groundwater
    - Surface water
  - Historical and archeological sites
  - Recreational areas

  - Other planning issues, e.g. town and industrial development, agriculture, etc.
  - Infrastructure requirements
    - Access possibilities
    - Transport distance
    - Treatment possibilities of the leachate
- Receiving area facilities
  - Weightbridge for recording incoming waste according to type and origin
  - Office and staff buildings
  - Garage for machinery maintenance
  - Containers where waste from individuals can be received so that they do not have to go to the deposit area
- Internal roads all the way to the deposit are that can carry the heavy loads from the heavy trucks and compactors
- Deposit area
  - Size considering the amount of waste and other practical factors
  - Fence to protect wind-blown litter
- Control and monitoring
  - Controlling system has to ensure prohibition of banned wastes from disposal
  - Monitoring system should cover: leachate, surface runoff, recipients, groundwater and noise
- Operation manual

Example: landfill area requirement
Determine the area required for a new landfill site with a projected life of 20 years for a population of 150000 generating 2.5 kg per household per day. Assume the density of waste is 400 kg/m^3 and 5 persons per household. A planning restriction limits the height of the landfill to 10 m.

Solution:
Total waste generated = 2.5/5 x (150000) = 75000 kg/day = 27.375 x 10^6 kg/year
Volume of landfill space required = (27.375 x 106)/400 = 68437.5 m^3/year
Required land area = 68437.5/10 = 6843.75 m^2/year
Increasing this are by 50% to allow for roads, receiving areas, fencing, etc, required area for 20 years becomes

$$\underline{A = 6843.75 \times 20 \times 1.5 = 205312.5\ m^2 = 21\ ha}$$

5.3 Sources and types of hazardous wastes

The term "hazardous waste" means a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristics may:

(a) cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; or
(b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

Hazardous wastes exhibit one or more of the following characteristics:

- Ignitable- the substance causes or enhances fires. *Examples include waste: alcohols; acetone; acetic acid; xylene*
- Reactive- the substance reacts with others and may explode. *Examples: acids; bases; waste boiler treatment chemicals.*
- Corrosive- the substance destroys tissues or metals. *Examples: cyanide; explosives; sulfide- containing wastes.*
- Toxic- the substance is a danger to health, water, food and air. Examples: arsenic; mercury

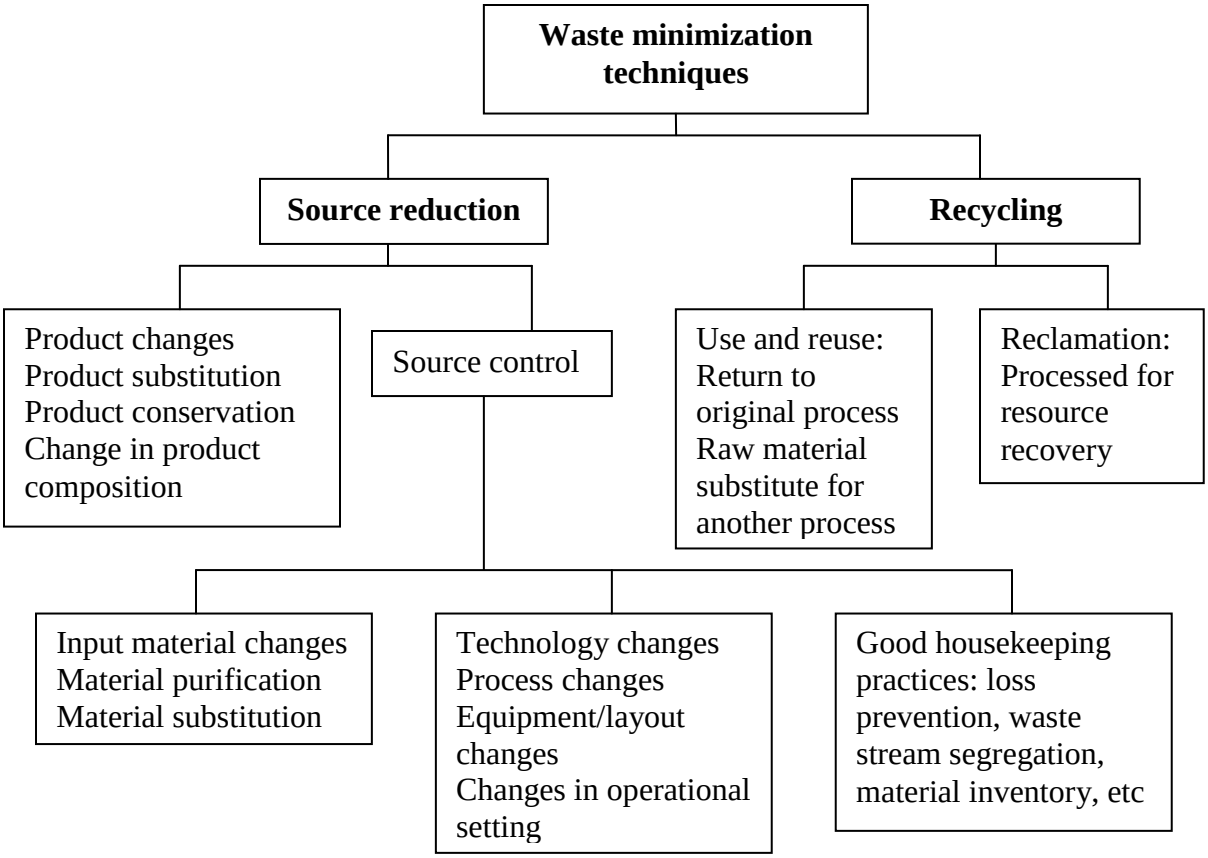
Hazardous wastes may be listed in applicable directives or identified through investigation in light of the above characteristics. Sources of hazardous wastes may include industries, hospitals, households, etc.

Household Hazardous Waste (HHW)
Leftover household products that contain corrosive, toxic, ignitable, or reactive ingredients are considered to be "household hazardous waste" or "HHW." Products, such as paints, cleaners, oils, batteries, and pesticides, that contain potentially hazardous ingredients require special care when you dispose of them. Examples include: Drain Cleaners (C), Oven Cleaners (C), Oil and Fuel Additives (I,T), Waxes, Polishes and Cleaners (I,C), Herbicides (T,H), Fungicides or Wood Perservatives (H), Batteries (C,T), Pool Chemicals (R), Fingernail Polish Remover (I), Electronic Items (T).

5.4 Management options for hazardous wastes

Hazardous waste management options include waste minimization practices, and treatment and disposal facilities.

Waste minimization techniques



Treatment and disposal

- Thermal treatment- e.g. incineration
- Chemical treatment- e.g. neutralization
- Physical treatment- e.g. filtration
- Landfill

Common solid waste disposal methods

In rural communities the following common useful simple and practical methods of solid waste intermediate treatments/reuse and disposal methods include:

- Composting
- Controlled Tipping/Burying
- Ploughing in the Fields
- Incineration

Composting

Composting is one of the means of waste minimization. The mechanism implies a biological waste treatment process. The action of microorganisms breaks down complex organic compounds into simpler ones. Composting is not final disposal method but converting waste into a useful product. Compost has been used in both the rural and semi urban areas of Ethiopia for quite a long time as a soil conditioner to grow mostly vegetables and crops but without processing it.

Composting process:

1. Sort and/or separate the compostable organic matter such as garbage, grass, dung, etc from the un compostable ones such as plastic, leather, ceramic, clay or metal products that hamper the decomposition process.

2. Mix in equal proportion all wastes including animal manure, kitchen waste, weeds and house sweepings. It may be necessary to add and mix human and animal waste to enhance and facilitate the biodegradation process. Adding these waste matters not only enhances the decomposition process but it also enriches the waste in nitrogen and phosphorous. Which are essential elements for plant growth. However, using human or animal waste need precautions as it may contain pathogenic organisms, which may contaminate the crops, the hand and feet of people working in the farm. This may create a perpetual communicable disease transmission condition outweighing the advantage of waste reuse.

3. Compost sites may be arranged by digging a shallow hole the size of which may vary with the amount of waste intended to be composted or the waste may be place above ground. Placing it above ground is easier to work with the waste in the process of composting.

4. Pile the sorted and mixed solid waste on the ground to a height of about 0.15 meters (15 centimeters). Lay horizontally four round sticks on top of the pile as shown in figure 3. The space in between the poles could be from 75- 90 cm.

5. On the corner of the wooden poles laid horizontally insert four poles vertically

6. Add the rest of the sorted out waste matter on top of the wooden poles for an additional 90 cm.

7. Cover the completed pile of waste with 50 cm earth and animals manure and take out the poles from the pile

The soil/manure cover will help in preventing rainwater from soaking into the pile. Reduce evaporation, lessen loss of nitrogen (nutrient), prevents fly breeding etc. The holes made by the poles will help in introducing oxygen into the pile hence making the composting process aerobic. Such method will not cause nuisance or smell.

Instead of using round wooden poles the waste could be piled up as it is and aerate it once or twice a week by turning it so that aerobic bacteria can remain active and proliferate and stabilize the waste.

Well-stabilized compost is:

- Dark looking
- Does not smell and
- Stable humus *f*

The compost supplies the elements that plants require for growth except some deficiencies in phosphorous and nitrogen. This may be improved by adding urine together with the humus.

Controlled Tipping/Burying

Solid wastes that are not recycled or used should be disposed. Disposal is effected in many different ways. But the most important method is that which is able to isolate the waste for good. A method that satisfies this is known as controlled tipping. It is a way of isolating any type of waste without bothering to sort or separate. Controlled tipping is a simple, effective and relatively cheaper method of refuse disposal. This method involves preparation of hole in the ground with a depth of 1-2 meters and width and length of 60 centimeters for a household. The method can be used as a one-time or a daily operation. If it is a daily operation the process is as follows:

1. A disposal site is identified within the compound of any residential, commercial or institutions. The site should not be:

- Near water sources
- Near to houses and kitchen
- Near a road or path

2. Pile the dugout earth near the pit for future use

3. Dump the generated solid waste (garbage, refuse etc) in the pit daily

4. Cover the waste matter with the excavated soil every day Waste generated every day is dumped into the pit and covered with earth so that flies and vermin don't get access to it. The process continues until the pit is filled after which it should be completely covered with earth and another one is dug next to the old one. With this method flies, mosquitoes, rodents, wild animals, birds and other nuisance animals will not have access to breed and feed. The decomposable waste will still condition the soil. Crops planted on completed sites grow better and the immediate surrounding of the dwelling house looks always clean.

Incineration

Incineration is a high temperature dry oxidation process that reduces organic and combustible waste to inorganic, incombustible matter and resulting in a very significant reduction of waste volume and weight.

Characteristics of wastes suitable for incineration:

- Content of combustible matter above 60%
- Content of non-combustible solids below 5%
- Content of non-combustible fines below 20%
- Moisture content below 30%

Waste types not to be incinerated:

- Pressurized gas containers
- Large amount of reactive chemical waste
- Silver salt and photographic or radiographic wastes
- Halogenated plastics such as polyvinyl chloride (PVC)
- Waste with high mercury or cadmium content, such as broken thermometers, used batteries, and lead lined wooden panels

- Sealed ampoules or ampoules containing heavy metals

  ⇒ Air pollution is undesirable characteristics of incinerator

  ⇒ Expensive and skill personnel is needed

  ⇒ May be located close to centre of waste production (advantageous)

Types of Incinerators

Incinerator can range from extremely sophisticated; high temperature once to very basic that operate at much lower temperatures. All types of incinerators, if operated properly, eliminate microorganisms from waste and reduce the waste to ashes. At a small community with the limited resources and where high-temperature incinerators are not affordable, waste may be incinerated in a drum incinerator. A drum incinerator is the simplest form of single-chamber incinerator. It can be made inexpensively and is better than open burning.

How to build and use a simple drum incinerator for waste disposal:

Step 1: where possible, select a site downwind from the health post.

Step 2: Build a simple incinerator using local materials (mud or stone) or a used oil drum (e.g., 80-100 liters drum). The size depends on the amount of daily waste collected.

Step 3: Make sure the incinerator has: Sufficient air inlets underneath for good combustion *f* loosely placed fire bars to allow for the expansion. An adequate opening for adding fresh refuse and for removal of ashes, a long enough chimney to allow for a good draft and evacuation of smoke.

Step 4: Place the drum on hardened earth or a concrete base.

Step 5: Burn all combustible waste, such as paper and cardboard, as well as used dressings and other contaminated wastes. If the waste or refuse is wet, add kerosene so that a hot fire burns all the waste. Ash from incinerated material can be treated as non-contaminated waste.

Ploughing in fields

Applying waste in farm fields for soil conditioning has been practiced in Ethiopia for a long time. This is a practice with a dual purpose, it is one hand a way of waste disposal and on the other hand a means of recovering and reusing waste for soil conditioning.

Human and animal excrements, sweepings from residential premises, left over food from people and animals; vegetables, leaves etc. are some of the domestic solid wastes that are ideal for using in farms preferably after composting. However, indiscriminate disposal of waste especially in

farm areas may be cause of diseases transmission and source of accidents from puncturing (nails, wire) or cutting (glass, tin) waste materials.

Other disposal methods

There are some other intermediate treatments or final disposal methods, which are not commonly used, in the rural communities of Ethiopia. Sanitary landfill: A method of disposing a refuse on land without creating nuisances or hazards to public health or safety. The characteristics of sanitary landfill that distinguish it from an open dump

1. The waste is placed in a suitably selected and prepared land fill site in a carefully prescribed manner
2. The waste materials is spread out and compacted with appropriate heavy machinery
3. The waste is covered each day with a layer of compacted soil

- ✓ It is effective method for permanent disposal if there is enough land and equipment
- ✓ Useless lands become usefull (hills, valleys) e.g. flat land for recreation

N.B. It may not appropriate in rural Ethiopia because of highly skilled professionals require for proper operation, planning, regulating and controlling and deposition of solid wastes on selected areas.

Dumping in to sea

- ✓ It is unsanitary since it affect aquatic ecosystem

Hog feeding for garbage

- ✓ Problem of pork tapeworm, trichinosis

Discharge to sewers

- ✓ Effective for garbage disposal only.
- ✓ It should be grinded to be disposed

Open dump

The most unsanitary disposal option

6 Environmental Impact Assessment

Development policies, plans, programs and projects have effects on the local, regional and national environments. Sustainable development requires the assessment of these developmental activities against sustainability criteria. The assessment methods can conveniently be classified hierarchically as shown in Fig. 6.1.

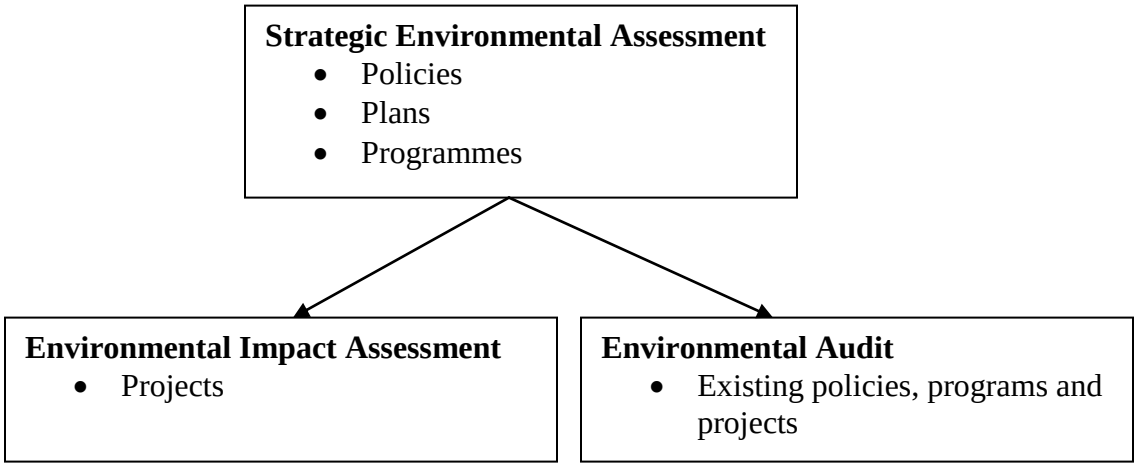


Fig. 6.1 Environmental assessment methods

Strategic Environmental Assessment (SEA)
SEA is applied to assess the environmental implications of policies, plans and programs. SEA is used to evaluate various policies such as land policy, energy policy, industrial policy, etc. against sustainability requirements. It can also be used to investigate the interdependence, complementarity, and contradiction of various policies, plans and programs (PPPs) with respect to sustainable development.

Environmental Impact Assessment (EIA)
EIA, which is increasingly applied in many countries, is used to assess the environmental consequences of specific projects such as road, industrial complexes, commercial centers, etc. In this case impacts of projects on the various environmental components (land, water, air) and the socio-economic environments within and beyond the city limit are analyzed. EIA of projects consider the opinions of all affected and interest groups.

In essence, EIA is a process, a systematic process that examines the environmental consequences of development actions, in advance. The emphasis, compared with many other mechanisms for environmental protection, is on prevention. Of course planners have traditionally assessed the impacts of developments on the environment, but invariably not in the systematic, holistic and multidisciplinary way required by EIA. The process evolves a number of steps, as outlined in Fig 6.2. It should be clearly noted that, although the steps are outlined in linear fashion, EIA should be a cyclical activity, with

feedback and interaction between the various steps. Below are brief descriptions of each step.

Project screening narrows the application of EIA to that project that may have significant environmental impacts. Screening may be partly determined by the EIA regulations operations operating in country at the time of assessment.

Scoping seeks to identify at an early stage, from all of a project's possible impacts and from all the alternatives that could be addressed, those that are the key, significant issues.

Consideration of alternatives seeks to insure that the proponent has considered other feasible approaches, including alternative project locations, scales, processes, layouts, operating conditions, and the "no action" option.

Description of the project/development action includes a clarification of the purpose and rationale of the project, and an understanding of its various characteristics – including stages of development, location and processes.

Description of the environmental baseline includes the establishment of both the present and future state of the environment, in the absence of the project, taking into account changes resulting from natural events and from other human activities.

Identification of key impacts brings together the previous steps with aims of ensuring that all potentially significant environmental impacts (adverse and beneficial) are identified and taken into account in the process.

The prediction of impacts aims to identify the magnitude and other dimensions of identify change in the environment with a project/action, by comparison with the situation without that project /action.

Evaluation and assessment of significant seeks to assets the relative significant of the predicated impacts to allow a focus on key adverse impacts

Mitigation involves the introduction of measures to avoid, reduce, remedy or compensate for any significant adverse impacts.

Public consultation and participation aims to assure the quality, comprehensiveness and effectiveness of the EIA, as well as to ensure that the public's views are adequately taken into consideration in the decision- making process

EIS presentation is a vital step in the process. If done badly, much good working the EIA may be negated.

Review involves a systematic appraisal of the quality of the EIS, as contribution to the decision- making process.

Decision-making on the project involves a consideration by the relevant authority of the EIS (including consultation responses) together with other material considerations.

Post decision monitoring involves the recording of outcome associated with development impacts after a decision to proceed. It can contribute to effective project management.

Auditing follows from monitoring. It can involve comparing actual outcomes with predicated outcomes, and can be used to assess the quality of predication and the effectiveness of mitigation. It provides a vital step in the EIA learning process.

