CATHOLIC UNIVERSITY OF RWANDA

FACULTY OF PUBLIC HEALTH AND HUMAN NUTRITION

DEPARTMENT OF PUBLIC HEALTH

LEVEL IV

ACADEMIC YEAR: 2021-2022

ENVIRONMENTAL HEALTH

Lecturer: Narcisse NTAWIGENERA

Save, January 2022

DESCRIPTION OF AIMS AND CONTENT

The module aims that the students would understand the analysis, application and integration of multi-sectoral approaches in solving environmental health concerns. They are expected to develop the ability to influence the prevention of diseases and negative conditions related to environmental factors.

The components of environmental health include water supply and water quality, occupational health and safety, environmental pollution, vectors and vermin control, solid and liquid waste management, environmental health education, disaster and emergency preparedness and inspection of premises.

LEARNING OUTCOMES

By the end of this module, students should be able to:

- Define Environmental Health and it's components
- Role of EHO in Environmental Health services
- Explain the concept of inter-relationships in environment and its sustainability
- Explain the influence of ecological factors on living things
- Explain the concept of bio-diversity
- Explain effects of climate change to human health.

The graduates will have developed the following competences:

- Promote sanitary conditions of homes and public places both in rural and urban settings.
- Monitor the quality and safety of water for human consumption
- Manage all types of wastes and pollutants in rural and urban areas.
- Organize health education for the community behavior change for health promotion.
- Prevent and manage emergencies and occupational hazards.

CONTENTS

CHAPTER ONE: HUMAN ENVIRONMENT 1

1.1. DEFINITION OF BASIC CONCEPTS AND COMPONENTS OF ENVIRONMENTAL HEALTH 1

1.1.1. Environment 1

1.1.2. Health 1

1.1.3. Environmental Health 1

1.2. ECOLOGY, ECOSYSTEM AND ECOSYSTEM PROCESSES AND FUNCTIONING 4

1.2.1. Ecology 4

1.2.2. Ecosystem 5

1.2.3. Ecosystem Processes and Functioning 6

1.2.3.1. Hydrologic and biogeochemical cycles 6

1.2.3.2. Bio-diversity 9

1.2.3.3. Conservation of natural resources, Pollution and Environmental Health 9

1.2.3.4. Population growth and depletion of natural resources 10

1.2.3.5. Preventing harm from pollution 11

1.3. SUSTAINABLE DEVELOPMENT 12

1.3.1. Respecting the web of life 13

1.3.2. Climate and Health 14

1.4. TOXICOLOGY 15

1.4.1. Introduction 15

1.4.2. Exposure routes 16

1.4.3. Toxicology and Environmental Public Health 17

1.4.3.1. Toxicant Classifications 17

1.4.3.1.1. Chemical Class 17

1.4.3.1.2. Source of Exposure 18

1.4.3.1.3. Organ System Affected 18

1.4.3.2. Toxicants in the body 19

1.4.3.2.1. Absorption........ 19

1.4.3.2.2. Distribution 19

1.4.3.2.3. Metabolism 19

1.4.3.2.4. Excretion 21

1.4.3.3. Toxicokinetics........ 21

1.5. OCCUPATIONAL HEALTH AND SAFETY 22

CHAPTER TWO: HYGIENE AND SANITATION........ 27

2.1. Importance of Hygiene and Sanitation 27

2.2. Good personal hygiene 28

2.3. Domestic hygiene........ 29

2.4. Poor hygiene and disease 31

2.5. House design and health........ 32

2.6. Sewage disposal 35

2.7. Rubbish disposal 36

2.8. Protection from pests 37

2.9. House cleaning—tidying and maintaining the yard........ 37

2.10. How germs and worms spread disease 38

2.11. Drinking water........ 39

2.11.1. Sources of Drinking Water 41

2.11.2. Human Uses of Water 42

2.11.3. Water: Pathways or Avenues of Human Exposure 45

2.11.4. Drinking Water and Chemicals........ 49

2.11.5. Drinking-Water Standards, Implications, and Analyses........ 50

2.12. Food hygiene 51
2.12.1. Introduction 51
2.12.2. Foodborne Illnesses and Their Causes 52
2.12.2.1. Parasites 52
2.12.2.2. Bacterial Infections 55
2.12.2.3. Viral Infections 56
2.12.2.4. Toxins 57
2.12.2.5. Inorganic and Organic Chemical Contaminants and Additives 59
2.12.2.6. Antibiotic and Hormone Use in Farm Animals 61
2.12.2.7. Care in Food Preservation and Handling 62
2.12.2.8. Components of an Effective Food Sanitation Program 64
2.12.2.9. Ways food can become contaminated through incorrect food handling 66
2.12.2.10. Food and Health 77
CHAPTER THREE: ENVIRONMENTAL POLLUTION 79
3.1. DEFINITION OF COMMON TERMINOLOGIES 79
3.2. TYPES OF POLLUTION 79
3.2.1. AIR POLLUTION 79
3.2.2. NOISE POLLUTION 83
3.2.3. WATER POLLUTION 85
3.2.4. SOIL POLLUTION 89
3.2.5. RADIATION POLLUTION 90
CHAPTER FOUR: WASTE MANAGEMENT 94
4.1. LIQUID WASTE 94
4.1.1. Treatment of Liquid Waste 94
4.1.1.1.Municipal waste 94

4.1.1.2. Industrial wastes 96
4.2. SOLID WASTE 97
4.2.1. Solid Waste Management Strategies 98
4.2.1.1. Primary Prevention of Waste 99
4.2.1.2. Waste Treatment and Disposal 99
4.2.1.3. Sanitary Landfill 100
4.2.1.4. Incineration 102
4.3. HEALTH CARE WASTE 103
4.3.1. Health Problems from Health Care Waste 103
4.3.2. Preventing Harm from Health Care Waste 104
4.4. HEALTH CONCERNS FROM POOR WASTE MANAGEMENT 109
CHAPTER FIVE: ENVIRONMENTAL HEALTH EDUCATION AND PROMOTION 111
5.1. Health education and hygiene education 111
5.2. Environmental Health promotion 111
5.2.1. Hygiene promotion 111
5.2.2. Principles of community participation 112
5.2.3. Obstacles to community participation 113
5.2.4. Overcoming obstacles and reaching the community 114
5.2.5. Communication methods 115
5.2.6. Choosing an approach 117
REFERENCES 118

CHAPTER ONE: HUMAN ENVIRONMENT

1.1. DEFINITION OF BASIC CONCEPTS AND COMPONENTS OF ENVIRONMENTAL HEALTH

Many aspects of human well-being are influenced by the environment, and many diseases can be initiated, promoted, sustained, or stimulated by environmental factors. For this reason, the interactions of people with their environment are an important component of public health.