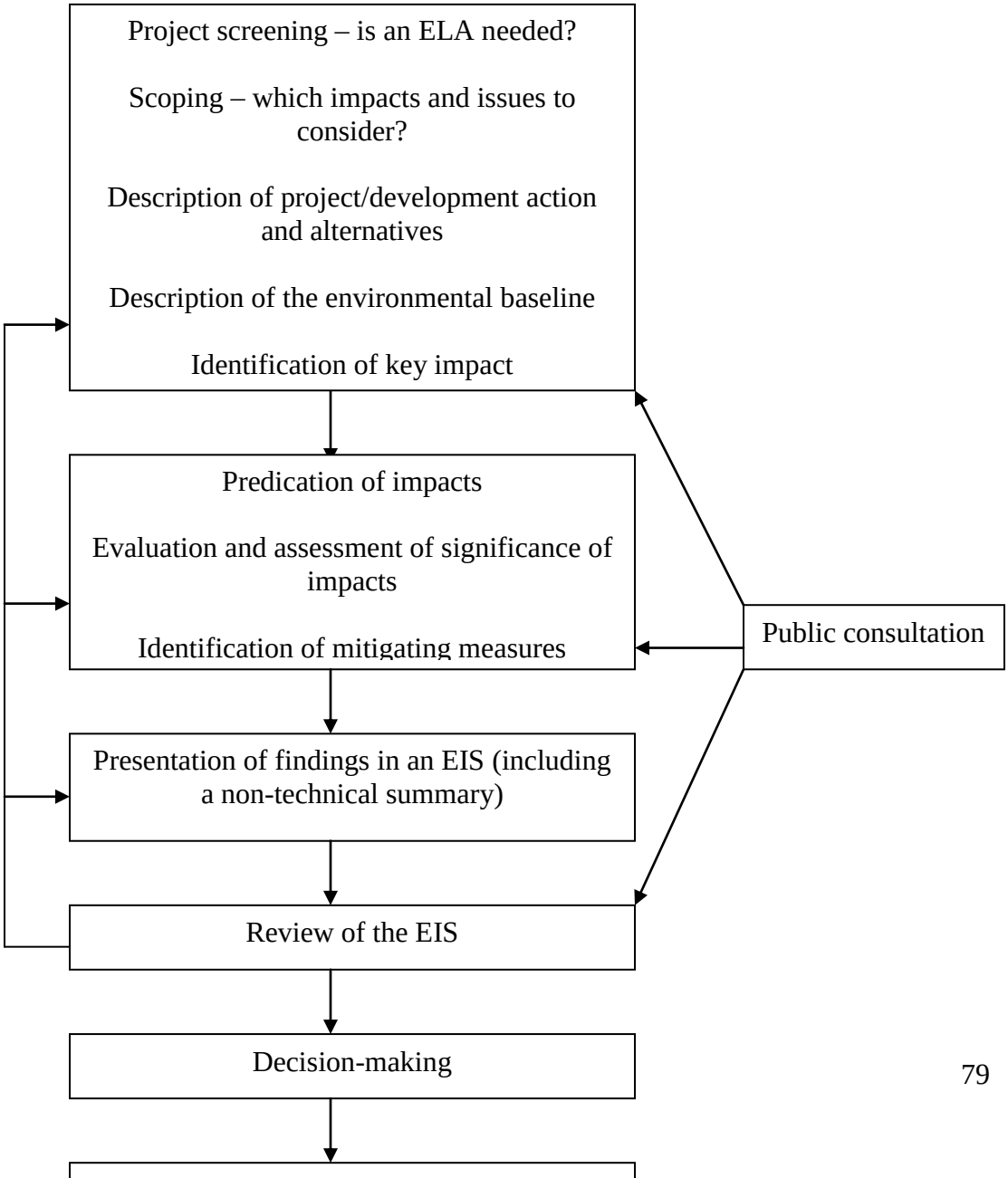


Figure 6.2 Important steps in the EIA process

Environmental impacts statements: the documentation

The environmental impact statement provides documentation of the information and estimate of impacts derived from the various steps in the process. Prevention is better than cure; an EIS revealing many significant unavoidable adverse impacts would provide valuable information that could contribute to the abandonment or substantial modification of a proposed development action. Where adverse impacts can be successfully reduced through mitigation measures there may be a different decision. Table 5.1 provides the content of an EIS for a project.

The *non-technical summary* is an important element in the documentation; EIA can be complex and the summery can help to improve communication with he various parties involved. Reflecting the potential complexity of the process, a *methods statement*, the beginning, provides an opportunity to clarify some basic information (e.g. who is the developer, who has produced the EIS, who has been consulted and now, what method have been used, what difficulties have been encountered and what are the limitations of the EIA?). *A summary statement of key issues*, up-front, can also help to improve communication. More enlightened EISs would also include a *monitoring programme*, either here or at the end of the document. The *background to the proposed development* covers the early steps in the EIA process, including clear description of the project, and baseline conditions (including relevant planning policies and plans). Within each of the topic areas of the EIS there would normally be the discussion of existing conditions, predicted impacts, scope for mitigation and residual impacts.

Table 6.1 an EIS for a project- typical content.

Non-technical summary
Part 1: Methods and key issue
- Methods statement
- Summery of key issues; monitoring programme statement

Part 2: Background to the proposed development
- Preliminary studies: need, planning, alternatives, sites selection
- Site description /baseline conditions
- Description of proposed development
- Constrictive activates and programme

Part 3: Environmental impact assessment –topic areas
- Land use, landscape and visual quality
- Geology, topography and soils
- Hydrology and water quality
- Air quality and climate
- Ecology: terrestrial and aquatic
- Noise
- Transport
- Socio-economic
- Interrelationships between effects

Environmental Audit (EA)

EA is used to evaluate the environmental impacts of existing policies, land uses and socio-economic activities. After performing EA, a city should realize its weak points in

environmental performance and be able to point out the relevant matters that need change in order to improve the quality of its environment. Environmental data that covers different issues has to be collected. The issues include:

- Socio-economic background
- Housing conditions
- Health conditions
- Natural environment
- Land use
- Urban transport
- Energy use
- Air pollution
- Noise pollution
- Water and sanitation
- Solid and hazardous wastes

The results of the EA should be presented in the form of an environmental review report that has the following parts:

- General background information: intended to provide a historical, geophysical and socio-economic perspective on urban development for each city and to briefly explain how developmental activities and the environment have interacted over time.
- Status of the environment: summarizes existing information on the quality of various environmental media (air, water, land, and cultural property) and briefly analyses the key natural hazardous that affect the urban area.
- Development-environment interactions: describes how development-oriented activities and services in the public, private, and informal sectors influence environmental quality and how environmental factors constrain or promote development.
- Setting for environmental management: identifies the key public and private actors engaged in environmental management affecting the city, existing management functions (instruments of intervention used and mechanisms for coordination and decision making), constraints on effective management, and the initiatives that are being undertaken to improve environmental management.

Annex

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FEDERAL NEGARIT GAZETA

OF THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

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9th Year No. 12
ADDIS ABABA 3rd December, 2002

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የአካባቢ ብክለት ቁጥጥር
አዋጅ

አንዳንድ ማሕበራዊና ኢኮኖሚያዊ የልማት ጥረቶች ልማቱን የሚቀለብስ ጎጂ አካባቢያዊ ተፅዕኖ ሊያስከትሉ የሚችሉ በመሆ ናቸው ፣

በአጠቃላዩ አካባቢን መጠበቅ ፣ በተለይም የሰውን ጤንነትና በጎ ሁኔታ እንደዚሁም የሕያዋንን ደሕንነትና የተፈጥሮን ሥነ ውበት ማቆየት የሁሉም ተግባርና ኃላፊነት በመሆኑ ፣

የመከላከያ ወይም የማስወገጃ እርምጃዎችን በመውሰድ በማሕበራዊና በኢኮኖሚያዊ ልማት ጥረቶች ሂደት የሚከሰተውንና የማይፈለገውን ብክለት ማስወገድ ሳይቻል መከላከል ተገቢ በመሆኑ ፣

በኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ ሕገ መንግሥት አንቀጽ ፶፭(፩) መሠረት የሚከተለው ታውጇል ።

ክፍል አንድ

፩· አጭር ርዕስ

ይህ አዋጅ "የአካባቢ ብክለት ቁጥጥር አዋጅ ቁጥር ፫፻/፲፱፻፺፭" ተብሎ ሊጠቀስ ይችላል ፣

፪· ትርጓሜ

በዚህ አዋጅ ውስጥ ፣

፩/ "ባለሥልጣን" ማለት የአካባቢ ጥበቃ ባለሥልጣን ነው፤

፪/ "ኬሚካል" ማለት ኤለመንት ፣ ወይም ያልተቀላቀለም ይሁን የተቀላቀለ ውሁድ ፣ ወይም ተቀምሞ በሰው የተሠራ ፣ ወይም ደግሞ ከተፈጥሮ የተገኘ ፣ ቁስአካል ነው፤

PROCLAMATION NO.300/2002
ENVIRONMENTAL POLLUTION CONTROL PROCLAMATION

WHEREAS, some social and economic development endeavors may inflict environmental harm that could make the endeavors counter-productive;

WHEREAS, the protection of the environment, in general, and the safeguarding of human health and well-being, as well as the maintaining of the biota and the aesthetic value of nature, in particular, are the duty and responsibility of all;

WHEREAS, it is appropriate to eliminate or, when not possible, to mitigate pollution as an undesirable consequence or social and economic development activities;

NOW, THEREFORE, in accordance with Article 55(1) of the Constitution of the Federal Democratic Republic of Ethiopia, it is hereby proclaimed as follows:

PART ONE

1. *Short Title*

This Proclamation may be cited as the "Environmental Pollution Control Proclamation No.300/2002".

2. *Definitions*

In this Proclamation:

1) "Authority" means the Environmental Protection Authority;
2) "Chemical" means an element or a compound whether by itself, or in a mixture or a preparation, whether manufactured or obtained from nature;

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፫· "አግባብ ያለው መሥሪያ ቤት" ማለት ይህ ስያሜ የተጠቀሰበት ድንጋጌ በሚነካው ጉዳይ ላይ በሕግ የተሰጠ ኃላፊነት ያለው የፌዴራል ወይም የክልል የመንግሥት አካል ነው ፤

፬· "ሥልጣን ያለው ፍርድ ቤት" ማለት በፌዴራል መንግሥት ሲሆን የመጀመሪያ ደረጃ ፍርድ ቤት ፣ እንዲሁም በብሔራዊ ክልላዊ መንግሥት ሲሆን በክልሉ ሕግ መሠረት የሚሰየም ፍርድ ቤት ነው ፤

፭· "ፍሳሽ" ማለት ተጣርቶ ወይም ሳይጣራ ፣ በቀጥታ ወይም ቀጥተኛ ባልሆነ መንገድ ወደ አካባቢ የሚለቀቅ ቆሻሻ ውሃ ወይም ሌላ ቆሻሻ ፈሳሽ ወይም ጋዝ ነው ።

፮· "አካባቢ" ማለት በመሬት ፣ በከባቢ አየር ፣ በአየር ሁኔታ እና በአየር ንብረት ፣ በውሀ ፣ በህያዋን ፣በድምፅ በሽታ ፣ በጣዕም ፣ በማህበራዊ ጉዳዮች እና በስነ ውበት ሳይወሰን ፣ በተፈጥሮአዊ ሁኔታቸው ወይም በሰው አማካኝነት ተሻሽለው ወይም ተለውጠው የሚገኙ ነገሮች በሙሉና ያሉበት ቦታ ፣ እንዲሁም መጠናቸውን ወይም ሁኔታቸውን ወይም ደግሞ የሰው ወይም የሌሎች ሕያዋን በጎ ሁኔታን የሚነኩ ተስተጋብሮቶቻቸው ድምር ነው ፤

፯· "የአካባቢ ተቆጣጣሪ ወይም ተቆጣጣሪዎች" ማለት በዚህ አዋጅ አንቀጽ ፯ /፩/ መሠረት የሚሰየመው አካል ነው ፤

፰· "አደገኛ ነገር" ማለት በሰው ጤና ወይም በአካባቢ ላይ ጉዳይ የሚያደርስ ጠጣር ፣ ፈሳሽ ወይም ጋዝ ወይም ተክል፣ እንስሳ ወይም ረቂቅ ሕዋስ ነው ።

፱· "አደገኛ ቆሻሻ" ማለት ተፈላጊነት የሌለው ሆኖ በአካባቢ ወይም በሰው ደህንነት ወይም ጤና ላይ ጉዳት ያደርሳል ተብሎ የሚታመን ማንኛውም ነገር ነው ።

፲· "ሰው" ማለት የተፈጥሮ ሰው ወይም በሕግ የሰውነት መብት የተሰጠው አካል ነው ፤

፲፩· "በካይ" ማለት ፈሳሽ ፣ ጠጣር ወይም ጋዝ የሆነ ፣ በቀጥታም ሆነ ቀጥተኛ ባልሆነ መንገድ ፣

ሀ) ያረፈበትን የአካባቢ ክፍል ጥራት በመለወጥ ጠቀሜታ የመስጠት አቅሙን የሚያጓድል ፣ ወይም

ለ) በሰው ጤና ወይም በሌሎች ሕያዋን ላይ ጉዳት የሚያደርስ ወይም ሊያደርስ የሚችል መርዝን ፣ በሽታን ፣ ክርፋትን ፣ ጨረርን ፣ ድምፅን ፣ ንዝረትን ፣ ሙቀትን ወይም ሌላ ክስተትን የሚያመነጭ ፣ ማንኛውም ነገር ነው ፤

፲፪· "ብክለት" ማለት በዚህ አዋጅ ወይም አግባብ ባለው ሌላ ሕግ የተደነገገን ማንኛውንም ግዴታ ፣ ማዕቀብ ወይም ገደብ ጥሶ የማንኛውንም አካባቢ ክፍል ቁሳዊ ፣ ጨረራዊ ፣ ሙቀታዊ ፣ ንጥረ ነገራዊ ፣ ሥነሕይወታዊ ወይም ሌላ ባህርይን በመለወጥ የተፈጠረ ፣ በሰው ጤና ወይም በጎነት ወይም ደግሞ በሌሎች ሕያዋን ላይ አደገኛ የሆነ ወይም አደገኛ ሊሆን የሚችል ሁኔታ ነው፤

፲፫· "ክልል" ማለት በኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ ሕገ መንግሥት አንቀጽ ፵፯/፩/ የተመለከቱት የአገሪቷ ክፍሎች ማለት ሲሆን ፣ ለዚህ አዋጅ አፈፃፀም የአዲስ አበባ እንደዚሁም የድሬዳዋ አስተዳደሮችንም ይጨምራል ።

፲፬· "የክልል የአካባቢ መሥሪያ ቤት "ማለት ለአካባቢና ለተፈጥሮ ሀብት ጥበቃ ወይም ቁጥጥር በክልሉ መንግሥት ኃላፊነት የተሰጠው ማንኛውም የክልል መንግሥት አካል ነው ፤

፲፭· "መልቀቅ" ማለት በውል ታስቦም ይሁን ሳይታሰብ በካይን ወደ ማንኛውም የአካባቢ ክፍል መጨመር ነው።

ክፍል ሁለት
የብክለት ቁጥጥር

የብክለት ቁጥጥር

፫· ማንም ሰው ተገቢን የአካባቢ ደረጃ በመተላለፍ አካባቢን ሊበክል ወይም በሌላ ሰው በኩል እንዲበከል ሊያደርግ አይፈቀድለትም ።

፪· ሕግ በመተላለፍ ማንኛውንም በካይ ወደ አካባቢ በሚለቅ ሰው ላይ ባለሥልጣኑ ወይም የሚመለከተው የክልል የአካባቢ መሥሪያ ቤት አስተዳደራዊ ወይም ሕጋዊ ዕርምጃ መውሰድ ይችላል።

3) "Competent Agency" means any Federal or Regional Government organ entrusted by law with a responsibility related to the subject specified in the provision where the term is used;

4) "Competent Court" means, in the case of the Federal Government, a first instance court and in the case of a national regional state, a court designated on the basis of the law of that state;

5) "Effluent" means waste water, gas or other fluid, treated or untreated, discharged directly or indirectly into the environment;

6) "Environment" means the totality of all materials whether in their natural state or modified or changed by humans, their external spaces and the interactions which affect their quality or quantity and the welfare of human or other living beings, including but not restricted to, land, atmosphere, weather and climate, water, living things, sound, odour, taste, social factors, and aesthetics;

7) "Environmental Inspector or Inspectors" means the body designated under Article 7(1) of this Proclamation;

8) "Hazardous material' means any substance in solid, liquid or gaseous state, or any plant, animal or micro organism that is injurious to human health or the environment;

9) "Hazardous Waste" means any unwanted material that is believed to be deleterious to human safety or health or the environment;

10) "Person" means any natural or juridical person;

11) "Pollutant" means any substance whether liquid, solid, or gas which directly or indirectly:

(a) alters the quality of any part of the receiving environment so as to effect its beneficial use adversely; or

(b) produces toxic substances, diseases, objectionable odour, radioactivity, noise, vibration, heat, or any other phenomenon that is hazardous or potentially hazardous to human health or to other living things;

12) "Pollution" means any condition which is hazardous or potentially hazardous to human health, safety, or welfare or to living things created by altering any physical, radioactive, thermal, chemical, biological or other property of any part of the environment in contravention of any condition, limitation or restriction made under this Proclamation or under any other relevant law;

13) "Region" means any of those parts of Ethiopia specified as such under Article 47(1) of the Constitution of the Federal Democratic Republic of Ethiopia and, for the purpose of this Proclamation, includes the Addis Ababa and Dire Dawa Administrations;

14) "Regional Environmental Agency" means any regional government organ entrusted, by the government of that region, with responsibility for the protection or regulation of the environment and natural resources;

15) "Release" means placing any pollutant in the environment in any way be it intentionally or otherwise.

PART TWO
Control of Pollution

3. *Control of Pollution*

1) No person shall pollute or cause any other person to pollute the environment by violating the relevant environmental standard.

2) The Authority or the relevant Regional environmental agency may take an administrative or legal measure against a person who, in violation of law, release any pollutant to the environment.

፫· ብክለትን ወይም ሌላ አካባቢያዊ ጉዳትን ሊያስከትል በሚችል የተግባር መስክ የተሰማራ ማንኛው ሰው ፣ የቆሻሻ መመንጨትን ለማስወገድ ወይም ወደተፈላጊው መጠን ለመቀነስ በባለሥልጣኑ ወይም በሚመለከተው የክልል የአካባቢ መሥሪያ ቤት ትዕዛዝ መሠረት በተገቢ ቴክኖሎጂና ሲቻልም ቆሻሻን መልሶ በጥቅም ላይ ለማዋል በሚያስችሉ ዘዴዎች መጠቀም አለበት።

፬· ብክለትን ያደረሰ ማንኛውም ሰው፣ ባለሥልጣኑ ወይም የሚመለከተው የክልል የአካባቢ መሥሪያ ቤት በሚወስነው ሁኔታና የጊዜ ገደብ መሠረት አካባቢውን ከበካይ ማፅዳት፣ ወይም ለማፅጃ የወጣውን ወጪ መሸፈን አለበት።

፭· በጤና ወይም በአካባቢ ላይ አደጋ እንዳያስከትል ከሚያሰጋ የሥራ እንቅስቃሴ ሊመጣ የሚችል ጉዳትን ለመከላከል ባለሥልጣኑ ወይም የሚመለከተው የክልል የአካባቢ መሥሪያ ቤት ድርጅትን እስከ መዝጋት ወይም ወደ ሌላ ቦታ እስከ ማዛወር የሚደርስ ማንኛውንም አስፈላጊ እርምጃ መውሰድ ይችላል።

፭· ስለአደገኛ ቆሻሻ፣ ኬሚካልና ጨረር አመንጪ ቁስ አያያዝ

፩· ከባለሥልጣኑ ወይም ከሚመለከተው የክልል የአካባቢ መሥሪያ ቤት ፈቃድ ሳይያዝ ማንኛውንም አደገኛ ቆሻሻን ማመንጨት፣ ማስቀመጥ፣ ማከማቸት፣ ማጓጓዝ፣ ማምከን ወይም ማስወገድ የተከለከለ ነው።

፪· ማንኛውንም አደገኛ ቆሻሻ በመሰብሰብ፣ መልሶ በጥቅም ላይ በማዋል፣ በማጓጓዝ፣ በማምከን ወይም በማስወገድ ሥራ የተሰማራ ማንኛውም ሰው በአካባቢ ወይም በሰው ጤና ወይም በጎ ሁኔታ ላይ ጉዳት እንዳይደርስ ተገቢውን የጥንቃቄ እርምጃ መውሰድ አለበት።

፫· ጨረር አመንጪ ቁስን ወደ አገር ውስጥ ለማስገባት፣ ከክርሰ ምድር ለማውጣት፣ ለማጣራት፣ ለማስቀመጥ፣ እንደዚሁም በአገር ውስጥ ለማሰራጨት፣ ለማከማቸት፣ ለማጓጓዝ፣ በጥቅም ላይ ለማዋል ወይም ለማስወገድ፣ አግባብ ካለው መሥሪያ ቤት ፈቃድ መገኘት አለበት።

፬· አደገኛ ተብሎ የተመደበን ወይም ለተወሰነ አገልግሎት ብቻ እንዲውል የተወሰነን ኬሚካል ወደ አገር ውስጥ ለማስገባት፣ ለመቀመም፣ ለማስቀመጥ፣ በአገር ውስጥ ለማሰራጨት፣ ለማከማቸት፣ ለማጓጓዝ፣ ወይም በጥቅም ላይ ለማዋል ከባለሥልጣኑ ወይም ደግሞ ከሚመለከተው የክልል የአካባቢ መሥሪያ ቤት ወይም አግባብ ካለው ከሌላ መሥሪያ ቤት ፈቃድ መገኘት አለበት።

፭· አደገኛ የሆነ ወይም ለተወሰነ አገልግሎት የሚውል ኬሚካልን በመቀመም፣ በማምረት ወይም በማጓጓዝ ወይም በኬሚካሉ በመነገድ ሥራ ላይ የተሰማራ ማንኛውም ሰው ኬሚካሉ በተገቢዎቹ ደረጃዎች መሠረት መመዝገቡን፣ መታሸጉንና ምልክት የተለጠፈበት መሆኑን ማረጋገጥ አለበት።

፮· የከተማ ቆሻሻ አያያዝ

፩· የከተማ አስተዳደሮች የተቀናጀ የከተማ ቆሻሻ አያያዝ ሥርዓትን በማውጣት፣ የከተማ ቆሻሻ መሰብሰቡን፣ መጓጓዙን፣ እንደተገቢነቱም በጥቅም ላይ መዋሉን፣ መምከኑን ወይም ጉዳት እንዳያመጣ ተደርጎ መወገዱን ማረጋገጥ አለባቸው፣

፪· ከሚመለከተው የክልል የአካባቢ መሥሪያ ቤት ጋር በመተባበር፣ ባለሥልጣኑ የከተሞች የቆሻሻ አያያዝ እና አጠቃቀም ሥርዓቶችን ብቃት መመዘንና የአተገባበራቸውንም ውጤታማነት መገምገም፣ መከታተልና ማረጋገጥ አለበት።

፫· ለሕዝብ ክፍት የሆነ ቦታን የሚያስተዳድር ማንም ሰው፣ ምንጊዜም በቂና ተስማሚ የመፀዳጃ ቤት፣ የቆሻሻ ማጠራቀሚያ ዕቃዎችና አስፈላጊ የሆኑ ሌሎች መገልገያዎች በቦታው መዘጋጀታቸውን ማረጋገጥ አለበት።

3) Any person engaged in any field of activity which is likely which is to cause pollution or any other environmental hazard shall, when the Authority or the relevant regional environmental agency so decides, install a sound technology that avoids or reduces, to the required minimum, the generation of waste and, when feasible, apply methods for the recycling of waste.

4) Any person who causes any pollution shall be required to clean up or pay the cost of cleaning up the polluted environment in such a manner and within such a period as shall be determined by the Authority or by the relevant regional environmental agency.

5) When any activity poses a risk to human health or to the environment, the Authority or the relevant regional environmental agency shall take any necessary measure upto the closure or relocation of any enterprise in order to prevent harm.

4. *Management of Hazardous Waste, Chemical and Radioactive Substance*

1) The generation, keeping, storage, transportation, treatment or disposal of any hazardous waste without a permit from the Authority or the relevant regional environmental agency is prohibited.

2) Any person engaged in the collection, recycling, transportation, treatment or disposal of any hazardous waste shall take appropriate precaution to prevent any damage to the environment or to human health or well-being.

3) The importation, mining, processing, keeping, distribution, storage, transportation or use of radioactive substances shall be subject to a permit from the competent agency.

4) The importation, preparation, keeping, distribution, storage, transportation or use of a chemical categorized as hazardous or of restricted use, shall be subject to a permit from the Authority or the relevant regional environmental agency or from any other competent agency.

5) Any person engaged in the preparation, production, manufacturing or transportation or in trading in any hazardous or restricted chemical may ensure that the chemical is registered, packed and labeled as per the applicable standards.

5. *Management of Municipal Waste*

1) All urban administrations shall ensure the collection, transportation, and, as appropriate, the recycling, treatment or safe disposal of municipal waste through the institution of an integrated municipal waste management system.

2) In collaboration with the relevant regional environmental agency, the Authority shall monitor and evaluate the adequacy of municipal waste management systems and ensure the effectiveness of their implementation.

3) Any person responsible for the maintenance of any premise to which the public has access shall, at all times, ensure that adequate and suitable toilets and containers and other required facilities are provided for the disposal of waste.

፬· ባለሥልጣኑ ከየሚመለከተው የክልል የአካባቢ መሥሪያ ቤት እንዲሁም አግባብ ካላቸው ሌሎች መሥሪያ ቤቶች ጋር በመተባበር፣ የከተሞች የቆሻሻ ማስወገጃ መገልገያ ዎችን መገምገምና በአጥጋቢ ሁኔታ መሟላታቸውን ለማረጋገጥ አስፈላጊ የሆኑ እርምጃዎችን መውሰድ አለበት።

ክፍል ሶስት
ስለአካባቢ ደረጃዎች

፮· ስለአካባቢ ደረጃዎች

፩· አግባብ ካላቸው መሥሪያ ቤቶች ጋር በመመካከር፣ ባለሥልጣኑ በሣይንሳዊና በአካባቢያዊ መርሆዎች ላይ የተመሠረቱና ተግባራዊ ለመሆን የሚችሉ የአካባቢ ደረጃዎችን ያዘጋጃል። እነዚህም ደረጃዎች ቢያንስ የሚከ ተሉትን ማካተት አለባቸው፣

ሀ) ወደ ውሃ አካላትና ወደ ፍሳሽ መቀበያ መስመሮች የሚለቀቁ ፍሳሾች ደረጃዎች፣

ለ) የአካባቢ አየር ጥራትን የሚገልፁና ለማይንቀሳ ቀሱና ለሚንቀሳቀሱ የአየር ብክለት ምንጮች የተፈ ቀዱትን የልቀት መጠኖች የሚወስኑ የአየር ጥራት ደረጃዎች፣

ሐ) ወደ አፈር የሚጨመሩ ኬሚካሎችን ወይም በአፈር ላይ ወይም ውስጥ የሚወገዱ ቁሶችን ዓይነትና መጠን የሚወስኑ የአፈር ጥራት ደረጃዎች፣

መ) የአሰፋፈር ሁኔታንና የአገሪቱ የሣይንስና የቴክ ኖሎጂ አቅምን በማገናዘብ የሚፈቀደውን ከፍተኛ የድምፅ መጠን የሚወስኑ የድምፅ ልቀት ደረጃዎች፣

ሠ) ለተለያዩ የቆሻሻ ዓይነቶች አመነጫጨት፣ አያያዝ፣ አከመቻቸት፣ አመላከን፣ አጓጓዝና አወጋገድ የሚያ ገለግሉ የመጠንና የአተገባበር ደረጃዎች።

፪· የሚያስከትለውን ጠንቅ ለመግታት በሚከረፋ ሽታ ምንጮች ላይ ቁጥጥር መካሄድ አለበት።

፫· ባለሥልጣኑ አካባቢን ለመጠበቅ ወይም መልሶ እንዲያ ገግም ለማድረግ እንደአስፈላጊነቱ ለተለያዩ ሥፍራዎች የተለያዩ የአካባቢ ደረጃዎችን ሊያወጣ ይችላል።

፬· ብሔራዊ ክልላዊ መንግሥታት በየራሳቸው ልዩ ሁኔታ በመመሥረት በፌዴራሉ እርከን ከተወሰኑት የጠበቁ ደረጃዎችን አውጥተው በሥራ ላይ ሊያውሉ ይችላሉ። በፌዴራሉ እርከን ከተወሰኑት የላሉ ደረጃዎች እንዲ ያወጡ ግን አይፈቀድላቸውም።

፭· የሕዝብ ጥቅምን ለማጎልበት ሊባል አግባብ ያለውን የአካባቢ ደረጃ እንዲያሟሉ የሚጠበቅባቸውን የተወሰኑ ተፈላጊ ሁኔታዎችን ተፈፃሚነት ባለሥልጣኑ ለተወሰነ ጊዜ እንዲታለፉ ሊፈቅድ ይችላል።

ክፍል አራት
ስለአካባቢ ተቆጣጣሪዎች

፯· ስለአካባቢ ተቆጣጣሪዎች

፩· የአካባቢ ተቆጣጣሪዎች /ከዚህ በኋላ "ተቆጣጣሪዎች" እየተባሉ የሚጠሩ/ በባለሥልጣኑ ወይም በሚመለከተው የክልል የአካባቢ መሥሪያ ቤት ይሰየማሉ፣

፪· ተቆጣጣሪዎች በዚህ አዋጅ መሠረት ሥልጣንና ተግባራ ቸውን ሲወጡ ሥራቸውን በትጋትና ያለአድልዎ መፈፀም አለባቸው።

፰· የተቆጣጣሪዎች ሥልጣንና ተግባር

፩· የአካባቢ ተቆጣጣሪዎች የሚከተሉት ሥልጣንና ተግባራት ይኖሯቸዋል፤

ሀ) የአካባቢ ደረጃዎችና ተዛማጅ ግዴታዎች በሥራ ላይ መዋላቸውን ማረጋገጥ፣

ለ) የዚህ አንቀጽ ንዑስ አንቀጽ (፫) እና (፮) ድንጋጌዎች እንደተጠበቁ ሆኖ፤ ሳያሳውቁ ወይም ፍርድ ቤት ትዕዛዝ ሳይዙ በማንኛውም ተገቢ መስሎ በሚታ ያቸው ጊዜ ወደ ማንኛውም ቦታ ወይም ቅጥር ግቢ መግባት፣

4) The Authority shall, in collaboration with the relevant regional environmental agencies and any other competent agencies, monitor the situation with regard to the availability of waste disposal facilities and take the necessary measures to ensure that their availability is satisfactory.

PART THREE
Environmental Standards

6. *Environmental Standards*

1) In consultation with competent agencies, the Authority shall formulate practicable environmental standards based on scientific and environmental principles. The sectors that require standards shall include at least the following:
   (a) Standards for the discharge of effluents into water bodies and sewage systems.
   (b) Air quality standards that specify the ambient air quality and give the allowable amounts of emission for both stationary and mobile air pollution sources.
   (c) Standards for the types and amounts of substances that can be applied to the soil or be disposed of on or in it.
   (d) Standards for noise providing for the maximum allowable noise level taking into account the settlement patterns and the availability of scientific and technological capacity in the country.
   (e) Waste management standards specifying the levels allowed and the methods to be used in the generation, handling, storage, treatment, transport and disposal of the various types of waste.
2) Sources of noxious odour shall be regulated so that the nuisance they cause is prevented.
3) The Authority may prescribe different environmental standards for different areas as it may find necessary to protect or rehabilitate the environment.
4) National regional states may, based on their specific situation, adopt environmental standards that are more stringent than those determined at the Federal level. However, they shall not adopt standards which are less rigorous than those determined at the Federal level.
5) The Authority may, for a fixed period of time, authorize the waiver of the duty to comply with some requirements of specified environmental standards in order to promote public benefit.

PART FOUR
Environmental Inspectors

7. *Environmental Inspectors*

1) Environmental inspectors (hereinafter referred to as "inspectors") shall be assigned by the Authority or by the relevant regional environmental agency.
2) Inspectors shall exercise due diligence and impartiality in the discharge of their powers and duties under this Proclamation.

8. *Powers and Duties of Inspectors*

1) Inspectors shall have the following powers and duties:
   (a) ensure compliance with environmental standards and related requirements;
   (b) without prejudice to Sub-Articles (3) and (6) of this Article, enter any land or premises at any time which seems appropriate to them without prior notice or court order;

ሐ) ማንኛውንም ሰው ብቻውን ወይም በምስክር ፊት መጠየቅ፣

መ) ከብክለት ጋር ግንኙነት ያለውን ማንኛውንም ወረቀት፣ ማሕደር ወይም ሌላ ሠነድ መፈተሽ፣ መገልበጥ ወይም ለይቶ መቅዳት፣

ሠ) የማንኛውንም ቁስ ናሙናዎች እንደአስፈላጊነቱ ያለክፍያ መውሰድና በአካባቢ ወይም በሕይወት ላይ ጉዳት የሚያደርስ መሆን አለመሆኑን ለመወሰን መመርመር ወይም ማስመርመር፣

ረ) ይህ አዋጅ እና አግባብ ያለው ማንም ሌላ ሕግ መከበሩን ለማረጋገጥ ሸቀጥን፣ የአመራረት ሂደትን ወይም መገልገያን በፎቶግራፍ ማንሣት ፣ መለካት፣ መሳል ወይም መፈተሽ፣

ሰ) ይህን አዋጅ ወይም አግባብ ያለውን ሌላ ሕግ በመተላለፍ ጥፋት ተፈጽሞበታል የተባለ መሣሪያን ወይም ሌላ ነገርን መያዝ፣

፪· የተመደበው ተቆጣጣሪ የዚህን አዋጅ ወይም ማንኛውንም አግባብ ያለውን ሕግ ድንጋጌ ለተላለፈ ሰው የመተላለፉን ምንነት ይዘረዝርለታል፣ ይህንኑ መተላለፍ በተወሰነ ጊዜ ውስጥ ለማስቀረት መውሰድ ያለበትን እርምጃ በመግለጽም እርምጃው እንዲወሰድ ሊያዝ ይችላል።

፫· የተመደበው ተቆጣጣሪ ማንኛውም እንቅስቃሴ በአካባቢ ላይ ጉዳት ሊያደርስ ይችላል ብሎ ሲጠረጥር እንቅስቃሴውን እስከ ማስቆም የሚደርስ የእርምት እርምጃ እንዲወሰድ ትዕዛዝ ይሰጣል።

፬· ማንኛውም የተመደበ ተቆጣጣሪ በባለሥልጣኑ ወይም በሚመለከተው የክልል የአካባቢ መሥሪያ ቤት የተሰጠ፣ የመሥሪያ ቤቱ ማህተም ያለበት መታወቂያ መያዝ ፣ ሲጠየቅም ማሳየት አለበት።

፭· ናሙና ሲወሰድ ባለንብረቱ የመገኘት ወይም ወኪል የመላክ መብት ስላለው ይህንኑ መብት እንዲያውቀው መደረግ አለበት።

፮· የሥራ አፈፃፀም ቅልጥፍናውን የሚበድልበት ካልሆነ በስተቀር ማንኛውም የተመደበ ተቆጣጣሪ ወደ ማንም ድርጅት ቅጥር ግቢ ወይም ቦታ ሲገባ ለባለንብረቱ ማስታወቅ አለበት።

፱· ስለይግባኝ

፩· ተቆጣጣሪው በወሰደው ማንኛውም እርምጃ ቅር የተሰኘ ማንኛውም ሰው፣ እርምጃው ከተወሰደበት ቀን አንስቶ በአሥር ቀናት ውስጥ ለባለሥልጣኑ ወይም ለሚመለከተው የክልል የአካባቢ መሥሪያ ቤት የበላይ ኃላፊ ይግባኝ ማለት ይችላል።

፪· በዚህ አንቀጽ ንዑስ አንቀጽ /፩/ መሠረት ውሳኔ ያልተሰጠ በመሆኑ ወይም የተሰጠው ውሣኔ ተገቢ ባለመሆኑ ቅር የተሰኘ ሰው ውሣኔው ከተሰጠበት ወይም የሚሰጥበት የጊዜ ገደብ ካለፈበት ቀን አንስቶ በሰላሣ ቀናት ውስጥ ክስ መመሰረት ይችላል፣

፲· ስለ ማበረታቻ

፩· ብክለትን ለመከላከል ወይም መጠኑን ለመቀነስ በሚያስችል በማንኛውም ዘዴ መጠቀም ለሚጀምር ለማንኛውም ነባር ድርጅት የሚሰጥ ማበረታቻ በዚህ አዋጅ ሥር በሚወጣ ደንብ ይወሰናል።

፪· በባለሥልጣኑ ሲረጋገጥ ብክለትን ለመከላከል ሲባል ወደ አገር ውስጥ የሚገባ መሣሪያ ከገቢ ዕቃዎች የጉምሩክ ቀረጥ ክፍያ ነፃ ይሆናል።

፲፩· ስለመክሰስ መብት

፩· ነገሩ የሚመለከተው መሆኑን ማስረዳት ሳይጠበቅበት፣ ማንኛውም ሰው በአካባቢ ላይ ጉዳት አድርሷል ወይም ጉዳት ሊያስከትል የሚችል ተግባር እየፈጸመ ነው በሚለው በማንኛውም ሰው ላይ ለባለሥልጣኑ ወይም ለሚመለከተው የክልል መሥሪያ ቤት ቅሬታ የማቅረብ መብት አለው።

(c) question any person alone or in the presence of witnesses;

(d) check, copy or extract any paper, file or any other document related to pollution;

(e) take, free of charge, samples of any material as required and carry out or cause to be carried out tests to determine whether or not it causes harm to the environment or to life;

(f) take photographs, measure, draw, or examine any commodity, process or facility in order to ensure compliance with this Proclamation and with any other relevant law;

(g) seize any equipment or any other object which is believed to have been used in the commission of an offence under this Proclamation or any other relevant law.

2) When a person contravenes any of the provisions of this Proclamation or of any other relevant law, the inspector on duty shall specify the matter constituting the contravention and may also specify the measures that shall be taken to remedy the contravention within a given period of time.

3) When an inspector on duty suspects that any activity may cause damage to the environment, he shall order the taking of corrective measures upto the immediate cessation of the activity.

4) Every inspector shall have an identity card issued by the Authority or by the relevant regional environmental agency, bearing its official seal and show it when requested;

5) Whenever a sample is to be taken, the proprietor has the right to be present or to send his representative and he shall be informed accordingly.

6) When an inspector on duty visits an undertaking, he shall notify the proprietor unless he considers that such notification may be prejudicial to the efficient performance of his duty.

9. *Right to Appeal*

1) Any person dissatisfied with any of the measures taken by the inspector may appeal to the Head of the Authority or the relevant regional environmental agency, as the case may be, within ten days from the date on which the measure was taken.

2) Any person dissatisfied because no decision has been given as provided under Sub-Article (1) of this Article, or feels that the decision given is inappropriate, may institute a court case within thirty days from the date on which the decision was given or the deadline for decision has elapsed.

10. *Incentives*

1) Incentives for the introduction of methods that enable the prevention or minimizatin of pollution into an existing undertaking shall be determined by regulations issued hereunder.

2) Importation of new equipment that is destined to control pollution shall, upon verification by the Authority, be exempted from payment of custom duty.

11. *Right to standing*

1) Any person shall have, without the need to show any vested interest, the right to lodge a complaint at the Authority or the relevant regional environmental agency against any peron allegedly causing actual or potential damage to the environment.