1.1.1. Environment

Environment is defined as the complex of physical, chemical, and biotic factors (as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival.

If our focus is on human health, we can consider the environment to be all the external (or nongenetic) factors: physical, nutritional, social, behavioral, and others that act on humans.

1.1.2. Health

A widely accepted definition of *health* comes from the 1948 constitution of the World Health Organization (2005): "A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." This broad definition goes well beyond the rather mechanistic view that prevails in some medic al settings to include many dimensions of comfort and well-being.

1.1.3. Environmental Health

1.1.3.1. Definition of Environmental health

Environmental health has been defined in many ways:

"Environmental health comprises those aspects of human health and disease that are determined by factors in the environment. It also refers to the theory and practice of assessing and controlling factors in the environment that can potentially affect health. It includes both the direct pathological effects of chemicals, radiation and some biological agents, and the effects (often indirect) on health and wellbeing of the broad physical, psychological, social and aesthetic environment, which includes housing, urban developmental land use and transport".

"Environmental health is the branch of public health that protects against the effects of environmental hazards that can adversely affect health or the ecological balances essential to human health and environmental quality" (Agency for Toxic Substances and Disease Registry, cited in U.S. Department of Health and Human Services [DHHS], 1998).

"Environmental health is the discipline that focuses on the interrelationships between people and their environment, promotes human health and well-being, and fosters a safe and healthful environment" (U.S. National Center for Environmental Health, cited in DHHS, 1998).

In 1993, the World Health Organization (WHO) defined environmental health as those aspects of human health, including quality of life, that are determined by physical, biological, social, and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can potentially affect adversely the health of present and future generations.

1.1.3.2. The evolution of Environmental Health

Human concern for environmental health dates from ancient times, and it has evolved and expanded over the centuries. Our ancestors confronted other challenges that we would now identify with environmental health. One was food safety; there must have been procedures for preserving food, and people must have fallen ill and died from eating spoiled food. Dietary restrictions in ancient Jewish and Islamic law, such as bans on eating pork, presumably evolved from the recognition that certain foods could cause disease. Another challenge was clean water; we can assume that early peoples learned not to defecate near or otherwise soil their water sources. In the ruins of ancient civilizations from India to Rome, from Greece to Egypt to South America, archeologists have found the remains of water pipes, toilets, and sewage lines, some dating back more than 4,000 years. Still another environmental hazard was polluted air; there is evidence in the sinus cavities of ancient cave dwellers of high levels of smoke in their caves (Brimblecombe, 1988), foreshadowing modern indoor air concerns in homes that burn biomass fuels or coal.

An intriguing passage in the biblical book of Leviticus (14:33–45) may refer to an environmental health problem well recognized today: mold in buildings.Still another ancient environmental health challenge, especially in cities, was rodents. European history was changed forever when infestations of rats in fourteenth-century cities led to the Black Death. Modern cities continue to struggle periodically with infestations of rats and other pests), whose control depends in large part on environmental modifications.

At the dawn of the twenty-first century, then, while traditional sanitarian functions remained essential, the environmental health field had moved well beyond its origins. Awareness of chemical toxicity had advanced rapidly, fueled by discoveries in toxicology and epidemiology. At the same time, the complex relationships inherent in environmental health—the effects of environmental conditions on human psychology, and the links between human health and ecosystem function—were better and better recognized. In practical terms, clinical services in environmental health had developed, and regulation had advanced through a combination of political action and scientific evidence.

Environmental health is a dynamic, evolving field. Looking ahead, we can identify at least five trends that will further shape environmental health: environmental justice, a focus on susceptible groups, scientific advances, global change, and moves toward sustainability. The world population should consider the importance of Sustainable development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

1.1.3.3. Role of Environmental Health Officer

It is clear that environmental health professionals work on different spatial scales, but it is not always so clear who is an environmental health professional. Certainly, the director of environment, health, and safety at health facility or at a manufacturing firm; an environmental epidemiology researcher at a university; or a physician working for an environmental advocacy group would self-identify and be recognized by others as an environmental health professional. But many other people work in fields that have an impact on the environment and human health. The engineer who designs power plants helps to protect the respiratory health of asthmatic children living downwind if she includes sophisticated emissions controls. The transportation planner who enables people to walk instead of drive also protects public health by helping to clean up the air. The security officer who maintains urban green spaces may contribute greatly to the well-being of people in his city. In fact much of environmental health is determined by "upstream" forces that seem at first glance to have little to do with environment or health.

An Environmental Health Officer (also known as a Public Health Inspector), investigates health hazards in a wide variety of settings, and will take action to mitigate or eliminate the hazards. Usually the public perception of a health inspector is someone who examines restaurants and ensures they maintain sanitary standards for food safety set by the regulating authority. However, public health inspectors have much broader job duties, including inspecting, substandard housing conditions, public schools, day cares, nursing homes… Depending on their jurisdiction, Environmental Health Officers often permit and inspect wells, private water systems, and individual subsurface sewage disposal (septic) systems. Other tasks include: campground inspections, tanning salon inspections, beauty salon inspections, and correctional facility inspections. The public health inspector (environmental health officer) also plays a vital role in community projects such as those concerning health promotion, tobacco reduction, healthy built environments/healthy communities, food security, and emergency preparedness. They may also respond to complaints such as animal bites, waste complaints, odor complaints, or sewage overflows.

1.2. ECOLOGY, ECOSYSTEM AND ECOSYSTEM PROCESSES AND FUNCTIONING

1.2.1. Ecology

Ecology is defined as the study of the interactions between organisms and their environments, including both the living (biotic) and nonliving (abiotic) components. Ecology involves subject matter that is often readily observable and evident all around us.

From the moment of birth, each of us interacts with the environment. We begin our life's journey by developing relationships both with other humans and with nonhuman organisms and by engaging in interactions with our physical surroundings. The concepts and principles that make up the ecological sciences deal with how nature works. Nearly everybody at one time or another actively observes and even ponders nature, making almost everybody an ecologist of sorts. This is true even for someone who has lived entirely in an urban environment. Ecology is also a broad scientific discipline. In fact the development of ecological thought has involved subsuming numerous ideas from such other sciences as geology, physics, sociology, and economics.