፪. ባለሥልጣኑ ወይም የሚመለከተው የክልል የአካባቢ መሥሪያ ቤት በሰላሳ ቀናት ውስጥ ውሣኔ ካልሰጠ ወይም ቅሬታ አቅራቢው በውሳኔው ካልተስማማ ፣ ውሳኔው ከተሰጠበት ወይም የሚሰጥበት የጊዜ ገደብ ካለፈበት ቀን አንስቶ በስድሳ ቀናት ውስጥ በፍርድ ቤት ክስ መመሥረት ይችላል።

ክፍል አምስት
ጥፋትና ቅጣት

፲፪. ጠቅላላ

፩. ይህን አዋጅ ወይም አግባብ ያለውን ሌላ ሕግ የተላለፈ ፣ ነገር ግን ጥፋቱ በወንጀለኛ መቅጫ ሕግም ሆነ በዚህ አዋጅ ቅጣት ያልተመደበለት ሆኖ የተገኘ ማንም ሰው ጥፋተኛነቱ ሲረጋገጥ፣

ሀ) የተፈጥሮ ሰው ሲሆን፣ ከአምስት ሺህ ብር በማያንስና ከአስር ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ወይም ከአንድ ዓመት በማይበልጥ እሥራት ወይም በሁለቱም ይቀጣል፣

ለ) በሕግ የሰውነት መብት የተሰጠው ሲሆን ከአሥር ሺህ ብር በማያንስና ከሃያ ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ይቀጣል።

፪. በዚህ አንቀጽ ንዑስ አንቀጽ /፩/ መሠረት በሕግ የሰውነት መብት የተሰጠው አካል ጥፋተኛነቱ ሲረጋገጥ የተፈፀመውን ጥፋት ማወቅ የነበረበትና ኃላፊነቱን በብቃት ያልተወጣው የሥራ ኃላፊ ከአምስት ሺህ ብር በማያንስና ከአስር ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ወይም ከሁለት ዓመት በማይበልጥ እሥራት ወይም በሁለቱም ይቀጣል፣

፫. በወንጀለኛ መቅጫ ሕግ መሠረት የከበደ ቅጣት የሚያስቀጣ ካልሆነ በስተቀር ፣ በዚህ አዋጅ የተደነገጉት ቅጣቶች ተፈፃሚ ይሆናሉ።

፲፫. ከተቆጣጣሪዎች ጋር በተያያዘ ስለሚፈፀሙ ጥፋቶች

፩. የተመደበ ተቆጣጣሪን ሥራውን እንዳያከናውን ያደናቀፈ ወይም ያሰናከለ ፣ ተቆጣጣሪው በሕግ መሠረት የጠየቀውን ወይም ያዘዘውን ያልፈፀመ ፣ በማስመሰል ተቆጣጣሪ ነው ሊባል የሞከረ ፣ ተቆጣጣሪው ወደ ማንኛውም ቦታ ወይም ቅጥር ግቢ እንዳይገባ ወይም መዛግብት እንዳይመረምር ያደናቀፈ ማንኛውም ወረቀት፣ ማሕደር ፣ ወይም ሌላ ሰነድ እንዳይፈትሽ ፣ እንዳይገለብጥ ፣ ወይም ለይቶ እንዳይቀዳ የከለከለ ፣ ለተቆጣጣሪ መረጃ የከለከለ፣ ያሳሳተ ወይም የተሳሳተ መረጃ የሰጠ ማንም ሰው ጥፋት ፈጽሟል፣

፪. በዚህ አንቀጽ ንዑስ አንቀጽ /፩/ መሠረት ጥፋት የፈፀመ የተፈጥሮ ሰው ጥፋተኛነቱ ሲረጋገጥ ከሰስት ሺህ ብር በማያንስና ከአሥር ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ይቀጣል፣ ጥፋቱን የፈፀመው በሕግ የሰውነት መብት የተሰጠው አካል ከሆነ ደግሞ ጥፋተኛነቱ ሲረጋገጥ ከብር አሥር ሺህ በማያንስና ከብር ሃያ ሺህ በማይበልጥ የገንዘብ መቀጮ ይቀጣል፣ የሥራ ኃላፊውም ከአንድ ዓመት በማያንስ እና ከሁለት ዓመት በማይበልጥ እሥራት ወይም ከአምስት ሺህ ብር በማያንስና ከአስር ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ወይም በሁለቱም ይቀጣል።

፲፬. መዛግብትን በተመለከተ ስለሚፈፀሙ ጥፋቶች

አንድ ሰው በዚህ አዋጅ ወይም በሥሩ በሚወጡ ደንቦች መሠረት በመዝገብ እንዲያስፍር የተጠየቀውን የእንቅስቃሴ፣ የምርት ፣ የቆሻሻ ዓይነት ባሕርይ ወይም መጠን ወይም ሌላ ተፈላጊ መረጃ በተገቢው ሳይመዘግብ ከቀረ ወይም በመዝገብ የሰፈረውን ከለወጠ ፣ ከአስር ሺህ ብር በማያንስና ከሃያ ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ይቀጣል።

2) When the Authority or regional environmental agency fails to give a decision within thirty days or when the person who has lodged the complaint is dissatisfied with the decision, he may institute a court case with in sixty days from the date the decision was given or the deadline for decision has elapsed.

PART FIVE
Offences and Penalties

12. *General*

1) A person who, under this Proclamation or under any other relevant law, commits an offence for which no penalty is provided for either in the Penal Code or under this Proclamation, is liable on conviction:
   (a) in the case of a natural person, to a fine of not less than five thousand Birr and not more than ten thousand Birr or an imprisonment of not more than one year or both;
   (b) in the case of a juridical person, to a fine of not less than ten thousand Birr and not more than twenty thousand Birr.

2) Where a juridical person is convicted pursuant to Sub-Article (1) of this Article, the officer in charge who should have known the commission of the offence, and who failed to fulfill his duty appropriately shall be liable to a fine of not less than five thousand Birr and not more than ten thousand Birr or an imprisonment of not more than two years or both.

3) Unless the provisions of the Penal Code provide more severe penalties, the penalties laid down under this Proclamation shall be applicable.

13. *Offences Relating to Inspectors*

1) A person commits an offence if he hinders or obstructs an inspector on duty in the execution of his duty, fails to comply with a lawful order or requirement made by an inspector, impersonates an inspector, or refuses an inspector entry into any land or premise or hinders an inspector from getting access to records, prevents an inspector from checking, copying or extracting any paper, file or any other document, withholds, misleads or gives wrong information to an inspector.

2) A natural person who commits an offence under Sub-Article (1) of this Article is liable, on conviction, to a fine of not less than three thousand Birr and not more than ten thousand Birr, and, in the case of a juridical person, to a fine of not less than ten thousand Birr and and not more than twenty thousand Birr, and imprisonment of the officer in charge for a term of not less than one year and not more than two years or a fine of not less than five thousand Birr and not more than ten thousand Birr or both.

14. *Offences Relating to Records*

A person commits an offence if he fails to comply with this Proclamation or any regulations issued hereunder to keep records of activities or products or of the types, characteristics or amounts of waste or of any other information, or if he alters any record shall be liable, on conviction, to a fine of not less than ten thousand Birr and not more than twenty thousand Birr.

፲፭· አደገኛ የሆነ ቆሻሻንና ሌላ ቁስን በተመለከተ ስለሚፈፀም ጥፋት

፩· አንድ ሰው አደገኛ ቆሻሻን ወይም አደገኛ ነገርን አግባብ ባላቸው ሕጎች መሠረት ካልያዘ፣ መለጠፍ ያለበት ዝርዝርን አሳስቶ ከለጠፈ ወይም ጭራሹን ካልለጠፈ ፣ ወይም ደግሞ ማንኛውንም አደገኛ ቆሻሻን፣ ወይም ሌላ ነገርን በተመለከተ መረጃ ከነፈገ ወይም ያልተፈቀደ የአደገኛ ቆሻሻ ዝውውርን ለማካሄድ ከሞከረ ወይም ካካሄደ ወይም ደግሞ እንዲካሄድ ለመርዳት ከሞከረ ወይም ከረዳ ጥፋተኛ ነው።

፪· በዚህ አንቀጽ ንዑስ አንቀጽ /፩/ መሠረት ጥፋት የፈፀመ የተፈጥሮ ሰው ጥፋተኛነቱ ሲረጋገጥ ከሃያ ሺህ ብር በማያንስና ከሃምሳ ሺህ ብር በማይበልጥ የገንዘብ መቀጮ፣ ጥፋቱን የፈፀመው በሕግ የሰውነት መብት የተሰጠው አካል ከሆነ ደግሞ ከሃምሳ ሺህ ብር በማያንስና ከአንድ መቶ ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ይቀጣል። የሥራ ኃላፊውም ከሦስት ዓመት በማያንስና ከስድስት ዓመት በማይበልጥ እሥራት ወይም ከሰላሳ ሺህ ብር በማያንስና ከሰባ ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ወይም በሁለቱም ይቀጣል።

፲፮· ብክለትን በሚመለከት ስለሚፈፀም ጥፋት

አንድ የተፈጥሮ ሰው የዚህን አዋጅ ወይም በሥሩ የሚወጡትን ደንቦች በመተላለፍ በካይን ወደ አካባቢ በመልቀቅ ጥፋተኛ ሆኖ ሲገኝ፣ ከአንድ ሺህ ብር በማያንስና ከአምስት ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ወይም ከአንድ ዓመት በማያንስና ከአሥር ዓመት በማይበልጥ እሥራት ወይም በሁለቱም ይቀጣል። ጥፋቱን የፈፀመው በሕግ የሰውነት መብት የተሰጠው አካል ከሆነ ከአምስት ሺህ ብር በማያንስና ከሃያ አምስት ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ይቀጣል ፣ የሥራ ኃላፊውም ከአምስት ዓመት በማያንስና ከአስር ዓመት በማይበልጥ እሥራት ወይም ከአምስት ሺህ ብር በማያንስና ከአስር ሺህ ብር በማይበልጥ የገንዘብ መቀጮ ወይም በሁለቱም ይቀጣል።

፲፯· ስለመውረስ እና ወደ ነበረበት ሁኔታ ስለመመለስ

ይህን አዋጅና በሥሩ የሚወጡትን ደንቦች በመጣስ ጥፋተኛነቱ በተረጋገጠበት ሰው ላይ ከሚወሰንበት ማንኛውም ቅጣት በተጨማሪ ፍርድ ቤቱ ፣

ሀ) ለጥፋቱ ተግባር የዋለ ማንኛውም ነገር ተወርሶ ለመን ግሥት ገቢ እንዲሆን ወይም በሌላ መንገድ እንዲወገድ፣

ለ) አካባቢውን የማፅጃ ወይም መሣሪያውን ፣ ኬሚካሉን ወይም ዕቃውን የማስወገጃ ወጪ ተከሳሹ እንዲከፍል፣ እንደዚሁም፣

ሐ) ጉዳት የደረሰበትን አካባቢ ተከሳሹ በራሱ ወጪ ወደ ነበረበት ሁኔታ እንዲመልስ ወይም ይህ የማይቻል ከሆነ ተገቢ ካሣ እንዲከፍል ማዘዝ ይችላል።

ክፍል ስድስት

ልዩ ልዩ ድንጋጌዎች

፲፰· የመሸጋገሪያ ድንጋጌ

በሥራ ላይ ያሉ ተቋማት ይህን አዋጅ እንዴት ተፈፃሚ እንደሚያደርጉት በዚህ አዋጅ ሥር በሚወጣ ደንብ ይወሰናል።

፲፱· መረጃ የመስጠት ግዴታ

፩· የዚህን አዋጅ ወይም ከዚህ አዋጅ ጋራ ግንኙነት ያለውን የሌላ ሕግ ድንጋጌ የሚመለከት ተግባርን የሚያከናውን ማንኛውም ሰው ባለሥልጣኑ ወይም የሚመለከተው የክልል የአካባቢ መሥሪያ ቤት በሚፈልገው መሠረት የሥራ እንቅስቃሴውን መረጃ ማቅረብ አለበት።

ባለሥልጣኑ ማንኛውንም አካባቢን የሚመለከት መረጃ የማግኘት መብት አለው።

15. *Offences Relating to Wastes and Other Materials that are Hazardous*

1) A person commits an offence if he fails to manage a hazardous waste or another substance according to the relevant laws, mislabels or fails to label or in any way withholds information about any hazardous waste or other material or attempts to take part or takes part or attempts to aid or aids in the illegal traffic of any hazardous waste or other material.

2) A natural person who commits an offence under Sub Article (1) of this Article is liable, on conviction, to a fine of not less than twenty thousand Birr and not more than fifty thousand Birr and in the case of a juridical person to a fine of not less than fifty thousand Birr and not more than one hundred thousand Birr, and to a term of imprisonment of the officer in charge of not less than five years and not more than ten years, or a fine of not less than five thousand Birr and not more than ten thousand Birr of both.

16. *Offences Relating to Pollution*

A natural person commits an offence if he discharges any pollutant contrary to the provisions of this Proclamation or regulations issued hereunder and is liable, on conviction, to a fine of not less than one thousand Birr and not more than five thousand Birr or to an imprisonment of not less than one year and not more than ten years or both and, in the case of a juridical person, to a fine of not less than five thousand Birr and not more than twenty five thousand Birr and an imprisonment of the officer in charge for a term of not less than five years and not more than ten years, or a fine of not less than five thousand Birr and not more than ten thousand Birr or both.

17. *Forfeiture and Restoration*

The court, before which a person is prosecuted for an offence under this Proclamation or regulations issued hereunder, may, in addition to any penalty it impose upon the convicted person, order:

(a) the confiscation of any thing used in the commission of the offence in favor of the state or to dispose of it in any other way;

(b) that the cost of cleaning up and the disposing of the substance, chemical or equipment seized be borne by the convicted person; and

(c) the convicted person to restore to the state in which the environment was prior to the infliction of the damage, and when such restoration is not possible to pay appropriate compensation.

PART SIX

Miscellaneous Provisions

18. *Transitory Provision*

Regulations to be issued hereunder shall determine the manner in which existing undertakings shall comply with this Proclamation.

19. *Duty to Provide Information*

1) Any person engaged in an activity pertaining to any of the provisions of this proclamation or any other related law shall provide any information on his activity as required by the Authority or the relevant regional environmental agency.

2) The Authority shall have access to all environmental data and information.

፳. ደንብ የማውጣት ሥልጣን
የሚኒስትሮች ምክር ቤት ይህንን አዋጅ በተሟላ ሁኔታ ተግባራዊ ለማድረግ አስፈላጊ የሆኑ ደንቦችን ሊያወጣ ይችላል።

፳፩. ተፈፃሚነት የሌላቸው ሕጎች
ከዚህ አዋጅ ጋር ተቃራኒ የሆነ ሕግ ወይም አሠራር በዚህ አዋጅ በተመለከቱት ጉዳዮች ላይ ተፈፃሚነት አይኖረውም።

፳፪. አዋጁ የሚፀናበት ጊዜ

ይህ አዋጅ ከኅዳር ፳፬ ቀን ፲፱፻፺፮ ዓ.ም ጀምሮ የፀና ይሆናል።

አዲስ አበባ ኅዳር ፳፬ ቀን ፲፱፻፺፮ ዓ.ም

ግርማ ወልደጊዮርጊስ
የኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ
ፕሬዚዳንት

20. *Power to Issue Regulations*
The Council of Ministers may issue Regulations necessary for the effective implementation of this Proclamation.

21. *Inapplicable Laws*
Any law or practice inconsistent with this Proclamation is inapplicable regarding matters provided herein.

22. Effective Date

This Proclamation shall come into force as of the 3rd day of December, 2002.

Done at Addis Ababa, this 3rd day of December, 2002.

GIRMA WOLDE GIORGIS
PRESIDENT OF THE FEDERAL
DEMOCRATIC REPUBLIC OF ETHIOPIA

የኢትዮጵያ ፌደራላዊ ዲሞክራሲያዊ ሪፐብሊክ

ፌደራል ነጋሪት ጋዜጣ

FEDERAL NEGARIT GAZETTE OF THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

ሃያ አምስተኛ ዓመት ቁጥር ፺
አዲስ አበባ መስከረም ፲፪ ቀን ፪ሺ፲፪ ዓ.ም

በኢትዮጵያ ፌደራላዊ ዲሞክራሲያዊ ሪፐብሊክ
የሕዝብ ተወካዮች ምክር ቤት ጠባቂነት የወጣ

25th Year No. 90
ADDIS ABABA 23rd September 2019

ማውጫ

CONTENT

አዋጅ ቁጥር ፩፻፩፺/፪ሺ፲፩

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መንግስት ለሕዝብ አገልግሎት ለሚያከናውናቸው የልማት ሥራዎች መሬትን መጠቀም አስፈላጊ ስለሆነ፤

የአገራቱ ከተሞች ከጊዜ ወደ ጊዜ እያደጉና የነዋሪዎቹም ቁጥር እየጨመረ በመሄዱ በከተሞች ፕላን መሠረት ለመኖሪያ ቤት ግንባታ፣ ለመሠረተ ልማት፣ ለኢንቨስትመንትና ለሌሎች አገልግሎቶች የሚውል የከተማ መሬትን መልሶ ማልማት አስፈላጊ በመሆኑ፣እንዲሁም በገጠር ለሚከናወኑ የልማት ሥራዎች መሬት አዘጋጅቶ ማቅረብ በማስፈለጉ፤

የመሬት ይዞታ እንዲለቅ ለተደረገ ባለይዞታ ተገቢና ተመጣጣኝ ካሣና የተነሽ ድጋፍ ለመክፈል ግምት ውስጥ መግባት የሚገባቸውን መሠረታዊ መርሆዎችን ለይቶ መወሰን በማስፈለጉ፤

PROCLAMATION NO.1161/2019

A PROCLAMATION TO DETERMINE EXPROPRIATION OF LANDHOLDINGS FOR PUBLIC PURPOSE, PAYMENTS OF COMPENSATION AND RESETLEMENT

WHERE AS, it is necessary that government needs to use land for development works it carries out for public services;

WHEREAS, land expropriation has become necessary to address the steadily growing urban population which requires more land for building houses, infrastructure; and for redevelopment of the urban slams to invigorate investment and other services; and for development activities in rural areas;

WHEREAS, it is essential to determine the types of compensable properties and lost economic interests and the principles thereof and establish the methods of valuation in order to pay land holders whose landholdings and property are expropriated or damaged or lost their economic interests in the

ነጋሪ ዋጋ
Unit Price 22.75

ነጋሪት ጋዜጣ ፖ.ሣ.ቁ. ፹፻፩
Negarit G. P.O.Box 80001

ካሣውን የመተመን፣ የመክፈል እና ተነሺዎችን መልሶ የማቋቋም ሥልጣንና ኃላፊነት ያለባቸውን አካላት በግልጽ ለይቶ ለመወሰን በማስፈለጉ፤

በነባሩ ሕግ ያጋጠሙ የሕግ ክፍተቶችን ለማስተካከልና ሌሎች የመሬት ይዞታ የሚለቀቅበትን እና ካሣ የሚከፈልበት ሥርዓቱን ይበልጥ ውጤታማ የሚያደርጉ ድንጋጌዎችን ማካተት አስፈላጊ ሆኖ በመገኘቱ፤

ከይዞታ መነሳትና ካሳ ክፍያ ጋር ተያይዞ ስለሚኖር የቅሬታ አቀራረብና ውሳኔ አሰጣጥ ስርዓት በግልጽ መወሰን አስፈላጊ በመሆኑ፤

የፌደራል መንግሥት የመሬት አጠቃቀም ሕግ የማውጣት ሥልጣን እንዳለው በሕገ መንግስቱ አንቀጽ ፶፩(፰) በመደንገጉ፣ ለህዝብ ጥቅም ሲባል የሚለቀቅ ንብረትን በሚመለከት ተመጣጣኝ ካሣ በቅድሚያ እንዲከፈል በአንቀጽ ፵(፰) በመደንገጉ እንዲሁም ተነሺዎች በመንግስት ዕርዳታ እንዲቋቋሙ በአንቀጽ ፵፬(፬) የተቀመጠውን መሠረተ ሀሳብ በዝርዝር መደንገግ በማስፈለጉ፤

በኢትዮጵያ ፌደራላዊ ዲሞክራሲያዊ ሪፐብሊክ ሕገ መንግሥት አንቀጽ ፶፭ (፪)(ሀ) መሠረት የሚከተለው ታውጇል።

፩.አጭር ርዕስ

ይህ አዋጅ "ለሕዝብ ጥቅም ሲባል የመሬት ይዞታ የሚለቀቅበት፣ካሣ የሚከፈልበት እና ተነሺዎች መልሰው የሚቋቋሙበትን ሁኔታ ለመወሰን የወጣ አዋጅ ቁጥር ፩ሺ፩፻፷፩/፪ሺ፲፩" ተብሎ ሊጠቀስ ይችላል።

process of expropriation fair and equitable compensation;

WHERE AS, it is necessary to identify and define the powers and responsibilities of authorities which are in charge of property valuation; payment of compensation and resettlement;

WHEREAS, it is necessary to rectify and fill gaps envisaged in the former law and to include other provisions to make the system of expropriation of land holdings and payment of compensation more effective;

WHERE AS, it is necessary to determine the decision making process and grievances procedure related with the expropriation and payment of compensation ;

WHEREAS, it is necessary to enact detailed laws to implement the general powers given to the Federal Government under the Constitution of Federal Democratic Republic of Ethiopia to enact laws regarding land use under Article 51(5); and Expropriate of Private property for Public Purposes and payment of fair and equitable compensation to the expropriated land holders under Article 40(8) and provide support to resettle displaced people under Article 44 (2);

NOW, THEREFORE, in accordance with Article 55 (2) (a) of the Constitution of the Federal Democratic Republic of Ethiopia, it is hereby proclaimed as follows;

1. Short Title

This Proclamation may be cited as the"Expropriation of Land holdings for Public Purposes, Payments of Compensation and Resetlement Proclamation No. 1161/2019".

፪. ትርጓሜ

የቃሉ አገባብ ሌላ ትርጉም የሚያሰጠው ካልሆነ በስተቀር በዚህ አዋጅ ውስጥ:-

፩/"የህዝብ ጥቅም" ማለት በቀጥታም ሆነ በተዘዋዋሪ መንገድ ማሕበራዊና ኢኮኖሚያዊ ልማትን ለማጎልበት የክልል ካቢኔ፤ የአዲስ አበባ፤ የድሬዳዋ ወይም አግባብ ባለው የፌደራል አካል በመሬት አጠቃቀም ዕቅድ ወይም በልማት ዕቅድ ወይም በመሠረተ ልማት መሪ ፕላን መሠረት ለሕዝብ የተሻለ የጋራ ጥቅምና ዕድገት ያመጣል ተብሎ የተወሰነው ነው።

፪/"የንብረት ካሣ" ማለት የመሬት ይዞታውን እንዲለቅ ለሚወሰንበት ባለይዞታ በመሬቱ ላይ ለሰፈረው ንብረት ወይም ላደረገው ቋሚ ማሻሻያ በዓይነት ወይም በገንዘብ ወይም በሁለቱም የሚከፈል ክፍያ ነው።

፫/"የልማት ተነሽ ካሣ" ማለት ባለይዞታው የመሬት ይዞታውን ሲለቅ በመሬቱ ላይ የመጠቀም መብቱ በመቋረጡ ምክንያት የሚደርስን ጉዳት ለማካካስ የሚከፈል ክፍያ ነው።

፬/"የልማት ተነሽ ድጋፍ" ማለት የመሬት ባለይዞታ ከመሬቱ በጊዜያዊም ሆነ በቋሚነት ሲነሳ ከአዲሱ አካባቢ ጋር መላመድ እንዲችል ከንብረት እና ከልማት ተነሽ ካሣ በተጨማሪ በዓይነት ወይም በገንዘብ የሚሰጥ ድጋፍ ነው።

፭/"የኢኮኖሚ ጉዳት ካሣ" ማለት ከቦታቸው ያልተነሱ ነገር ግን መሬት ለሕዝብ ጥቅም በመለቀቁ ምክንያት በመቀጠር ወይም በመነገድ ወይም በማከራየት እና ከመሳሰሉት ያገኙት የነበረ ገቢ በመቋረጡ ለሚደርስ ጉዳት የሚከፈል ካሣ ነው።

፮/"የማህበራዊ ትስስር መቋረጥና ሥነ-ልቦና ጉዳት ካሣ" ማለት ለተነሺ ከነበረበት አካባቢ በመነሳቱ የነበረው ማህበራዊ ትስስር በመቋረጡ የሚከፈል

2. Definition

Unless the context requires otherwise, in this Proclamation:

1/"Public Purpose" means decision that is made by the cabinet of a Regional State, Addis Ababa, Dire Dawa or the appropriate Federal Authority on basis of approved land use plan or; development plan or; structural plan under the belief that the land use will directly or indirectly bring better economic and social development to the public;

2/"Property Compensation" means, payment to be made in cash or in kind or in both to a person for his property or permanent improvements situated on his expropriated landholding;

3/ "Displacement Compensation" means payment to be made to a land holder for the loss of his use right on the land as a result of expropriation;

4 / Displacement Assistance" means payment to be made, in addition to property and displacement compensations, for a landholder who permanently or temporarily displaced in order to help him adjust to the new place;

5/"Economic Loss Compensation" means payment to be made to those who are not displaced but who suffer loss of employment, trade; or rentals, or similar activities as a consequence of expropriation of land for public purposes;

6/"Social Ties Discontinuance and Moral Damage Compensation" means payment to be made to displaced people for the breakup of their social ties and moral

የማህበራዊ ትስስር መቋረጥ እና የሥነ-ልቦና ጉዳት ማካካሻ ክፍያ ነው።

damage suffered;

፯/"መልሶ ማቋቋም" ማለት ለልማት ተብለው በተወሰደው መሬት ምክንያት የሚያገኙት ጥቅም ለሚቋረጥባቸው ተነሺዎች ዘላቂ የገቢ ምንጭ እንዲኖራቸው የሚሰጥ ድጋፍ ነው።

7/"Resettlement" means support provided to people who are not physically displaced but lost their economic benefit due to expropriation of land for public purposes and so as to enable them generate sustainable income.

፰/"ተመና" ማለት ለህዝብ ጥቅም በሚለቀቅ መሬት ላይ ለሠፈረ ንብረት ወጥ የሆነ የካሣ ስሌት የሚሰራበት ዘዴ ነው።

8/"Valuation " means a common compensation valuation method used to calculate the value of property on expropriated land;

፱/"ቋሚ ማሻሻያ" ማለት በይዞታው ላይ የምንጣሮ፣ ድልደላና እርከን ሥራ፣ ውሃ መከተር ሥራ እና የግቢ ንጣፍና ማስዋብ የመሳሰሉትን ሥራዎች ያጠቃልላል።

9/"Permanent Improvement" means improvements made permanently to the land like clearing, leveling and terracing the land, including the costs of water reservoir and other agricultural infrastructure and urban courtyard floors and other decoration works.

፲/"የማቋቋሚያ ማዕቀፍ" ማለት ለህዝብ ጥቅም ሲባል ከመሬት ይዞታቸው እንዲነሱ ሲደረግ ዘላቂ የሆነ የገቢ ምንጭ ሊኖራቸው የሚያስችል የሥራ መርሐ ግብር ነው።

10/"Resettlement package" means work program to people whose landholding is expropriated for public purpose so as to enable them generate sustainable income;

፲፩/"የወል ይዞታ" ማለት ከመንግሥት ወይም ከግል ይዞታነት ውጭ የሚገኝና የአካባቢው ማህበረሰብ ለግጠኝ፣ ለደንና ለማህበራዊ አገልግሎት በጋራ የሚጠቀሙበት የመሬት ይዞታ ነው።

11/"Communal landholding" means land which is neither state owned nor individually held; and which is held and used by communities for grazing, forestry, and other social services, etc;

፲፪/"ክልል" ማለት በኢትዮጵያ ፌደራላዊ ዴሞክራሲያዊ ሪፐብሊክ ሕገ መንግሥት አንቀጽ ፵፯(፩) የተመለከተው ማንኛውም ክልል ነው።

12/ "Region" means any region referred to in Article 47(1) of the Federal Democratic Republic of Ethiopia Constitution;

፲፫/"የከተማ አስተዳደር" ማለት በሕግ የከተማ አስተዳደር ሥልጣንና ተግባር የተሰጠው አካል ነው።

13/"Urban administration" means an organ to which urban administrative powers and duties have been given by law;

፲፬/"መሠረተ ልማት" ማለት ከመሬት በላይ ወይም ከመሬት በታች ያለ መንገድ፣ የባቡር ሀዲድ፣ የአውሮፕላን ማረፊያ፣ የቴሌኮሙኒኬሽን፣ የኤሌክትሪክ ኃይል፣ የመስኖ፣ የውሃ መስመር ወይም የፍሳሽ ማስወገጃ መስመር ሲሆን ሌሎች ተያያዥ ግንባታዎችንም ይጨምራል።

14/"Infrastructure" means road, railway, airport, telecommunication, electric power, irrigation, water supply line or sewerage line found on or below the ground and includes other related constructions.

፲፩/"የአገልግሎት መስመር" ማለት ለህዝብ ጥቅም ሲባል የሚለቀቅ መሬት ከመሬቱ በላይ ወይም ውስጥ የተዘረጋ የውሃ፣ የፍሳሽ፣ የኤሌክትሪክ ወይም የስልክ መስመር ሲሆን ሌሎች ተመሳሳይ ስራዎችንም ይጨምራል።

15/ "Utility line" means water, sewerage, electric or telephone line existing on or under a land to be expropriated for public purpose;

፲፪/"ተነሺ" ማለት ለሕዝብ ጥቅም መሬት በሚለቀቅበት ጊዜ በተለቀቀው መሬት ላይ ይኖር የነበሩ ባለይዞታ፣ ተከራይ፣ ተጥቅሞም ሆነ በግል ይሰራ የነበረ፣እና በጥገኝነት ይኖር የነበረን ያጠቃልላል።

16/"Displaced People" means a person,households,firms,or public or private institutions who has been living in occupied land,including tenants,employed and self-employoyed persons on the land for public benefit,

፲፫/"አቤቱታ ሰሚ" ማለት በዚህ አዋጅ አፈፃፀም ላይ ለሚነሳ ቅሬታ የሚመለከት እና ውሳኔ የሚሰጥ አካል ነው።

17/" Complaint Hearing Body" means the body that deals with and resolves complaints about the implementation of this Proclamation.

፲፬/"ይግባኝ ሰሚ" ማለት አቤቱታ ሰሚ አካል የሰጠውን ውሳኔ በይግባኝ ተመልክቶ ውሳኔ የሚሰጥ አካል ነው።

18/"Appeal body" means a body that reveiws the decision g iven by a compliant hearing body and pass its decision.

፲፬/"እውቅና ያለው ገማች" ማለት ቋሚ ንብረቶችን ለመገመት አግባብ ባለው አካል እውቅና የተሰጠው ገማች አካል ነው።

19/"Recognized Evaluater" means an evaluator that has been accredited by the appropriate body for the estimation of fixed assets.

፲፭/"አስቸኳይ ልማት" ማለት በመደበኛው የጊዜ ሰሌዳ መሄድ የማይችልና ለከፍተኛ ወጪ ሊዳርግ ወይም ከፍተኛ ገንዘብ ሊያሳጣ የሚችል መሆኑ ተረጋግጦ በመንግስት የተወሰነ የልማት አይነት ነው፣

20/Urgent Development" means a development which does not be implemented by the normal schedule and which the government ensures it as costly or potentially costly.

፲፮/"ውስብስብ መሰረተ ልማት" ማለት በተለመደው አሰራር የማይሰራ፣በአገር ውስጥ ባለው ባለሙያ የማይሰራ እቃዎችም በክምችት የማይያዝበት፣ ከአገር ውጪ ግዥ የሚጠይቅ እና መሰል ስራ ሆኖ በመሰረተ ልማት ባለሙያ የተረጋገጠ እና በመሰረተ ልማት ተቋም ሀላፊ የፀደቀ ተጨማሪ ጊዜ የሚያስፈልገው የመሰረተ ልማት አይነት ነው፣

21/ Complex Infrastructure" means infrastructure which can not be done as usual ,can not be done by the country's professionals, where goods are not stored, requires purchasing abroad, and a similar act proved by an infrastructure expert and approved by the Head of Infrastructure Institution and is type of infrastructure that needs more time.

፳፪/"ሀገራዊ ወይም ክልላዊ ፋይዳ ያላቸው ልማቶች" ማለት ለኢትዮጵያ እድገትና ትራንፎርሜሽን ከፍተኛ ለውጥ የሚያመጡ የልማት ፕሮጀክቶች ወይም የትብብር መስኮችን ለማስፋት በሚደረጉ እንቅስቃሴዎች ሀገራቱ ከሌሎች ሀገሮች ጋር ለሚኖራት የተሻለ ግንኙነት መሰረት እንዲጥሉ የታቀዱ ልማቶች ናችው።

22/"Development of National or Regional Sigaificance" means a development that is intended to bring great chanage on the bases of development projects or creat better relations with other countries through development projects or activities to promote change in Ethiopia.

፳፫/"ሰው" ማለት ማንኛውም የተፈጥሮ ሰው ወይም በሕግ የሰውነት መብት የተሰጠው አካል ነው።

23/"Person" meanS any natural or legal person.

፳፬/ማንኛውም በወንድ ጾታ የተደነገገው የሴትንም ጾታ ይጨምራል።

24/Any expression in the Masculine gender includes the Feminine.

፫. <u>የተፈጻሚነት ወሰን</u>

ይህ አዋጅ ለሕዝብ ጥቅም ሲባል የመሬት ይዞታ የሚለቀቅበትን፣ ካሣ የሚከፈልበትንና ተነሺዎች መልሰው የሚቋቋሙበትን ሁኔታ በሚመለከት በመላ ሀገሪቱ በከተማም ሆነ በገጠር ተፈጻሚ ይሆናል።

3. <u>Scope of Application</u>

This Proclamation shall apply throughout the country in rural and urban centers in matters relating to land expropriation; payment of compensation; and resettlement of landholders whose land is expropriated for public purpose.

፬. <u>መርሆዎች</u>

፩/የመሬት ይዞታ ለሕዝብ ጥቅም እንዲለቀቅ የሚደረገው በመሬት አጠቃቀም ዕቅድ ወይም በከተሞች መዋቅራዊ ዕቅድ ወይም በመሠረተ ልማት መሪ ፕላን መሠረት መሆን አለበት።

4. <u>Principles</u>

1/ Expropriation of land for public purposes shall be made only on the basis of approved land use plan; urban structural plan; or development master plan.

፪/ለሕዝብ ጥቅም መሬት ሲለቀቅ የሚከፈል ካሣና የሚሰጥ የማቋቋሚያ ድጋፍ የተነሺዎችን የኑሮ ሁኔታ የሚያሻሽልና የሚያስቀጥል መሆን አለበት።

2/Compensation and resettlement Assistance Compensation for the expropriated land shall sustainably restore and improve the livelihood of displaced people.

፫/ በፌደራል መንግስትም ሆነ በክልል መንግስታት፣በአዲስ አበባ ወይም ድሬዳዋ ከተማ አስተዳደሮች ለሚከናወኑ የልማት ሥራዎች በአንድ አካባቢ ለሚገኙ ቦታዎች ለሠፈረ ንብረት እና ተጓዳኝ ጥቅም ማጣት የሚከፈል የካሣ ነጠላ ዋጋ ተመን ተመሳሳይ መሆን አለበት።

3/The amount of compensation to be paid at Federal, or Regional or Addis Ababa or DireDawa level for similar properties and economic losses in the same areas shall be similar.

፬/ለሕዝብ ጥቅም መሬት እንዲለቀቅ ሲደረግ አሰራሩ ግልጽ፣አሳታፊ፣ ፍትሃዊ እና ተጠያቂነትን የተከተለ መሆን አለበት።

ክፍል ሁለት

መሬት ለማስለቀቅ ስለሚፈፀም ሥነ-ሥርዓት

፭.የሚለቀቀው መሬት ለሕዝብ ጥቅም መሆኑን ስለመወሰን

፩/አግባብ ያለው የፌደራል አካል ወይም የክልል፣አዲስ አበባ ወይም ድሬዳዋ ካቢኔ በቀጥታም ይሁን በተዘዋዋሪ የተሻለ ልማት ያመጣል ብሎ በመሬት አጠቃቀም እቅድ ወይም በልማት እቅድ ወይም በመሠረተ ልማት መሪ ፕላን መሠረት የሚለቀቀውን መሬት ለሕዝብ ጥቅም መሆኑን ይወስናል።

፪/ በዚህ አንቀጽ ንኡስ አንቀጽ ፩ መሠረት ለመወሰን መሪ ፕላኑ ዝርዝር የማስፈፀሚያ ፕላን ሊኖረው ይገባል።

፫/ለሕዝብ ጥቅም መሬት እንዲለቀቅ ሲወሰን ለካሣ እና መልሶ ማቋቋም የሚያስፈልግ በጀትና በጀቱ በማን እንደሚሸፈን አብሮ መወሰን አለበት።

፬/የመሬት ባለይዞታዎች በዚህ አንቀጽ ንኡስ አንቀጽ ፩ እና ፪ የተገለፀው መስፈርት ሳይሟላ መሬታቸው ለሕዝብ ጥቅም እንዲለቀቅ የሚሰጥ የሕዝብ ጥቅም ውሳኔ ላይ አቤቱታ ሊያቀርቡ ይችላሉ።

፭/የዚህ አንቀጽ ንዑስ አንቀጽ ፩ ድንጋጌ ቢኖርም እንደ አስፈላጊነቱ የክልሉ፣ የአዲስ አበባ እና የድሬዳዋ ካቢኔ ለሕዝብ ጥቅም ሲባል መሬት ማስለቀቅ ውሳኔ የመስጠት ሥልጣኑን ለዞን ወይም ለወረዳ አስተዳደሩ በውክልና ሊሰጥ ይችላል።

4/Where land is expropriated for public purpose, the procedure shall be transparent, participatory,fair and accountable.

Part II

Procedure to Expropriate Land

5. Decision on Expropriation for Public Purpose

1/ The appropriate Federal Authority, or a Regional, Addis Ababa, Dire Dawa cabinet shall decide on the basis of an approved land use plan; or master plan; or structural plan whether the expropriated land directly or indirectly brings better development and is beneficial to the public.

2/The Master Plan; referred under sub article 1 of this Article shall have detailed action plan.

3/The budget necessary to cover the costs of compensation and resettelemnt and the responsible body that shall cover these costs shall be made clear at the time when expropriation for public purpose is decided.

4/ Land holders may file objections on the public purpose decision where their land is expropriated in the absence of the fulfillment of the requirements provided under sub articles (1) and (2) of this Article.

5/ Not with standing to sub article 1 of this Article, a Regional፣ Addis Ababa, Dire Dawa cabinet may delegate a Woreda or City Administration to decide on land expropriation for public purpose.