Every organism interacts with a multitude of other organisms, contributes to the flow of energy and materials (the currency of ecological systems), and responds to the physical environment in myriad subtle ways. We humans, the most conscious species, are unconscious of most of the ways in which we influence and are influenced by our environment; they are in effect invisible to us. For example, most people know little of the organisms and processes that underlie the ecological systems responsible for the oxygen we breathe, the water we use, the food we eat, and the infectious illnesses we contract.

Ecosystem ecology stresses energy flows and material cycles, including the ways in which energy and materials are modified by human activities. It aims to understand how energy and materials (such as water, carbon, nitrogen, phosphorus, and other elements) essential to growth and metabolism — from the organism level to the entire ecosystem — flow in, out, and through and are compartmentalized and transformed.

1.2.2. Ecosystem

The **ecosystem** is in many ways the most important concept and functional entity in ecology, much as the cell is in physiology. An ecosystem is formed by the interactions of living organisms with their physical environment. Much as particular kinds of cells make up tissues and organ systems, various kinds of ecosystems make up Earth's living environmental systems. Collectively, these ecosystems constitute the **biosphere**, a central concept in ecology. The biosphere is the largest known ecosystem, in which all other ecosystems are embedded; it consists of all the Earth's living organisms interacting with the physical environment.

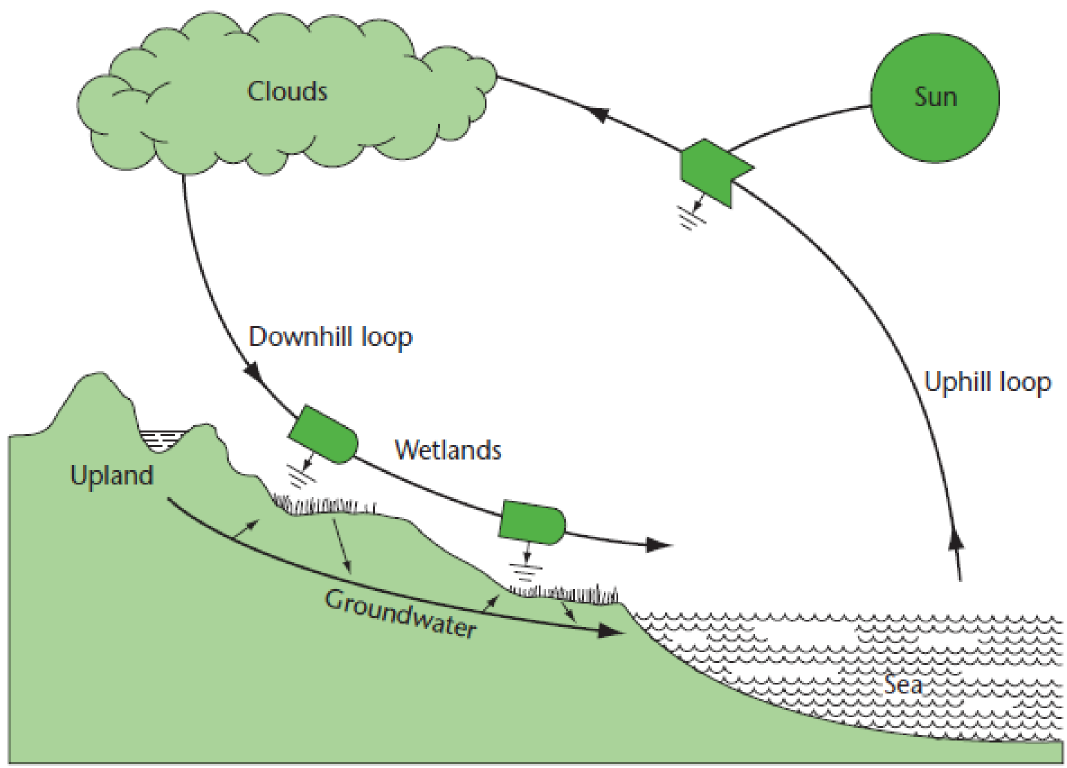
Certain critical features or climatic factors determine the character of ecosystems. Prime among them are the amount of precipitation, the temperature, and the availability of soil nutrients. These features in turn predict the kind of vegetation that grows, defining the major ecological zones, or **biomes**.

Basically, biomes are the world's major geographic regions defined by characteristic ecosystem type. Major biome types include tundra, boreal forest, temperate forest, tropical forest, scrubland, grassland and savannah, and desert; these are divided into subtypes such as coniferous or deciduous forest, semiarid or tropical scrubland, and so on. The traits of the organisms that make up a biome or ecosystem type and the physical structure of the vegetation, including its height and density, are responses to evolutionary and ecological constraints and to opportunities posed largely by climate. Local circumstances such as geology and landscape (topography) can also have a strong influence on the ecosystem type that develops in an area. But even these **abiotic** factors are ultimately shaped or determined in part by biological, or **biotic**, factors. For example, the reshaping of rocks and landforms, or **geomorphology**, is partly a consequence of the interaction of vegetation cover and rainfall. Vegetation influences not only rainfall but also the rates of erosion in uplands and sedimentation in lowlands, including deposition of sediments and soil downstream in river systems.