፮.መሬት የማስለቀቅ ሥልጣን

በዚህ አዋጅ አንቀጽ ፭ መሠረት ለሕዝብ ጥቅም እንዲለቀቅ ውሳኔ የተሰጠበትን መሬት የከተማው ወይም የወረዳው አስተዳደር መሬቱ የማስለቀቅ እና የመረከብ ሥልጣን አለው።

፯.ለባለይዞታዎች ቅድሚያ የማልማት መብት ስለመስጠት

፩/በከተማ ለመልሶ ማልማት በተከለለ ቦታ ውስጥ ያለ ባለይዞታ በፕላኑ መሠረት ይዞታውን በግልም ሆነ በጋራ ቅድሚያ የማልማት መብት አለው።

፪/የገጠር መሬት ባለይዞታ ለእርሻ ስራ የሚለቀቅ ሲሆን አቅሙ ካለው ይዞታውን በግልም ይሁን በቡድን በመሬት አጠቃቀም ፕላኑ መሠረት ቅድሚያ የማልማት መብት አለው።

፫/በዚህ አንቀጽ ንኡስ አንቀጽ ፩ እና ፪ መሰረት ለተነሺው ቅድሚያ የማልማት መብት የሚጠበቅለት በፕላኑ መሠረት ለማልማት አቅም ማሳያ ማቅረብ ሲችል ነው።

፬/ቅድሚያ የማልማት መብት የሚሰጥበት ዝርዝር ሁኔታ እና አቅም ማሳያ መጠንና የጊዜ ገደብ በደንብ ይወሰናል።

፰.መሬት የሚለቀቅበት ሥርዓት

፩/የከተማ አስተዳደር ወይም የወረዳ አስተዳደር መሬት ሲያስለቅቅ መከተል ያለበት ቅደም ተከተል፡-

ሀ)ተነሺዎች ከመነሳታቸው ቢያንስ ከአንድ ዓመት በፊት ስለልማቱ ዓይነት፣ጠቀሜታና አጠቃላይ ሂደት በማወያየት እንዲያውቁት ማድረግ አለበት።

ለ)በዚህ አንቀፅ ፊደል ተራ (ሀ) የተጠቀሰው ቢኖርም የሚመለከተው የፌደራል ወይም የክልል መንግስት ሀገራዊ ወይም ክልላዊ ፋይዳ ላለው ለአስቸኳይ ልማት መሬት እንዲለቀቅ

6. Powers to Clear Landholdings

The City or Woreda administration has the power to order evacuation and takeover land decided to be expropriated for public purpose under Article 5 of this proclamation.

7. Giving Priority Rights to Develop Land for the Landholders

1/ Landholders whose holdings are within the urban area to be redeveloped shall have priority rights to develop their land according to the plan either individually or in a group.

2/ Rural landholders for Agricultural use shall have priority rights to develop their landholdings according to land use plan either individually or in groups.

3/ Priority Rights to develop Land as per sub Article 1 and 2 of this Article will be preserved for the Landholders, when the capacity to develop the land as per the plan is presented.

4/ The details of the the right to develop first and the extent of the capacity to develop, and the time frame shall be determined by a Regulation.

8. Procedure of the Landholding Handover

1/The City or Woreda Administration shall follow the following orders when land holders hand over their lands:

a) shall consult land holders who are to be displaced at least one year before they handover their holdings on the type; benefits and general process of the project.

b) notwithstanding to paragraph (a) of this Article, land holders who are to be displaced may be consulted on the type; benefits and general process of the project in less than one year if the concerned Federal or

[illegible] Regional State decides that the land is required urgently for investment.

ሐ) [illegible]

c) Collect landholding rights and conduct inventory, amount and size of all compensable properties from displaced people or their legal representatives whose landholdings are determined to be expropriated. Propreties added after the expropriateion notification is given to the land holder are not compensated.

መ) [illegible]

d) Decide the legal rights of the holders by checking the authority of the documents collected as sub article 1 (c) of this article,calculate,determine,and pay the amount of the compensation and other related rights,

ሠ) [illegible]

e) Notify the land holder or his agent in writing to hand over the land expropriated for public purpose with the description of the amount of compensation the landholder shall be paid; and/or the size and location of the land or house in kind compensation.

ረ) [illegible]

f) Where the building is state owned the order for handing over shall be given to the Housing Administration Authority and to the lessee.

ሰ) [illegible]

g) Pay compensation or provide substitute land before the displacement of people from their landholding.

ሸ) [illegible]

h) The details of expropriation of landholdings procedure shall be provided in a Regulation to be enacted to implement this Proclamation.

፪/ [illegible]

2/ Landholders or their agents whose landholdings are to be expropriated shall submit landholding certificates or other proofs that show their landholding rights over the lands that is decided to be expropriated to the urban or rural land administration office on the time schedule of the office.

፫/ ተነሺው የካሣ ግምት በጽሁፍ እንዲያውቅ ከተደረገበት ቀን ጀምሮ:-

ሀ) በሶስት ወር ጊዜ ውስጥ ተገቢው ካሣ ካልተከፈለው በመሬቱ ላይ ከቋሚ ተክልና ግንባታ በስተቀር ሌሎች ሥራዎችን መስራት ይችላል።

ለ) በስድስት ወር ጊዜ ውስጥ ተገቢው ካሣ ካልተከፈለው በመሬቱ ላይ ማንኛውንም በፕላን የሚፈቀድ እና ቀጣይ የቦታውን የልማት ወጪ በመንግስት ላይ የማያዛባ ሥራ መስራት ይችላል፡፡

ሐ) በዚህ ንዑስ አንቀጽ በፊደል ተራ "ሀ" እና "ለ" መሰረት የተሰራ ሥራ ወይም የተደረገ ለውጥ በካሣ ስሌቱ ውስጥ እንዲገባ መደረግ አለበት።

፬/ የማስለቀቂያ ትዕዛዝ የደረሰው ባለይዞታ ትዕዛዙ በደረሰው በ፴ (ሰላሳ)ቀናት ውስጥ ካሣ እና ምትክ ቦታ ወይም ቤት መውሰድ አለበት።

፭/ የማስለቀቂያ ትዕዛዝ የደረሰው ባለይዞታ በዚህ አንቀጽ ንዑስ አንቀጽ ፬ መሠረት በተቀመጠ ጊዜ ገደብ ውስጥ የካሣ ክፍያውን ካልወሰደ በከተማው ወይም በወረዳው አስተዳደር ስም በሚከፈት ዝግ የባንክ ሂሳብ እንዲቀመጥለት ይደረጋል።

፮/ ለባለይዞታ የሚሰጠው የመልቀቂያ የጊዜ ገደብ ካሣና ምትክ ቦታ ከተቀበለ ወይም ካሣው በዝግ ሂሳብ ከተቀመጠበት ቀን ጀምሮ ከ ፩፻፳ (አንድ መቶ ሀያ) ቀናት መብለጥ የለበትም።

፯/ በሚለቀቀው መሬት ላይ ሰብል፣ ቋሚ ተክል ወይም ቋሚ የሆነ ሌላ ንብረት ከሌለ ባለይዞታው የልማት ተነሺ ካሣ ከተከፈለው በኋላ በ፴ (ሰላሳ) ቀናት ውስጥ ይዞታውን ለከተማ ወይም ለወረዳ አስተዳደር ማስረከብ አለበት።

፰/በሕገ-ወጥ መንገድ በተያዘ ቦታ ላይ ለሰፈረ ንብረት ካሣ መክፈል ሳያስፈልግ ለ፴ (ሰላሳ) ቀናት የሚቆይ የጽሁፍ ማስጠንቀቂያ በመስጠት ወይም በቦታው በሰፈረው ንብረት ላይ በመለጠፍ እንዲለቀቅ ይደረጋል።

3/ As of the date of notification in writing on the amount of compensation, the landholder may:

a/ Plant seasonal crops and start other activities on the land other than perennial crops and buildings where the compensation is not paid within three months of the notice on the amount of compensation.

b) Begin developing any kind of activity approved by the plan and does not affect the government's ongoing cost of development of the site where compensation is not paid within six months of the notice on the amount of compensation.

c) Property developed or any change made under sub articles (a) and (b) of this Article shall be included in the valuation for compensation.

4/ Land holder who is served with notice to handover his landholding shall take the compensation and replacement plot or house within 30(thirt) days of notice.

5/ Where the land holder who is served with notice fails to comply with the order within the time prescribed under sub article 4 of this Article, the compensation payment shall be deposited in the closed bank account of the city or Woreda Administration.

6/ The land holder may be forced to handover the land within 120 (one hundred and twenty) days of the payment in cash or in kind compensation; or after the cash is deposited in the bank.

7/ Where there is no permanent property or crop on the expropriated land, the land holder shall hand over his landholding within 30 (thirty) days of the payment of compensation to the City or Woreda Administration.

8/ Where the land expropriated is under illegal occupation, the occupant shall evacuate without claim for compensation within 30 (thirty) days of notice.

፱/የማስለቀቂያ ትዕዛዝ የደረሰው ባለይዞታ ወይም ባለንብረት በዚህ አንቀጽ ንዑስ አንቀጽ (፮) እና (፯) በተጠቀሰው የጊዜ ገደብ ውስጥ ያለ በቂ ምክንያት መሬቱን ካላስረከበ የከተማ ወይም የወረዳ አስተዳደሩ መሬቱን በራሱ ይረከባል። አስፈላጊም ሲሆን ለመረከብ የፖሊስ ኃይል ትብብር ሊጠይቅ ይችላል።

፱. መሬት እንዲለቀቅለት የተወሰነለት አካል ኃላፊነት

፩/ መሬት እንዲለቀቅለት የተወሰነለት አካል ለሥራው የሚፈለገውን መሬት መጠንና የሚገኝበትን ትክክለኛ ስፍራ የሚያሳይ ውሳኔ የተሰጠበት ማስረጃ ቢያንስ ሥራው ከመጀመሩ ከአንድ ዓመት በፊት ለከተማው ወይም ለወረዳው አስተዳደር ማቅረብ አለበት።

፪/መሬቱ ለሕዝብ ጥቅም እንዲውል ሲወሰን የመሬት ይዞታቸውን እንዲለቁ ለሚደረጉ ባለይዞታዎች የሚከፈለውን ካሣ እና የመቋቋሚያ ድጋፍ ወጪ እንዲሸፍን ከተወሰነ ገንዘቡን ለከተማው ወይም ለወረዳው አስተዳደር ገቢ ያደርጋል።

፫/ በዚህ አንቀጽ ንዑስ አንቀጽ ፪ መሠረት ገንዘቡ ገቢ ተደርጎ ለተነሺዎች ካልተከፈለ የከተማው ወይም የወረዳው አስተዳደር መሬት አያስለቅቅም።

፲. የአገልግሎት መስመሮች ስለሚነሱበት ሥርዓት

፩/የከተማው ወይም የወረዳው አስተዳደር በሚለቀቀው መሬት በላይ ወይም በታች የአገልግሎት መስመር መኖር አለመኖሩን የአገልግሎት መሥመር ባለቤት ለሆኑ ተቋማት ምላሽ እንዲሰጡበት በጽሁፍ ጥያቄ ማቅረብ አለበት።

9/Where the landholder fails without justifiable reason ,to hand over his landholding within the time prescribed under sub articles 6 and 7 of this article, the City; or Woreda Administration can take over the expropriated land directly, and as may be necessary,may ask cooperation of the police force.

9. Responsibilities of the Land Requiring Body

1/ Land Requiring Body shall submit to the City or Woreda Administration the decision that shows the size and exact location of the land to be expropriated at least one year before the commencement of the project.

2/ Pay the money required for compensation and resettlement to the City or Woreda Administration, when it is decided that compensation and resettlement payment shall be made to thedisplaced people.

3/City or Woreda Administration shall not require handing over of the land until payments are made to landholders who may be displaced as per sub-article 2 this Article.

10. Procedure for Removal of Utility Lines

1/ The City or Woreda Administration shall request in writing utility line owner organizations to reply if they have utility lines over or under ground on the land to be expropriated.

፪/በዚህ አንቀፅ ንኡስ አንቀፅ ፩ መሠረት ጥያቄ የቀረበለት ተቋም ንብረት ካለው ለሚነሳው ንብረት ካሣ እውቅና ባለው ገለልተኛ ግማች በማስተመን ከነዝርዝር ማስረጃው ጥያቄው በደረሰው በ፴ (ሰላሳ) ቀን ውስጥ በጽሁፍ ለጠያቂው አካል ይልካል።

፫/የከተማው ወይም የወረዳው አስተዳደር በዚህ አንቀጽ ንዑስ አንቀጽ (፪) መሠረት ግምቱ በደረሰው በ፴(ሰላሳ) ቀናት ውስጥ ለባለንብረቱ የንብረቱን ግምት ካሣ ይከፍላል።

፬/የአገልግሎት መስመሩ ባለቤት ክፍያው በተፈጸመለት በ፷ (ስልሳ) ቀናት ውስጥ ካሣ የተከፈለበትን የአገልግሎት መስመር አጠናቆ ማንሳትና መሬቱን መልቀቅ አለበት።

፭/የዚህ አንቀፅ ንዑስ አንቀፅ ፬ እንደተጠበቀ ሆኖ የአገልግሎት መስመሩ ባለቤት ክፍያው በተፈፀመ በ፩፻፳ (አንድ መቶ ሀያ) ቀናት ውስጥ ውስብስብነት ያላቸውን የመሰረተ ልማት መስመሮች አጠናቆ ማንሳትና መሬቱን መልቀቅ አለበት።

፮/በዚህ አንቀፅ ንዑስ አንቀፅ ፬ እና ፭ በተቀመጠው የጊዜ ገደብ መሰረት ልማቱ ካልተነሳ በአንቀፅ ፰ ንዑስ አንቀፅ ፱ መሰረትበማስነሳት ይዞታው የሚወሰድ ሲሆን በወቅቱ ተገቢውን ስራ ያልተወጣ የመሰረተ ልማት ተቋም ለሚደርሰው ጉዳት ተጠያቂ ይሆናል። ዝርዝሩ በደንብ ይወሰናል።

2/ The organization that has utility lines on the expropriated land shall estimate the value of the utility line to be affected and send it with evidence to the City or Woreda Administration that requested it under sub article 1 of this Article within 30 (thirty) days of receiving the request.

3/The city or Woreda Administration shall pay the compensation within 30 (thirty) days of receiving the estimated cost of the utility lines to the owner organization under sub article 2 of this article.

4/ The utility line owner shall remove utility lines and clear the land within 60(sixty) days after the payment has been made.

5/ Notwithstanding to sub Article (4) of this Article, the utility line owner shall remove complex utility lines and clear the land within 120 (one hundred and twenty) days after the payment has been made.

6/ If the development is not cleared with in the time frame set pursuant to sub article 4 and sub artice 5 of this Article,it shall be cleared and expropriated as per sub Article 9 of Article 8.The Institution of the Infrastructure that failed to discharge its responsibility shall be liable for the damage incurred due to this.The details shall be determined by a Regulation.

ክፍል ሦስት

የካሣ አወሳሰን፣ ምትክ አሰጣጥ እና መልሶ ማቋቋም

፲፩.ለሕዝብ ጥቅም መሬት ሲለቀቅ ለተነሺዎች ስለሚከፈል ካሣ

ለሕዝብ ጥቅም መሬት እንዲለቀቅ ሲደረግ

PART III

DETERMINATION OF COMPENSATION, SUBSTITUTION AND RESETTLEMENT

11. COMPENSATION TO BE PAID TO LAND HOLDERS WHERE LAND IS EXPROPRIATED FOR PUBLIC PURPOSE

Where land is expropriated for public purposes

ለተነሺው ባለው የንብረትና የይዞታ መብት መሠረት የንብረት እና የልማት ተነሽ ካሣ ይከፈላል።

፲፪.የንብረት ካሣ

፩/የመሬት ይዞታን እንዲለቅ የሚደረግ ባለይዞታ በመሬቱ ላይ ለሚገኘው ንብረት እንዲሁም በመሬቱ ላይ ላደረገው ቋሚ ማሻሻያ ካሣ ይከፈለዋል።

፪/በሚለቀቀው የመሬት ይዞታ ላይ ለሰፈረው ንብረት የሚከፈል ካሣ ንብረቱን ለመተካት የሚያስችል ይሆናል።

፫/ በዚህ አንቀጽ ንዑስ አንቀጽ ፪ የተጠቀሰው እንደተጠበቀ ሆኖ ለሚነሳው ቤት የሚከፈለው አነስተኛ የካሣ መጠን እንደየክልሉ፤እንደአዲስ አበባ እና ድሬዳዋ ተጨባጭ ሁኔታ ወይም ክልሉ፤ አዲስ አበባ እና ድሬዳዋ አስተዳደር በሚያወጣው ስታንዳርድ መሰረት ቢያንስ ዝቅተኛውን የቤት ደረጃ ሊያስገነባ የሚችል መሆን አለበት።

፬/ በመሬት ይዞታው ላይ ለተደረገ ቋሚ ማሻሻል የሚከፈል ካሣ በመሬቱ ላይ የዋለውን ገንዘብና የጉልበት ዋጋ የሚተካ ክፍያ በአካባቢው ወቅታዊ ዋጋ ተሰልቶ ይሆናል።

፭/ንብረቱ ከሚገኝበት ስፍራ ወደ ሌላ አካባቢ ተዛውሮ እንደገና ሊተከልና አገልግሎት ለመስጠት የሚችል ከሆነ የማንሻ፣ የማጓጓዣና መልሶ የመትከያ ወጪ የሚሸፍን ካሣ መከፈል አለበት።

፮/ የተለያዩ ንብረቶች የሚሰሉበት የካሣ ቀመር እና ዝርዝር አፈፃፀማቸው በደንብ ይወሰናል።

፲፫.ስለ የልማት ተነሽ ካሳ እና ምትክ ቦታ

፩/በቋሚነት ስለሚነሳ የገጠር መሬት ባለይዞታ የሚሰጥ ካሳ እና ምትክ ቦታ፡-

ሀ)የመሬት ይዞታውን በቋሚነት እንዲለቅ

compensation for the property and displacement shall be paid to the landholders.

12. Property Compensation

1/ The landholder whose land is expropriated shall be paid compensation for the property on the land and the permanent improvement made on the land.

2/The amount of compensation for the property on the land shall cover the cost of replacing the property anew.

3/ Without prejudice to sub article 2 of this Article, the minimum compensation payable to a housing unit, may not, in any way, be less than the current cost of constructing a house per the standard or on the basis of the objective conditions of each Regional State, Addis Ababa and Dire Dawa City Administration.

4/Compensation for permanent improvement to land shall be equal to the current value of capital and labor expended on the land.

5/Where the property on the land can be relocated and continue its service as before, the cost of removing, transporting, and erecting the property shall be paid as compensation.

6/ Valuation methods to determine compensation for various properties and detail prescriptions applicable thereto shall be provided for by a Regulation.

13.Displacement Compensation and Land Substitution

1/ Displacement compensation and land substituttion for Rural Landholders permanently displaced:

a) a landholder who is to be diplaced permanently shall

የሚደረግ የገጠር መሬት ባለይዞታ እንደአስፈላጊው ሁኔታ ከተመለከታቸው መሬት ተመጣጣኝ ምርት የሚሰጠንና ምትክ መሬት የሚገኝ ሊሆን ምትክ መሬት ይሰጠዋል።

ለ)በዚህ ንዑስ አንቀጽ ፊደል ተራ "ሀ" መሠረት ተመጣጣኝ ምትክ መሬት የሚሰጠው ከሆነ መሬቱን ከመልቀቁ በፊት በነበሩት ሶስት ዓመታት ውስጥ በከፍተኛው ከመሬቱ ሊያገኝ ከነበረው ከፍተኛውን የአንድ ዓመት ገቢ በመቅታዊ ቁጥ ተባዝቶ የሚገኝ ካሳ ይከፈለዋል፤

ሐ)በዚህ ንዑስ አንቀጽ ፊደል ተራ "ሀ" መሠረት ተመጣጣኝ ምትክ መሬት የማይሰጠው ከሆነ መሬቱን እንዲለቅ ከመደረጉ በፊት በነበሩት ሶስት ዓመታት ውስጥ ከመሬቱ ሊያገኝ የነበረውን ከፍተኛ ዓመታዊ ገቢ በአስራ አምስት ተባዝቶ የሚገኝ ካሳ መከፈል አለበት።

መ)ከመኖሪያ ቦታው የሚነሳ ከሆነ ከሰፈሩበለት አበባ ወይም ድሬዳዋ ከተማ አስተዳደሮች በሚያወጡት መመሪያ የሚወሰን ምትክ ቦታ እና የሚሰጥ ተነሺ ድጋፍ መከፈል አለበት።

ሠ) በጊዜያዊነት ለሚለቀቁ መሬት የሚከፈል የሚሰጥ ተነሺ ካሳ በማንኛውም ሁኔታ በዘላቂነት ከሚከፈል የሚሰጥ ተነሺ ድጋፍ መብለጥ የለበትም።

ረ) የዚህ ንዑስ አንቀጽ ዝርዝር አፈፃፀም ይህን አዋጅ ለማስፈጸም በሚወጣ ደንብ ይወሰናል።

፪/ በጊዜያዊነት ስለሚነሳ የገጠር መሬት ባለይዞታ የሚሰጥ የሚሰጥ ተነሺ ድጋፍ ስለ፡-

ሀ)ይዞታውን ለተወሰነ ጊዜ እንዲለቅ ለሚደረግ የገጠር መሬት ባለይዞታ መሬቱ ከመለቀቁ በፊት በነበሩት ሶስት ዓመታት ውስጥ ያገኘው ከፍተኛ ዓመታዊ ገቢ መሬቱ እስከሚመለስ ድረስ ባለው

be substitute for a reasonable proportion of the land taken from the area, shall be given a substitute land if it is available.

b) Where equivalent substitute land is given as per paragraph (a) of this sub article, calculated by the current price the land holder shall be paid a one year landholding compensation income which is equal to the highest income he annually used to generate in the last three years preceding the expropriation of the land.

c) Where equivalent substitute land as per paragraph (a) of this sub article is not available, the land holder shall be paid displacement compensation which is equivalent to fifteen times the highest annual income he generated during the last three years preceding the expropriation of the land.

d) Where the landholder is to be displaced from his residence, land for building houses shall be given; and displacement assistance determined by Directives to be issued by Regional States, Addis Ababa and Dire Dawa City Administrations shall be paid.

e) The amount of compensation given to the temporarily dispalced people shall not be greater than the amount of compensation given to permanently displaced people.

f) Implementation of this sub article shall be determinet by a Regulation to be enacted to implement this Proclamation.

2/ Displacement compensation for temporarily displaced Rural landholders :

a) a rural landholder whose landholding has been provisionally expropriated shall, be paid displacement compensation for lost income based on the highest annual income secured during the last three years preceding the

ጊዜ ታሳቢ የልማት ተነሺ ድጋፍ ካሣ ይከፈለዋል።

ለ)በዚህ ንዑስ አንቀጽ ፊደል ተራ "ሀ" የሚከፈለው የልማት ተነሺ ካሣ መሬቱ የነበረውን ምርታማነት ለመመለስ የሚወስደውን በአካባቢ የግብርና ተቋም የሚወሰን ተጨማሪ ጊዜ ታሳቢ ማድረግ አለበት።

b) Displacement compensation paid under paragraph (a) of this sub article shall take in to consideration the amount of additional time necessary for the land to regain its productivity which shall be determined by the surrounding Agricultural Institution.

ሐ)መሬቱ ተመልሶ በፊት ይሰጥ የነበረውን አገልግሎት መስጠት የማይችል ከሆነ በቋሚነት እንደለቀቀ ተቆጥሮ በዚህ አንቀፅ ንዑስ አንቀፅ ፩ መሰረት የልማት ተነሺ ካሳ ወይም ምትክ ቦታ ይሰጠዋል፤

c) If the land fails to to serve as before,it shall be consided as expropriated permanently and pursuant to sub article 1 of this article, either a displacement compensation or substitute land shall be given to the land holder.

መ)መሬቱ በጊዜያዊነት በተለቀቀበት ጊዜ የተከፈለ የልማት ተነሺ ካሣ በዚህ ንኡስ አንቀጽ ፊደል ተራ "ሐ" መሠረት በቋሚነት እንዲለቀቀ ተቆጥሮ ከሚከፈል ካሳ ተቀንሶ ለተነሺው ልዩነቱ ይሰጠዋል።

d) The displacement compensation paid for temporary expropriation under sub-article (1) of this Article, shall be deducted from payment of compensation paid for the land considered as permanently expropriated and the difference shall be paid to the land holder.

ሠ)በጊዜያዊነት ለሚለቀቅ መሬት የሚከፈል የልማት ተነሽ ካሣ በማንኛውም ሁኔታ በዘላቂነት ከሚከፈል የልማት ተነሽ ካሣ መብለጥ የለበትም።

e) Displacement compensation for temporary expropriation shall not in any way exceed to the amount of compensation payable to permanent displaced compensation.

ረ)የዚህ ንዑስ አንቀፅ ዝርዝር አፈፃፀም ይህን አዋጅ ለማስፈጸም በሚወጣ ደንብ ይወሰናል።

f) The detail implementation of this sub-article shall be provided in a regulation to be enacted to implement this Proclamation.

ደ/ስለወል ይዞታ የልማት ተነሺ ካሣ

በቋሚነት ወይም በጊዜያዊነት ለሚለቀቅ የወል ይዞታ የልማት ተነሽ ካሣ ስሌት እና አከፋፈል ሁኔታ ክልሉ፤አዲስ አበባ፤ድሬዳዋ በሚያወጣው መመሪያ የሚወሰን ሆኖ መመሪያው ሊወጣ፡-

3/Displacement Compensation for Communal Landholding

The valuation method and manner of payment to permanent and temporary expropriation of communal land holdings shall be determined in a directive to be issued by Regional States, Addis Ababa, Dire Dawa City Administrations and shall take the following into consideration:

ሀ)ለተወሰደው የወል መሬት የልማት ተነሽ ካሣ ስሌት የወል መሬቱ ይሰጥ የነበረውን ጥቅም ወይም ጥቅሙ የቀረባቸውን የእ�ኗር ዘይቤ ወይም ሙያዳደሪያ መሠረት ያደረገ ሊሆን ይገባል።

a) Valuation of displacement compensation for communal landholding shall be based on the use of the communal land; or the lost benefits and livelihood of the displaced People.

ለ) የወል መሬቱ ተጠቃሚዎች በግልጽ መለየት አለበት።

ሐ)በወል መሬቱ ላይ የሚገኙ የግልና የወል ንብረት መለየት አለበት።

መ)የወል መሬት በመወሰዱ ምክንያት በካሣ የተገኘውን ገንዘብ ለማህበረሰቡ አባላት እኩል ሊከፈል ወይም በዓይነት ሊጠቀሙበት የሚችሉበትን መንገድ መቅረጽ አለበት።

፬/በቋሚነት ስለሚነሳ የከተማ መሬት ባለይዞታ የሚሰጥ ልማት ተነሽ ካሳ እና ምትክ ቦታ

የከተማ መሬት ባለይዞታ ከይዞታው በቋሚነት ተነሺ በሚሆንበት ጊዜ የሚከፈለው የልማት ተነሽ ካሣ እና የሚሰጠው ምትክ ቦታ በሚከተለው አግባብ ይሆናል፦

ሀ) በቋሚነት ለሚነሳ የከተማ መሬት ባለይዞታ ምትክ ቦታ ወይም መኖሪያ ቤት በግዥ እንዲያገኝ ይመቻቻል።

ለ) የሚሰጠው ምትክ ቦታ ከሆነ በቦታው ቤት እስኪገነባ ለሁለት ዓመት የሚኖርበት ቤት ያለኪራይ ይሰጠዋል ወይም ለፈረሰበት ቤት በወቅታዊ የኪራይ ግምት ተሰልቶ የሁለት ዓመት የልማት ተነሽ ካሣ ይከፈለዋል።

ሐ) የሚሰጠው ምትክ ቤት ከሆነ ለፈረሰበት ቤት በወቅታዊ የኪራይ ግምት ተሰልቶ የአንድ ዓመት የልማት ተነሽ ካሣ ይከፈለዋል።

መ) በዚህ ንዑስ አንቀጽ ፊደል ተራ "ለ" እና "ሐ" የሚከፈል የልማት ተነሽ ካሣ መጠን ቢያንስ የአካባቢውን ዝቅተኛ የቤት ኪራይ ለመከራየት ከሚያስችል ያነሰ መሆን የለበትም።

b) Members of the community using the communal land shall be clearly identified.

c) Private and communal property on the expropriated communal land shall be identified.

d) The method of allocating the displacement compensation money or the use of it in kind to all members of the communal landholding community shall be clearly determined.

4/ **Displacement compensation and substitute land for Urban Landholders Permanently Displaced**

Where urban landholders are permanently displaced as a consequence of land expropriation, the valuation of the displacement compensation and substitute land given to them shall be as follows:

a) Landholders permanentlydisplaced shall be provided with substitute land for building houses; or an arrangement shall be made to let them purchase housing units;

b) Where substitute land is provided, a residential house shall be given to the displaced for two years free of charge until he constructs his residential housing or displacement compensation equal to two years housing rentals estimated on the basis of the rental market comparable to the house of the displaced shall be paid;

c) Where a substitute house is provided, the displaced shall be paid a one year displacement compensation equivalent to current rental price of the demolished house;

d) Displacement compensation payable under paragraph (b) and (c) of this sub-article shall not be less than the amount necessary to lease the lower standard housing in the area.

ሠ) ተነሺዎች በነበሩበት አካባቢ ለነበራቸው የማህበራዊ ትስስር መቋረጥና ለሚደርስ የሥነ-ልቦና ጉዳት ማካካሻ ይከፈላቸዋል። መጠኑ ይህን አዋጅ ለማስፈጸም በሚወጣ ደንብ ይወሰናል፤

ረ) የሚለቀቀው የሊዝ ይዞታ ከሆነ የሚሰጠው ምትክ ቦታ ከተለቀቀው መሬት በደረጃ እና በስፋት ተመጣጣኝ መሆን አለበት። ይህንን ለመፈፀም የማይቻል ከሆነ አማራጭ የአፈፃፀም ሁኔታ እንደየከተሞቹ ተጨባጭ ሁኔታ በመመሪያ የሚወሰን ይሆናል።

ሰ) የምትክ ቦታ ወይም ቤት አሰጣጥ፣ የልማት ተነሺ ካሳ እና ተያያዥ ጉዳዮች ዝርዝር አፈፃፀም ክልሎች፣አዲስ አበባ እና ድሬዳዋ ከተማ አስተዳደሮች በሚያወጡት መመሪያ ይወሰናል።

፭/በጊዜያዊነት ስለሚነሳ የከተማ መሬት ባለይዞታ የሚሰጥ የልማት ተነሺ ድጋፍ፦

ሀ) በጊዜያዊነት ለሚነሳ የከተማ ባለይዞታ ተነስቶ ለሚቆይበት ጊዜ ምትክ ቤት ወይም በወቅታዊ የኪራይ ግምት ተሰልቶ ተመጣጣኝ ቤት የሚከራይበት ክፍያ እንዲያገኝ ይደረጋል።

ለ) የከተማ ባለይዞታዎች በጊዜያዊነት በመነሳታቸው ምክንያት ላጡት ኢኮኖሚያዊ ጥቅም ካሳ ይከፈላቸዋል፤

ሐ) የዚህ ንዑስ አንቀጽ ዝርዝር አፈፃፀም ክልሎች፣አዲስ አበባ እና ድሬዳዋ አስተዳደሮች በሚያወጡት መመሪያ ይወሰናል።

፲፬. ገቢ በመቋረጡ ስለሚከፈል የኢኮኖሚ ጉዳት ካሳ

፩/ለሕዝብ ጥቅም ተብሎ ቦታ እንዲለቀቅ ከመደረጉ ጋር በተያያዘ ከይዞታው ሳይነሳ በጊዜያዊነት ወይም በዘላቂነት ሲያገኝ የነበረው

e) Displaced People shall be compensated for the breakup of their social ties and moral damage they suffer as result of the expropriation. The amount of compensation shall be determined by the regulation to be enacted to implement this Proclamation.

f) Where the expropriated land is under leasehold, the substitute land to be given shall be equivalent to the expropriated land in standard and size. If it is not possible to do this, the alternative operating situations shall be determined by a directive depending on the situation of the cities.

g) Provision of substitute land or house, displacement compensation and related matters shall be determined in directives that may be issued by Regional States, Addis Ababa and Dire Dawa City Administrations.

5/Displacement Assistance to Temporarily Displaced Urban Landholders:

a) Urban land holders' temporarilydisplaced shall be provided with substitute housing or compensation to lease a house equivalent to the current rental market of the expropriated house for the period till they displaced.

b) Urban land holders shall be paid compensation for the economic loss they suffer due to temporary displacement.

c) The details of this sub-article shall be determined by a Directive to be issued by Regional States, Addis Ababa, and Dire Dawa City Administrations.

14. **Compensation paid for Economic Loss of Income**

1/ a person who lost economic benefit either permanently or temporarily without being displaced as a consequence of land expropriation shall be paid compensation; the person entitled for the compensation, type and amount of

ኢኮኖሚያዊ ጥቅም ለተቋረጠበት ሰው የጉዳት ካሳ የሚከፈል ሲሆን ካሳው ስለሚገባው ተጎጂ እና የጉዳት ካሣው መጠንና አይነት ክልሉ በሚያወጣው መመሪያ የሚወሰን ይሆናል፤

ፀ/በዚህ አንቀፅ ንኡስ አንቀፅ ፩ መሠረት የካሳዉን መጠንና ዓይነት ለመወሰን ከመቀጠር፣ ከንግድ፣ ከኪራይ ከእርሻ ውጪ መሬትን በመጠቀም የሚገኝ ገቢ እና የመሳሰሉ ዓመታዊ የተጣራ ገቢን ታሳቢ ሊያደርግ ይችላል።

compensation shall be determined by the Directives issued by a Regional States.

2/ Incomes generated from employment, rentals, business and the like net annual income except that of the income genereated from agriculture may be considered for determination of the type and amount of compensation as per sub article 1 of this Article.

፲፭.ከገጠር ወደ ከተማ ለተካለለ የከተማ አካባቢ ባለይዞታ የመኖሪያ ቤት መስሪያ ቦታ ስለመወሰን

15. Residential Housing for Peri-Urban Landholders Incorporated in to Towns

፩/ ከገጠር ወደ ከተማ በተካለለ የአርሶ አደር ይዞታ ከመኖሪያ ቤቱ ለሚነሳ ባለይዞታ በክልሉ፣በአዲስ አበባ እና በድሬዳዋ ካቢኔ የሚወሰን ሆኖ የከተማውን ስታንዳርድ በመጠበቅ ከፍተኛ (አምስት መቶ)ሜትር ካሬ ያልበለጠ የመኖሪያ ቤት መስሪያ ቦታ መሰጠት አለበት።

1/A peri urban rural land holder whose residence is removed shall be entitled to not more than 500 sq. meters of land for building per the standard of the urban as it is decided by cabinet of the Regional State, Addis Ababa and Dire Dawa City Administrations.

፪/ ልጅ ሜው ፲፰ ዓመትና በላይ ለሆነው የባለይዞታውን ገቢ በመጋራት አብሮ የሚኖር አርሶ ወይም አርብቶ አደር ልጅ የቦታ ስፋት፡ የከተማውን አነስተኛ የመሬት ይዞታ ደረጃ የሆነ ለመኖሪያ ቤት መስሪያ ቦታ መሰጠት አለበት።

2/ Child of the displaced,peri urban landholder the age of 18 and above shall be provided with the minimum size of land per the standard of the town or city provided he lives with his parent.

፫/የዚህ አንቀጽ ንዑስ አንቀጽ ፩ ድንጋጌ ቢኖርም ለመኖሪያ የሚሰጠው ጠቅላላ የቦታ መጠን ከነበረው የመኖሪያ ይዞታ በላይ መሆን የለበትም።

3/ Notwithstanding to sub article 1 of this article, the total land size that is given to him shall not exceed the total residential area of thedisplaced landholder.

፬/በዚህ አንቀፅ ንዑስ አንቀፅ ፫ የተገለፀው የመኖሪያ ይዞታ መጠን የባለይዞታው መኖሪያ ቤት ያረፈበትና የአጥር ግቢውን ይጨምራል።

4/ Residential area under sub article 3 of this Article includes the area within the perimeter fence of the displaced land holder.

፭/የዚህ አንቀፅ ዝርዝሩ አፈፃፀም ክልሉ፣አዲስ አበባ እና ድሬዳዋ ከተማ አስተዳደሮች

5/ The details shall be determined by a Directive to be issued by the Regional State, Addis Ababa and Diredawa City

በሚያወጡት መመሪያ ይወሰናል።

፲፮. መልሶ ሰለማቋቋም

፩/ የክልል መንግሥትየአዲስ አበባ እና የድሬዳዋ አስተዳደር ለኮሮጌ ክፍያ እና ለመልሶ ማቋቋሚያ ፈንድ ያቋቁማል፤

፪/ ክልሎች፣አዲስ አበባ እና ድሬዳዋ ከተማ አስተዳደሮች ተጎጂዎችን በዘላቂነት ለማቋቋም የሚያስችል ማቋቋሚያ ማዕቀፍና የመቅረጽ ግዴታ አለባቸው።

፫/የክተማ ወይም የወረዳ አስተዳደር በተቀረፀው ማቋቋሚያ ማዕቀፍና በሚመደበው ማስፈጸሚያ በጀት ተጎጂዎችን የማቋቋም ግዴታ አለበት፤

፬/በገጠርም ሆነ በክተማ ለሕዝብ ጥቅም መሬት የሚለቀቀው ለኢንቨስትመንት ከሆነ ተጎጂዎች ከኢንቨስትመንቱ የሼር ባለቤት ሊሆኑ ይችላሉ።

፭/በገጠርም ሆነ በክተማ የልማት ተጎጂ በሼር ለመጠቀም ፍላጎት ሳሮት ባለሀብቱ ይህንን ለማደረግ የማያስችለው ሁኔታ ካለ ባለሀብቱ ለተጎጂዎች የኢኮኖሚ አሰቻይ ተለዋጭ መፍትሄ ሰተጎጂው፣ለባለሀብቱ እና ለአስተዳደሩ መለጠት አለበት። ዝርዝሩ በደንብ ይወሰናል።

፮/ /የመልሶ ማቋቋሚያ ማዕቀፍ ይዘትና ዝርዝር አፈፃፀም በደንብ ይወሰናል።

፲፯.ንብረት ሰለመገመት

፩/እንዲለቀቅ በሚፈለግ መሬት ሳይ ለሚገኝ ንብረት ካሣ የሚወጣውን አገር አቀፍ ተመር መሠረት በማደረግ በተመሰከረለት የግል ድርጅት ወይም ግለሰብ አማካሪዎች ይገመታል።

፪/የካሣውን መጠን የሚገምት የተመሰከረለት የግል ድርጅት ወይም ግለሰብ አማካሪዎች

Administrations

16. Resettlement

1/Regional States, Addis Ababa and Dire Dawa City Administrations shall establish fund for compensation payment and rehabilitation.

2/Regional States, Addis Ababa and Dire Dawa City Administrations shall develop resettlement packages that enable displaced people to sustainably resettle.

3/ Urban or Woreda Administrations shall have the duty to resettle the People displaced on the basis of the resettlement package and allocated budget.

4/ If the land expropriation for public purpose is for investment, the people who are displaced may own shares from the investment.

5/ People who are displaced from urban or rural areas and who lost their incomes as a consequence of land expropriation for public purpose,and who do not own shares from the investment, economic incentives shall be devised by the beneficiaries,the investor and Administration. The details shall be determined by a Regulation.

6/the contents and detail implementation of the resettlement package shall be determined by a Regulation.

17. Valuation of Property

1/Compensation for the Property situated on land to be expropriated shall be evaluated by Certified Private Institution or individual consultant valuators on the basis of a nationally approved valuation method.