1.2.3. Ecosystem Processes and Functioning

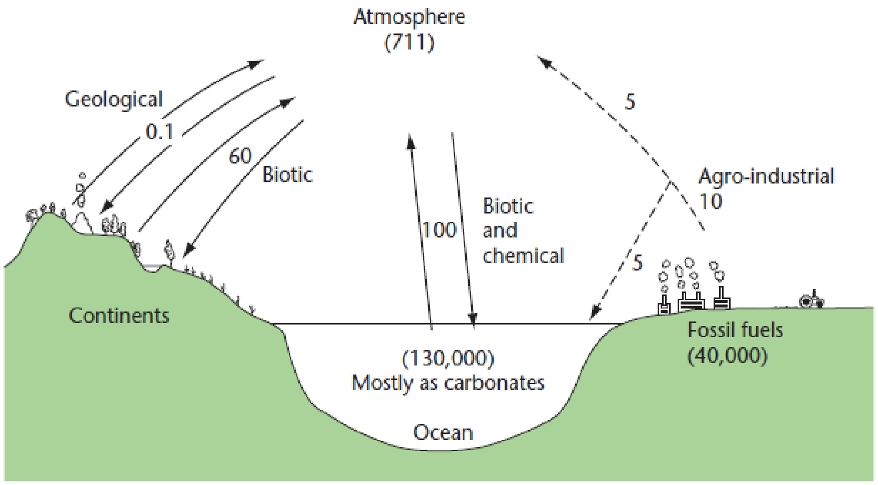
1.2.3.1. Hydrologic and biogeochemical cycles

Naturally mediated and regulated ecological processes, such as the breakdown of organic waste and the recycling of chemical elements, are part of what is called ecosystem functioning. For example, key processes in the back - and - forth movements of materials between living and nonliving biosphere components are the **hydrologic cycle** and the biogeochemical cycles, which include the **carbon cycle** and **nitrogen cycle**. Such cycling of water and elements is central to the functioning of ecosystems and the biosphere. Indeed, these processes are the basis of Earth's life support system, and thus are essential to human health. For example, they make possible the wetlands, marshes, and mangrove forests that provide key **ecosystem services** such as natural waste recycling, water filtration, barriers against storm surges and saltwater intrusion, and nurseries for fish and shellfish. The degradation of ecosystems and the alteration of their functioning can have severe health consequences. The benefits provided by ecosystems are indispensable to the well-being of people throughout the world. These benefits include food, natural fibers, a steady supply of clean water, regulation of some pests and diseases, medicinal substances, recreation, and protection from natural hazards such as storms and floods. Yet because of the complexity of ecosystems, the innumerable ways in which human well-being is linked to ecosystem productivity, and the limitations of economic methods and data, it is not yet possible to accurately measure the economic value of goods and services provided by ecosystems. The ecosystem services are divided into four categories: provisioning services, regulating services, supporting services, and cultural services. The functions particularly relevant to environmental health are the regulating services: provision and purification of water, recycling of wastes, and regulation of climate and of infectious diseases.



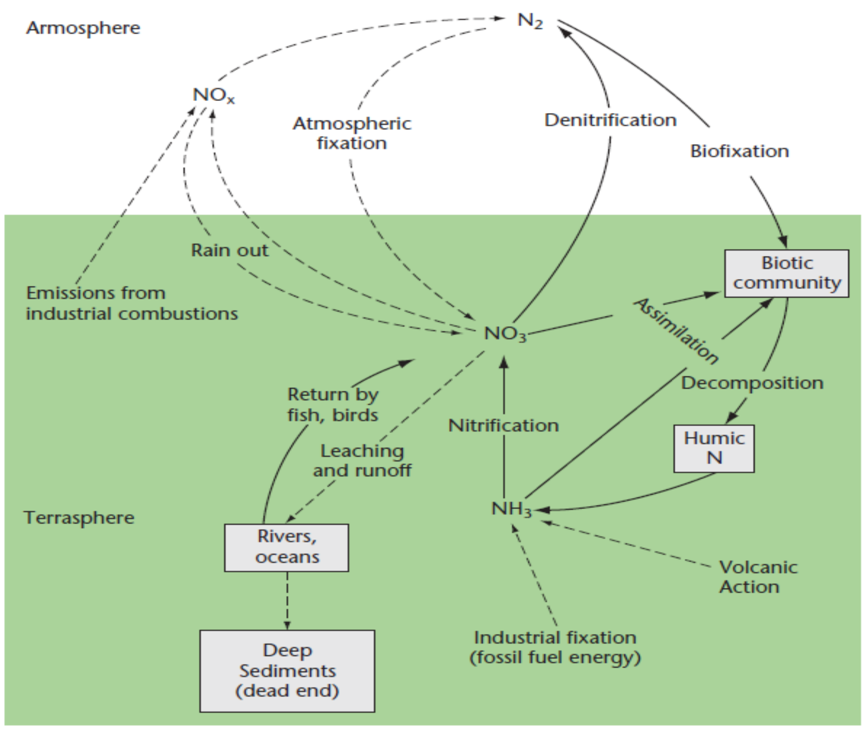
Hydrologic cycle

Water continually moves through various states. The uphill loop is driven by solar energy, and the downhill loop provides goods and services such as rainfall. (In Odum's notation, the pointed icon on the uphill loop represents the interaction of energy flows to produce higher quality energy, and the bullet-shaped icons on the downhill loop represent conversion and concentration of solar energy.)



Carbon cycle

Estimates of the amounts of carbon dioxide (in 10^9 tons) are shown in four major compartments: the atmosphere, oceans, terrestrial biomass, and soils and fossil fuels. Flux rates between compartments are shown by arrows. Note that the atmospheric pool of carbon is relatively small, especially in comparison to the fossil fuel reservoir, but it is active and changing. Most flows are balanced, as shown by pairs of solid lines, but there is a net transfer from fossil fuels to the atmosphere and oceans (shown by dotted lines) dating from the early industrial age.



Nitrogen cycle

Vital to all life on Earth, nitrogen is a key component of DNA and amino acids. Although nitrogen is bountiful in the atmosphere, usable forms are produced only by a few specialized microbes (*diazotrophs*) that are able to *fix* nitrogen (and by lightning, combustion, and industrial processes). Nitrogen is returned to the atmosphere via denitrification by both biotic and abiotic processes. Solid lines indicate natural biotic flows of nitrogen, and dashed lines indicate flows influenced by humans or other physical processes.

1.2.3.2. Bio-diversity

The concept of biological diversity is closely intertwined with the organizational hierarchy of biological systems and complex ecosystem functioning, including some ecological processes that affect human health. Biological diversity, or **biodiversity** as it often called, refers both to organismic variety at the various levels of the organizational hierarchy and to genetic diversity among individual organisms.

Ecosystems with greater numbers of species or with species populations harboring greater differences in their genetic makeup are said to have greater biodiversity. Ecosystems that retain higher levels of biological diversity often retain superior air, water, and soil quality and regulate pathogens more effectively. Moreover, greater biological diversity makes ecosystems more resilient and better able to assimilate environmental stressors, such as physical restructuring, invasive species, extreme weather events, overharvesting, or pollution.