2/It shall be evaluated by an Autonomous Government Organization established for that purpose where there is no

ከሌሉ ፈቃዱን የያዘ በመንግሥት በተረጋገጠ ተቋም ይገመታል።

፫/በዚህ አንቀጽ ንዑስ አንቀጽ ፩ እና ፪ መሠረት የካሣውን መጠን የሚገምት ድርጅት ከሌለ የሚለቀቀው መሬት እንደሚገኝበት አካባቢ የሚመለከተው የወረዳ ወይም የከተማ አስተዳደር ተገቢውን ሙያ ያላቸው አባላት የያዘ ግምት ኮሚቴ በማቋቋም የሚገመት ይሆናል።

፬/በዚህ አንቀጽ ንዑስ አንቀጽ ፫ መሠረት የሚቋቋመው ግምት ኮሚቴ ሥራውን የሚያከናውንበት የአሠራር ሥርዓት ክልሎች፣አዲስ አበባ እና ድሬዳዋ ከተማ አስተዳደሮች በሚያወጡት መመሪያ ይወሰናል።

፭/የዚህ አንቀጽ ንዑስ አንቀጽ ፩፣፪ እና ፫ ቢኖርም የሚነሳው ንብረት የተለየ እውቀት የሚጠይቅ ሲሆን አግባብ ባለው የመንግሥት ወይም የግል ድርጅት ሊገመት ይችላል።

፮/ የሚነሳው ንብረት የመንግሥት መሠረተ ልማት ወይም የአገልግሎት መስመር ከሆነ የካሣ ግምቱ የሚዘጋጀው በንብረቱ ባለቤት ይሆናል።

፯/የካሣ ግምት የሚሰላበት ነጠላ ዋጋ ቢበዛ በየሁለት ዓመቱ መከለስ አለበት።

፲፰.አቤቱታ ሰሚ አካል እና ይግባኝ ሰሚ ጉባኤ ስለማቋቋም

፩/ክልሎች፣አዲስ አበባ እና ድሬዳዋ ከተማ አስተዳደሮች በዚህ አዋጅ መሠረት በሚሰጥ ውሳኔ ላይ ለሚቀርብ አቤቱታ አቤቱታ ሰሚ አካል እና ይግባኝ ሰሚ ጉባኤ ማቋቋም አለባቸው።

፪/ክልሎች፣አዲስ አበባ እና ድሬዳዋ ከተማ አስተዳደሮች አቤቱታ ሰሚ አካል እና ይግባኝ ሰሚ ጉባኤ አስፈላጊ ነው ብለው በወሰኑት

private certified property valuation organization or individual consultant.

3/ Where the organizations under sub articles 1 and 2 of this article do not exist, it shall be, considering location of the expropriated land evaluated by valuation committee established by the relevant Urban or Woreda Administrations comprising proper professionals.

4/ The working procedures of the valuation committee established under sub article 3 of this article shall be determined by the Directive issued by Regional State, Addis Ababa and Dire Dawa City Administrations.

5/ Notwithstanding to sub-article 1,2 and 3 of this article, where the property assessed requires special expertise, the valuation may be made by a relevant Government or Private Organization.

6/ Where the property is state owned infrastructure or utility line; the valuation shall be made by the government entity owning it.

7/ The unit price of compensation valuation shall be revised at most every two years.

18. Establishing Complaint Hearing Body and Appeal Council

1/ Regional States, Addis Ababa and Dire Dawa City Administrations shall establish Complaint Hearing Body and Appeal Hearing Council which shall have jurisdiction to entertain grievances arising from decisions under this Proclamation.

2/ Regional States, Addis Ababa and Dire Dawa City Administrations may establish Complaint Hearing Body and Appeal Hearing Council in some of their towns as

ከተመሰከተው ሊያድቁሙ ይችላሉ።

ሀ/የአቤቱታ ሰሚ አካል እና የይግባኝ ሰሚ ጉባኤ አደረጃጀት ሥልጣንና ተግባር ይህን አዋጅ ለማስፈፀም በሚወጣ ደንብ ይወሰናል።

፲፱. አቤቱታ ስለማቅረብ

፩/የመሬት ይዞታ ማስለቀቂያ ትዕዛዝ የደረሰው ወይም እንዲለቅ ትዕዛዝ በተሰጠበት ንብረት ላይ መብቱ ወይም ጥቅሜ ተነካብኝ የሚል ማንኛውም ተነሽ ትዕዛዙ በደረሰው በ፴ (ሰላሳ) ቀናት ውስጥ አቤቱታውን፣ በዚህ አዋጅ አንቀጽ ፲፰ ንዑስ አንቀጽ ፩ መሠረት ለሚቋቋመው አቤቱታ ሰሚ አካል ማቅረብ ይችላል፤

፪/ በዚህ አንቀፅ ንዑስ አንቀፅ ፩ የተጠቀሰው አካል የሚቀርብለትን አቤቱታ ከመረመረ በኋላ በ፴ (ሰላሳ) ቀናት ውስጥ ውሳኔ በመስጠት ለተከራካሪ ወገኖች በጽሁፍ ያሳውቃል።

፳. ስለ ይግባኝ

፩/በዚህ አዋጅ አንቀፅ ፲፱ ንዑስ አንቀፅ ፩ መሠረት በተሰጠው ውሳኔ ቅር የተሰኘ ወገን አቤቱታውን ለይግባኝ ሰሚ ጉባኤ ውሳኔው በጽሁፍ ከደረሰው ቀን ጀምሮ በ፴ (ሰላሳ) ቀናት ውስጥ ማቅረብ አለበት።

፪/ይግባኝ ሰሚ ጉባኤው በሰጠው ውሳኔ ቅር የተሰኘ ወገን ውሳኔው በጽሁፍ ከደረሰው ቀን ጀምሮ በ፴ (ሰላሳ) ቀን ውስጥ ይግባኝ ለክልል ከፍተኛው ፍርድ ቤት፣ በአዲስ አበባ እና በድሬዳዋ ከተሞች ለፌደራል የመጀመሪያ ደረጃ ፍርድ ቤት ማቅረብ ይችላል።ውሳኔ ከተሰጠ በኋላ ይግባኝ ማለት የሚፈልግ ከሆነ ልማቱ እንዳይጓተት ቦታውን አስረክቦ ክርክሩን የመቀጠል መብት አለው።

፫/ተነሺው ንብረቱን በማስረከቡ እና በቅሬታ ምክንያት ካሳውን ባለመውሰዱ ለይግባኙኝ ክርክሩ

deemed necessary.

3/The structure, powers and duties of the Complaint Hearing Body and Appeal Hearing Council shall be determined in a Regulation that shall be enacted to implement this Proclamation

19. Complaints

1/Any person who received an order of expropriation of his landholding; or who has an interest or claim on the property to be expropriated may file an application within 30 (thirty) days of service of the order to the Complaint Hearing Body which is established as per sub-article 1 of Article 18 of this proclamation.

2/The body mentioned under sub article 1of this article, after investigating the complaint submitted to it; shall make its decisions within 30 (thirty) days of the filing of the application and notify in written to the parties.

20. Appeal

1/ A party who is aggrieved with the decision given under Article 19 sub article 1of ~~this~~ proclamation shall file an appeal to the Appeal Hearing Council within 30 (thirty) days of the receipt of the written notice of the decision thereof.

2/ A party aggrieved with the decision of the Appeal Hearing Council may file an appeal to the Regional High Court in case of Addis Ababa and Dire Dawa city, Federal First Instance Court within 30 (thirty) days of the receipt of the decision in writing.The party who is dissatisfied with the decision has the right to continue his claim, however, for the continuance of the development, he has to surrender his land holdings.

3/If the land holder faces economic loss due to the expropriation and is unble to file an appeal, the

የሚሆን በቂ ገንዘብ ከሌለው እና በዚህ ምክንያት የሚቸገር ከሆነ መንግስት ነፃ የህግ አገልግሎት የሚያገኝበትን ሁኔታ ያመቻቻል።

፳፩.አቤቱታ የቀረበበትን ቦታ ስለመረከብ

፩/የመሬት ማስለቀቅ ትእዛዝ የደረሰው ባለይዞታ በዚህ አዋጅ መሠረት አቤቱታ ያቀረበ ከሆነ የከተማው ወይም የወረዳው አስተዳደር ቦታውን መረከብ የሚችለው፡-

ሀ) በዚህ አዋጅ አንቀጽ ፲፱ ንዑስ አንቀጽ ፩ መሠረት አቤቱታ አቅርቦ ውሳኔው ከፀና እና በተሰጠው ውሳኔ ላይ ይግባኝ ላያቀርብ ሲቀር፣ ወይም

ለ)በዚህ አዋጅ አንቀጽ ፳ ንኡስ አንቀጽ ፪ መሠረት ይግባኙን ላያቀርብ ሲቀር፣

፪/የዚህ አንቀፅ ንዑስ አንቀፅ ፩ ቢኖርም አቤቱታ የቀረበበትን ቦታ በሕገ ወጥ መንገድ የተያዘ ቦታ ከሆነ በቦታው ላይ የሰፈሩ ንብረቶች በማውጣት የተሰራ ግንባታ እንዲፈርስ በማድረግ የከተማው ወይም የወረዳው አስተዳደር መሬቱን መረከብ ይችላል።

ክፍል አራት
ልዩ ልዩ ድንጋጌዎች

፳፪.የፌደራል ተቋማት ሥልጣንና ተግባር

በሌላ ሕግ ለሚኒስቴሩ የተሰጠ ሥልጣንና ተግባር እንደተጠበቀ ሆኖ፡-

፩/የከተማ ልማትና ኮንስትራክሽን ሚኒስቴር፡-

ሀ)ከተማን የሚመለከቱ የአዋጁ ድንጋጌዎች በከተሞች መከበራቸውን ይከታተላል፣ ያረጋግጣል፣

ለ)የከተማ ተነሺዎችን በማቋቋም ሥራ ላይ ድጋፍ ያደርጋል፣

ሐ)ክልሎች፣አዲስ አበባ እና ድሬዳዋ ከተሞች

government shall arrange for free legal services.

21. Taking Over Land under Complain

1/If the person who received an order of evacuation of his landholding filed a Complaint application as per this Proclamation, the Woreda or City administration may take over of the land only where:

a) The appeal is affirmed as per article 19 sub-article 1of this proclamation and failed to make an appeal on that decision; or

b) The land holder failed to make an appeal as per Article 20 sub-article 2 of this proclamation.

2/Notwithstanding to sub-article 1 of this Article where Land under complain is illegally occupied land, the Woreda or Urban Administration may takeover of the land after removing the property, demolishing building on the land.

Part IV
Miscellaneous Provisions

22. Powers and Functions of Federal Institutions

Without prejudice to powers and functions given to the Ministry under other Laws:

1/ Ministry of Construction and Urban Development shall:

a) Ensure and follow up implementation of provisions of this Proclamation pertaining to Urban in Urban Areas;

b) Support resettlement of displaced people from urban areas;

c) Provide technical and capacity building support to

አዋጁን ማስፈጸም እንዲችሉ የቴክኒክና እቅም ግንባታ ድጋፍ ያደርጋል፤

መ)አዋጁን ለማስፈጸም መመሪያዎች በወቅቱ መውጣታቸውን ይከታተላል፤ይደግፋል።

ሠ)በኩታ ማልማት ምክንያት የተነሱ ባለይዞታዎች ያሉበትን የኑሮ ሁኔታ ጥናት ያካሂዳል፤ ለታዩ ችግሮች መፍትሄ ይሰጣል።

፪/ የግብርና ሚኒስቴር

ሀ)የገጠር መሬትን የሚመለከቱ የአዋጁን ድንጋጌዎች በክልሎች መከበራቸውን ይከታተላል፤ ያረጋግጣል፤

ለ)የገጠር ተነሺዎችን በማቋቋም ሥራ ላይ ድጋፍ ያደርጋል፤

ሐ)ክልሎች፤አዲስአበባ እና ድሬዳዋ ከተማ አስተዳደሮች አዋጁን ማስፈጸም እንዲችሉ የቴክኒክና እቅም ግንባታ ድጋፍ ያደርጋል፤

ሸ፲.የክልሎች፤የአዲስ አበባ እና ድሬዳዋ ከተማ አስተዳደሮች ሥልጣንና ተግባር

፩/ይህንን አዋጅ እና አዋጁን ለማስፈፀም የሚወጣውን ደንብ እና መመሪያዎች በክልሉ፤ በአዲስ አበባ እና በድሬዳዋ ከተማ አስተዳደሮች ወይም ከተሞች እንዲፈጸሙ ክትትልና ድጋፍ ያደርጋል፤

፪/የመልሶ ማቋቋሚያ ማዕቀፍ ይቀርጻል፤ ይተገብራል።ይህን ማዕቀፍ የሚተገብር እና የሚመራ ራሱን የቻለ ተቋም ይቋቋማል ወይም ካሉት ተቋሞች ይህንን ሀላፊነት የሚወጣ ይሰየማል፤

፫/ከተሞችና ወረዳዎች አዋጁን ማስፈጸም እንዲችሉ የአቅም ግንባታ ድጋፍ ያደርጋል።

፬/በልማት ምክንያት የተነሱ አካላት ያሉበትን የኑሮ

Regional States, Addis Ababa, and Dire Dawa City Administrations;

d) Follow up and support the issuance of Directives required for the proper implementation of this Proclamation; and

e) Asses the living conditions the holders whose land has been expropriated for public purpose for urban development and provide solutions to problems discovered.

2/ Ministry of Agriculture shall

a) Follow up and ensure implementation of the provisions of this proclamation pertaining to rural areas in the Regions.

b) Support resettlement of displaced people from rural areas.

c) Provide technical and capacity building support to Regional States, Addis Ababa and Dire Dawa City Administrations to enable them implement this Proclamation.

23. Powers and Functions of Regional States,Addis Ababa and Dire Dawa City Administrations

1/ Follow up and ensure the implementation of this Proclamation and the Regulation and Directive enacted under it in Regional States, Addis Ababa Dire Dawa City Administrations;

2/ Develop and implement resettlement packages. An independent entity that implement and govern this framework shall be established or appointed from this institution to bear this responsibility.

3/ provide capacity building support to Urban and Woreda Administrations to enable them implement this Proclamation.

4/ asses the living conditions of the displaced persons and

ሁኔታ ጥናት ያካሂዳል፣ለተለዩ ችግሮች መፍትሄ ይሰጣል።

፳፬.የወረዳ እና የከተማ አስተዳደር ኃላፊነት

፩/ተነሺዎችን ስለልማቱ አይነት፣ጠቀሜታና አጠቃላይ ሂደቱ ላይ ግልጽ ውይይት በማድረግ እንዲሳተፉ ያደርጋል፣

፪/መሬት እንዲለቁ ለተደረጉ ባለይዞታዎች ተገቢውን ካሣ ይከፍላል ወይም እንዲከፈል ያደርጋል፣

፫/የመልሶ ማቋቋሚያ ማዕቀፍን ስራ ላይ ያውላል ፣

፬/ካሣ ተከፍሎበት እንዲለቀቅ በተወሰነ መሬት ላይ የሚገኘውን ንብረት በሚመለከት የተሟላ መረጃ ይይዛል፤

፭/ተነሺ አርሶ እና/ወይም አርብቶ አደሮች ኑሮአቸው እንዲሻሻል የድጋፍና ክትትል ሥራዎችን ይሠራል፤

፮/ተነሺዎችን የተመለከተ መረጃና ማስረጃ አደራጅቶ ይይዛል።

፳፭.ተጠያቂነት

በዚህ አዋጅ የተቀመጡ ግዴታዎችን በሀጉ አግባብና በወቅቱ ያልተገበረ ማንኛውም ግለሰብ፣ ተቋም እና የተቋም ሀላፊ አግባብ ባለው ህግ ተጠያቂ ይሆናል።

፳፮.ደንብና መመሪያ የማውጣት ሥልጣን

፩/የሚኒስትሮች ምክር ቤት ይህን አዋጅ ለማስፈጸም ደንብ ያወጣል።

፪/ክልሎች፣ አዲስ አበባ እና ድሬዳዋ ከተማ አስተዳደሮች ይህንን አዋጅ እና በዚህ አንቀጽ ንዑስ አንቀጽ ፩ መሠረት የሚወጣ ደንብ ለማስፈጸም መመሪያ ያወጣሉ።

provide solutions to the identified problems.

25.Responsibility of Woreda and Urban Administrations

Woreda and Urban Administrations shall:

1/organize consultative meetings with people that are going to be displaced on the type; benefits; and generally the process of the project;

2/Pay or make others pay the compensation to the landholders whose land holdings are expropriated.

3/ Implementing the resettlement packages.

4/Maintain record of the property located on the expropriated land.

5/ Support and ensure the improvement of the livelihood of displaced farmers and pastoralists.

6/Maintain record and evidences relating to the displaced.

25. Accountability

Any person, institution and institution who does not implement the provisions of this proclamaition shall be liable under the applicable law.

26. Power to Issue Regulation and Directive

1/The Council of Ministers shall issue regulation for the implementation of this Proclamation.

2/ Region states or Addis Ababa or Dire Dawa City Administrations may issue Directives necessary for the proper implementation of this Proclamation and Regulation issued per sub article 1 of this Article.

፳፯.የመሸጋገሪያ ድንጋጌ

ይህ አዋጅ ከመጽደቁ በፊት ክስ ቀርቦባቸው ውሳኔ ያላገኙ ጉዳዮች በቀድሞው አዋጅ ፬፻፶፭/፩ሺ.፱፻፺፯ መሠረት ይስተናገዳሉ።

፳፰.የተሻሩና ተፈፃሚነት የማይኖራቸው ሕጎች

፩/ለህዝብ ጥቅም ሲባል መሬት የሚለቀቅበትንና ለንብረት ካሣ የሚከፈልበትን ሁኔታዎች ለመወሰን የወጣ አዋጅ ቁጥር ፬፻፶፭/፲፱፻፺፯ በዚህ አዋጅ ተሽሯል።

፪/ከዚህ አዋጅ ጋር የሚቃረን ማንኛውም ሕግ ወይም የተለመደ አሰራር በዚህ አዋጅ ውስጥ በተመለከቱት ጉዳዮች ላይ ተፈፃሚነት አይኖረውም።

፳፱.አዋጁ የሚፀናበት ጊዜ

ይህ አዋጅ በፌዴራል ነጋሪት ጋዜጣ ታትሞ ከወጣበት ቀን ጀምሮ የፀና ይሆናል።

አዲስ አበባ መስከረም ፲፫ ቀን ፪ሺ.፲፪ ዓ.ም

ሳህለ ወርቅ ዘውዴ

የኢትዮጵያ ፌደራላዊ ዲሞክራሲያዊ

ሪፐብሊክ ፕሬዚዳንት

27. Transitional Provision

Cases pending in a court before the coming into force of this Proclamation shall be disposed under the previous Proclamation No. 455/1997.

28. Repealed and Inapplicable Laws

1/ The "Expropriation of Land holdings for Public Purposes and Payment of Compensation Proclamation No. 455/2005 is hereby repealed.

2/ No law, Regulation, Directive or practice shall, in so far as it is inconsistent with this Proclamation, be applicable with respect to matters provided for by this Proclamation.

29. Effective Date

This Proclamation shall enter into force as of its publication in the Federal Negarit Gazette.

Done at Addis Ababa, this September 23rd day of September, 2019

SAHELEWORK ZEWDE

PRESIDENT OF THE FEDERAL DEMOCRATIC

REPUBLIC OF ETHIOPIA

Assignment

Part-I

1. What are Specific environmental problems?
2. **What are Water quality parameters and standards?**
3. **Write Major types of water pollution**
4. What are water borne diseases in your area? What is domestic water source in your area?

Part-II

5. **List and discuss Group of bacteria and their Environmental significance**
6. Read the Ethiopian environmental policies and legislation attached with and write maximum of two pages essay.

Part-II

7. Discuss **Elements of solid waste management**
8. Discuss three common configurations of sanitary landfills
9. **What are Common solid waste disposal methods**

Part -III

10. **Discuss the** EIA steps
11. What is the use of ***Environmental Audit (EA)***