Overall, greater biodiversity offers numerous benefits for human health. Unfortunately, biodiversity is eroding at unprecedented and alarming rates, largely through the degradation of ecosystems (especially tropical forests), species extinctions, and the reduction of genetic diversity within species. Among higher organisms such as birds, mammals, reptiles, and amphibians, whose status can be relatively well monitored (in contrast to the status of millions upon millions of invertebrate species), species are now being extinguished due to human activities at least a thousand times faster than new species are being created.

1.2.3.3. Conservation of natural resources, Pollution and Environmental Health

One way to think about causes of environmental health problems is:

• **scarcity** (not enough) of essential things we need for a healthy life, such as clean air and water, healthy soil and forests, safe and comfortable shelter, and safe working conditions.

• **excess** (too much) of harmful things we do not need, such as trash, toxic chemicals, **pollution,** and **junk food**.

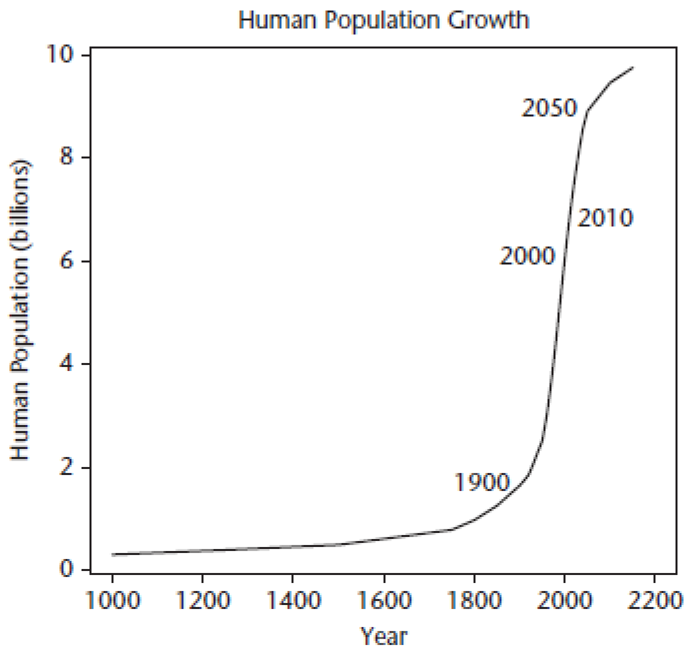
Improving environmental health depends on people preventing the conditions that caused both a scarcity of essential resources for life and an excess of pollution. By protecting our communities and our natural resources, we are protecting the future for our children, and our children's children.

1.2.3.4. Population growth and depletion of natural resources

Population ecology is in many ways at the core of all ecological science. The ecological definition of a population is “a group of interbreeding individuals in a particular locality.” The processes and mechanisms operating at the population level determine the abundance and distribution of species, which in turn define communities and ecosystems. Ecological science has long been interested in precisely how population size changes, including the mathematical details of such life history parameters as birthrate, death rate, reproductive age, and longevity. In many cases it is not clear why the numbers of a particular organism are what they are at any given time.

Yet this understanding is important not only for forest, wildlife, and fishery management but also for the control of organisms responsible for human disease as well as other pathogens and so - called pests injurious to livestock, crops, and food stocks.

The amount of water, trees, minerals, and other natural resources on Earth is limited, while the number of people using these resources is growing rapidly. But the number of people is not the real problem. The problem is how these natural resources are distributed and used. Any time one person or a group of people uses more than their fair share of resources, or causes an excess of pollution, this imbalance can lead to environmental health problems for others.



Some people believe the best way to prevent harm to our environment is to reduce the number of people. This way of thinking leads to 'population control' programs. These programs have failed to improve the lives of people anywhere because they do not address the root causes of environmental destruction, poverty, and poor health. When families have the resources they need to live with health and dignity, many choose to have fewer children. Only when communities, governments, and development programs plan for the survival of children, and the improvement of the social, political, and economic status of women, will the so-called "population problem" be solved. But reducing the number of people in the world will not address the problem of the unequal use of resources. The best way to reduce the harmful effect people have on the environment is for the rich to use fewer resources, and to use them in a way that conserves resources for the future and does not create an excess of pollution. By first changing the behavior of those who use the most, we can begin to make sure there will be enough for a healthy life for everyone.

1.2.3.5. Preventing harm from pollution

Pollution is the harm to people and the environment caused by an excess of poisonous or toxic substances from peoples' activities, especially wastes from industry, transportation, and agriculture. Toxic pollution travels through the environment in our air, water, and soil. Most pollution comes from things we use and are exposed to in our daily lives. The most common ways people are exposed to toxic pollution include:

• **smoke from fires,** especially when plastic is burned. We breathe in toxic smoke, and toxic ash pollutes our drinking water and our crop land.

• **smoke from factories** that pollutes air, water, and soil.

• **chemicals** used in factories, mining, and oil drilling and production that are dumped into water sources, and also pollute the air and land.

• **pesticides** used and handled near food, water sources, and at home.
When sprayed, they travel far through the air, causing great harm.

• **chemicals** in batteries, paints, dyes, and from making electronics that
harm the people who work with them.

• **motor exhaust** from automobiles that pollutes air, water, and soil.

Toxic pollution causes serious harm to people, plants, and animals not only where it is released but also far from the source. Protecting ourselves from the harm caused by pollution and toxic substances is an important part of sustainability.

1.3. SUSTAINABLE DEVELOPMENT

Sustainability means the ability to keep something going for a long time. Whether we are talking about a community institution such as a health clinic or recycling program, or a natural resource such as a forest, field, or spring, if it is not developed and used in sustainable ways, serious environmental health problems may result.

Sustainability also means being able to meet the daily needs of people now while planning for the needs of future generations. One of the greatest challenges facing people today is trying to meet all of our needs without harming the environment that feeds, houses, and clothes us, that gives us water, energy, and medicine, and is the very source of our survival.

All around us we see the signs of development that is not sustainable. There is an increasing scarcity of healthy food, clean air and water, and safe livelihoods. And there is an excess of pollution, deforestation, and illness. When communities grow in ways that are not sustainable, they create big problems for themselves and for future generations.

1.3.1. Respecting the web of life

The natural world is made up of a great variety of living things. The scientific word for the great number of different kinds of people, plants, animals, and insects that live on Earth is **biodiversity.** Long before scientists gave this name to the variety of living things, many people taught their children about the web of life. Just as a spider's web is made strong by the many threads connecting it, biodiversity depends on the web of life connecting all living things.

For example, people gather fruits to eat, which have nutrients that keep them healthy. These fruits grow on trees and bushes **pollinated** by insects. Without pollination, the fruit will not grow. Birds eat the insects, and the birds are hunted by foxes. A balance in the web of life means that there are just enough flowers, insects, birds, and foxes for all to live in the area. If you kill too many foxes, maybe because they are killing your chickens, then perhaps the number of birds will grow and they will eat too many of the insects. In this way, killing too many foxes can mean you have less fruit as well.

Unfortunately, the world is facing a great loss of biodiversity, with many plants and animals disappearing every year. Biodiversity is valuable in itself, but it is also valuable in the many ways this web of life protects human health.

Damage to the web of life leads to new illnesses

Loss of biodiversity means there are fewer kinds of plants and animals, and the natural balance among plants, animals, and people is disturbed.

This can cause new illnesses. Here are 2 examples of how a loss of biodiversity from **deforestation** caused new illnesses:

• Where people cut down tropical forests for farms and towns in Africa, there have been outbreaks of leishmaniasis, yellow fever, and sleeping sickness. These are diseases spread by insects that thrived when water pooled instead of being absorbed by the soil, and the animals that eat the insects lost their forest homes.

• When large numbers of trees were cut down in North America, the number of white-footed mice grew because their food supply increased and the number of animals that hunted them got smaller. These mice carried an illness called Lyme disease, which then spread to people.

1.3.2. Climate and Health

All over the world, the web of life is being torn apart. Deforestation, increased pollution of our water and air, and loss of wildlife are all visible examples. Less visible is the increase in temperature caused by pollution. This problem, called **global warming,** is changing the **climate** (what the weather is like in a place over a long period of time) in most parts of the world.

What seem like small increases in temperature are leading to big changes. Some places are having more floods and severe storms, and other places are having less rain and more droughts. Climate change caused by global warming is causing disasters all around the world, year after year, creating serious problems for people’s health.

•Flooding, severe storms, and drought cause crop loss, famine, destruction of homes, mass migration, injury, and death.

• Diseases worsen or spread because changing weather brings more insects and disease-carrying animals, and lets them move to new places.

• Hotter temperatures sometimes lead to increased illness and death.

Root causes of global warming

The environment has a natural ability to absorb pollution. But if too much pollution is put into the environment, the earth cannot absorb it. Over the last 100 years, when people started to remove and burn large amounts of **fossil fuels** such as oil and coal, the amount of pollution released into the environment increased faster than ever before. This is one of the root causes of global warming. Also, some chemicals invented for manufacturing pollute the air and cannot be absorbed. They too contribute to global warming.

Another root cause of global warming is the unfair, unequal, and unsustainable use of resources. Wealthy countries started global warming by using too many resources and causing too much pollution in pursuit of higher profits and a higher standard of living. When poorer countries start following the same unsustainable paths toward development, the pollution becomes even more impossible for the earth to bear. To prevent disasters caused by global warming, like the ones listed above and worse ones still to come, both developed and "underdeveloped" countries must change to a sustainable use of resources. We especially need to stop depending on fossil fuels and start using more clean energy.

1.4. TOXICOLOGY

1.4.1. Introduction

Toxicology (from the Greek *toxinos* , meaning " poison") is the study of the adverse effects of chemicals on biological systems. These adverse effects can range from mild skin irritation to liver damage, birth defects, and even death. Both natural and man - made chemicals are studied. However, most work in the field of toxicology is focused on the adverse effects of chemicals on human health. Section examines these adverse effects with an emphasis on the impact of environmental agents on human health, such as the deleterious effects of reactive gases on pulmonary function, environmental estrogens on reproductive function, and pesticides on neuronal function.

A basic tenet of toxicology is that all substances have the potential to be toxic. Paracelsus, the father of toxicology, was the first to articulate this concept. Although poisons such as strychnine, cyanide, or nerve gas come readily to mind, every compound can cause toxicity. Of course all compounds are not equally toxic; some have effects at minuscule doses and others require very high doses. For example, table salt (sodium chloride) used in moderation is fine in the human diet, but consuming half a cup of salt a day would eventually cause significant electrolyte and kidney problems and possibly death. Conversely, ingestion of even a small amount of potassium cyanide (one gram) can kill a human. It is the job of the toxicologist to determine the relative toxicity of various compounds. This information, when combined with information about the potential benefits of a compound, aids regulatory bodies in deciding whether a compound is acceptable for a particular use and what doses (for a medication) or exposures (for other chemicals) are permissible. For example, the general public (and regulatory agencies) would not tolerate a cold remedy that caused mild liver or kidney damage in 10 percent of users or a food additive that caused cancer in 1 in 1,000 consumers. However, if a new chemotherapeutic agent cured cancer in 80 percent of the cases, some mild liver or kidney damage might be found to be acceptable. Toxicology helps researchers to characterize the adverse effects that form part of the risk - benefit balance for a given chemical, and defining the **dose - response relationship** is perhaps the most critical aspect of this process.

The dose - response relationship quantitatively describes the association between exposure to a compound and the toxic effects produced by that exposure. In order for a chemical to exert a toxic effect, the chemical or its active metabolite must reach the site in the body where it can exert its adverse actions, it must do so at a concentration sufficient to cause an effect, and it must persist at this site long enough to exert the effect. In order to assess the toxicity of a given chemical, we need to know not only about the toxic effects it produces but also how an individual might be exposed to the compound and how frequently that exposure occurs

1.4.2. Exposure routes

Dermal exposure, ingestion, and **inhalation** are the major routes by which humans can be exposed to chemicals, and the route of administration can have a significant effect on the toxicity of certain chemicals. For example, the pesticide **chlorpyrifos** is ten times more toxic via oral administration than dermal application. Several issues must be considered when evaluating a dose - response relationship.

First and foremost, it must be known that the response observed is due to the exposure to the compound. Second, the magnitude of the response should be a function of the dose administered. Finally, there should be a quantitative method for measuring the response.

1.4.3. Toxicology and Environmental Public Health

Toxicology is an essential part of environmental health and of public health more generally. Public health professionals manage resources necessary to maintain health, prevent disease, and treat illnesses. A chemical or other environmental contaminant that harms humans at levels found in the environment raises obvious public health concern. The field of toxicology helps determine the conditions under which a given compound may cause adverse effects, so it is important for public health professionals.

Toxicology is integrated into public health practice in several ways. For example, in providing safe drinking water to a community, it is important to understand both the adverse effects of organisms found in the water and the adverse effects of chemicals used to kill the organisms. For instance, chlorination is an effective means of reducing microbiological contamination in water, but it can result in the presence of chlorinated organic compounds known as *disinfection by-products*. Toxicology can help in identifying these compounds, assessing the risk they pose, and balancing that risk against the risk of microbiological contaminants. Once again, the collaboration between professionals in related disciplines, risk assessment in this case, becomes critical in protecting the public.

1.4.3.1. Toxicant Classifications

Toxic compounds are categorized in three major ways: by chemical class, by source of exposure, and by effects on human health, or more specifically, on specific organ systems. A knowledge of each category helps in understanding toxicology.

1.4.3.1.1. Chemical Class

Examples of chemical classes are heavy metals, alcohols, and solvents. In essence the rules of chemistry create the classes, based on such features as functional groups, the presence of metallic elements, and physical properties, such as vapor pressure. Chemical classification may also address physical state, that is, whether a toxicant exists as a liquid, solid, gas, vapor, dust, or fume.

1.4.3.1.2. Source of Exposure

The second system of categorization is functional and is based on the source of exposure. Examples are industrial pollutants, waterborne toxicants, air pollutants, and pesticides. These categories are useful in identifying the source of a problem and are commonly used by environmental health professionals. However, chemicals used in similar ways may vary greatly in their mechanism of toxicity. Because this categorization system groups together chemicals with little chemistry in common, it can obscure connections based on molecular structure. To the toxicologist this system ignores the biological mechanisms that underlie toxicity.

1.4.3.1.3. Organ System Affected

The third system of categorization looks at the organ system in which toxic effects are most pronounced (the **target organ**). For example, toxins that damage the liver are referred to as **hepatotoxins** and those that target the kidney are called **nephrotoxins**. Compounds that damage the nervous system, whether peripheral or central, are **neurotoxins** . Chemicals that disrupt DNA structure or function are classed as **genetic toxicants, mutagens** , or **carcinogens** , depending on their specific effects. Other organ systems that can be the targets of toxicity include the respiratory system, cardiovascular system, skin, reproductive system, endocrine system, immune system, and blood. Fetal development is more a process than an organ system, but it too is often viewed as a target of toxic exposures.

Organ system classification of toxicants is favored by most toxicologists. When working to protect human health, one needs to consider how a chemical will affect a particular physiological function, whether it is blood pressure, respiration, memory, or urine production.

TABLE 2.1 Examples of Toxicants Classified in Three Ways

Chemical class	Alcohols Solvents Heavy metals Oxidants Acids
Source of exposure	Industrial wastes Agricultural chemicals Waterborne toxicants Air pollutants Food additives
Organ system affected	Kidney (nephrotoxins) Liver (hepatotoxins) Heart (cardiotoxins) Nervous system (neurotoxins) DNA (mutagens, carcinogens)

1.4.3.2. Toxicants in the body

After a person is exposed to a **xenobiotic** (a chemical foreign to the body), a sequence of steps determines the response to the chemical: **absorption** into the body, **distribution** throughout the body, **metabolism,** and **excretion.** Along the way, toxic effects may occur. Understanding the risks of a chemical exposure and how to reduce these risks requires understanding **toxicokinetics**, that is, the processes in this toxicological sequence.

1.4.3.2.1. Absorption

Once a person has come in contact with a toxic compound, that compound may gain access to the body. It is not enough for this compound to contact the skin, be inhaled into the lungs, or enter the intestinal track; it must actually traverse the biological barrier. Each of these pathways exhibits characteristics that affect absorption.

1.4.3.2.2. Distribution

Once in the bloodstream a toxicant can be distributed throughout the body. If the toxicant is lipid soluble, it is often carried through the aqueous environment of the bloodstream in association with blood proteins, such as albumin. Toxicants generally follow the laws of diffusion, moving from areas of high concentration to areas of low concentration. Chemicals absorbed in the intestine are shunted to the liver through the portal vein, in a *first - pass* process, and may undergo metabolism promptly. A limited number of chemicals may be excreted unchanged into bile or by the kidneys into urine.

1.4.3.2.3. Metabolism

Once in the body most toxicants undergo metabolic conversion, or **biotransformation** , a process mediated by enzymes. The majority of biotransformation reactions occur in the liver, which is rich in metabolic enzymes. However, nearly all cells in the body have some capacity for metabolizing xenobiotics. In general, metabolic transformations lead to products that are more polar and less fat soluble. The metabolic product is therefore more soluble in urine, which facilitates its excretion. For example, benzene is oxidized to phenol, and glutathione combines with halogenated aromatics to form nontoxic and more polar mercapturic acid metabolites.

Traditionally, metabolic transformations are divided into four categories: **oxidation, reduction, hydrolysis**, and **conjugation.** Transformations in the first three of these reaction categories, known as **phase I reactions** , generally increase the polarity of substrates and can either increase or decrease toxicity by revealing functional sites. Many compounds undergo **bioactivation** at this stage. In conjugation, the only **phase II reaction,** polar groups are added to the products of phase I reactions. Most chemicals pass sequentially through these two phases, although some are directly conjugated.

Oxidation is the most common biotransformation reaction. There are two general kinds of **oxidation reactions**: **direct addition of oxygen** to the carbon, nitrogen, sulfur, or other bond, and **dehydrogenation**. Most of these reactions are mediated by microsomal enzymes, although there are mitochondrial and cytoplasmic oxidases as well.

Conjugation involves combining a toxin with a normal body constituent. The result is generally a less toxic and more polar molecule, which can be more readily excreted. However, conjugation can be harmful if it occurs in excess and depletes the body of an essential constituent. Hydrolysis is a common reaction in a variety of biochemical pathways. Esters are hydrolyzed to acids and alcohols, and amides are hydrolyzed to acids and amines. Various combinations of these reactions may be assembled in response to the same toxicant.

Metabolic strategies for a particular toxin may vary widely among species, so an animal study, to be applicable to humans, should use a species with pathways similar to those of humans. The most prominent enzyme system for performing phase I reactions is the **cytochrome 450** system, also known as the mixed - function oxygenase system. These enzymes are found in the endoplasmic reticulum of hepatocytes and other cells. In recent years advances in molecular biology have greatly expanded our understanding of **cytochrome P450**. Dozens of distinct P450 genes have been identified and sequenced. They have been grouped into eight distinct families, and for many, specific functions have been identified. For example, the enzyme CYP1A1 metabolically activates **polycyclic aromatic hydrocarbons (PAHs** and the enzyme CYP2E1 bioactivates **vinyl chloride, methylene chloride**, and **urethane**.

The enzyme systems that metabolize xenobiotics are not static. When the demand is high, their synthesis can be enhanced in a process called **enzyme induction**. The resulting increase in enzyme activity helps the organism respond to subsequent exposures not only to the original xenobiotic but to similar substances as well. DDT and methylcholanthrene are examples of substances known to induce metabolic enzymes. People vary in their capacity for biotransformation in several ways. Two areas of variation have already been mentioned: genetic factors and enzyme induction. Other factors that account for interindividual differences in metabolism are general health, nutritional status, and concurrent medications.

1.4.3.2.4. Excretion

Excretion is the removal of potentially harmful or toxic substances from the body. These substances are usually waste materials produced by complex chemical reactions taking place in living cells. Biotransformation tends to make compounds more polar and less fat soluble; the beneficial outcome of this process is that toxins can be more readily excreted from the body. The major route of excretion of toxins and their metabolites is through the kidneys.

A second major organ of excretion is the liver. The liver occupies a strategic position because the portal circulation promptly delivers compounds to it following gastrointestinal absorption. Furthermore, the generous perfusion of the liver and the discontinuous capillary structure within it facilitate its filtration of the blood.

Volatile gases and vapors are excreted primarily by the lungs. The process is one of passive diffusion, governed by the difference between plasma and alveolar vapor pressure.

Other routes of excretion, although of minor significance quantitatively, are important for a variety of reasons. Excretion into mother's milk obviously introduces a risk to the infant, and because milk is more acidic (pH 6.5) than serum, basic compounds are concentrated in milk. Moreover, owing to the high fat content of breast milk (3 to 5 percent), fat - soluble substances such as DDT can also be passed to the infant. Some toxins, especially metals, are excreted in sweat or laid down in growing hair, which may be of use in diagnosis. Finally, some materials are secreted in the saliva and may then pose a subsequent gastrointestinal exposure hazard.

1.4.3.3. Toxicokinetics

It is a useful exercise to track a potentially toxic compound from the environment (water, air, soil, food) into and then through the body all the way to its molecular site of action. This process is referred to as toxicokinetics . Suppose that a given compound is generated as a by - product of a particular industrial process. Whereas an exposure assessor measures the concentrations of the compound in the air and an epidemiologist studies the incidence of certain diseases in the surrounding community, the toxicologist is concerned with how the compound gets into the body and what it does once it is there. For example, the compound may be inhaled into the lungs. Once there, it rapidly crosses the alveolar membrane and enters the pulmonary circulation. It travels through the pulmonary vein to the left side of the heart and then circulates throughout the entire body. A large proportion of the compound goes to the liver, where it is activated into a reactive epoxide. This metabolite then fi nds its way to the kidney, where it is reabsorbed along with salts and other polar compounds and transported across the cellular membrane of the proximal tubule. There it accumulates and damages cellular macromolecules.

PERSPECTIVE

"The Dose Makes the Poison"—Paracelsus

Philippus Aureolus Theophrastus Bombastus von Hohenheim (1493–1541; his friends called him Paracelsus) was a respected physician of his day. He stated, *Alle Ding sind Gift und nichts ohn Gift; alein die Dosis macht daβ ein Ding kein Gift ist* ("All things are poison and nothing is without poison; only the dose makes a thing not a poison"). This may be paraphrased as, all substances are toxic; the dose differentiates a remedy from a poison—or even more simply, the dose makes the poison.

1.5. OCCUPATIONAL HEALTH AND SAFETY

1.5.1. Definition and objectives

The joint international labor organization committee on Occupational health (1950) defined occupational health as "The highest degree of physical, mental and social well-being of workers in all occupations". It represents a dynamic equilibrium between the worker and his occupational environment. Occupational health and safety (OHS) relates to health, safety, and welfare issues in the workplace. OHS includes the laws, standards, and programs that are aimed at making the workplace better for workers, along with co-workers, family members, customers, and other stakeholders.

Occupational Health has the following objectives:

- To maintain and promote the physical, mental and social wellbeing of the workers.
- To prevent occupational diseases and injuries.

- To adapt the work place and work environment to the needs of the workers i.e application of ergonomics principle.

Occupational Health should be preventive rather than curative. Improving organization's occupational health and safety standards ensures good business, a better brand image, and higher employee morale.

Occupational health and safety is concerned with addressing many types of workplace hazards, such as:

- Chemicals
- Physical hazards
- Biological agents
- Psychological fallout
- Ergonomic issues
- Accidents

Occupational health and safety standards are in place to mandate the removal, reduction, or replacement of job site hazards. OHS programs should also include material that helps minimize the effects of the hazards. Employers and organization management are obliged to provide a safe working environment for all of their employees.

1.5.2. Occupational Health Care

Occupational health care is preventive health care, which is provided on the basis of the Occupational Health Care act. The objective of occupational health care is a healthy and safe working environment, a well-functioning working community, prevention of work-related diseases as well as the maintenance of employees' working ability and functional capacity, and promotion of their health. The advantages of Occupational health care are:

- Investigates and assesses load factors and hazards and gives expert assistance for eliminating them
- Gives information and advice
- Estimates employees' working ability and monitors their health condition

- By its knowledge and skills supports action for maintaining working ability in the development of individuals, working environment and working community, in this way also affecting productivity continued
- Prevents occupational diseases and other work-related illnesses
- Prevents premature incapacity for work, reduces pension costs
- Reduces absenteeism due to sickness
- Can make calculations of the profitability of occupational safety and health and occupational health care in cooperation with workplaces or encourage workplaces to make these themselves.

1.5.3. Functions of occupational health service

The functions of Occupational Health service include:

- Pre-employment medical examination.
- First Aid and emergency service.
- Supervision of the work environment for the control of dangerous substances in the work environment.
- Special periodic medical examination particularly for the workers in dangerous operations.
- Health education for disseminating information on specific hazards and risks in the work environment.
- Special examination and surveillance of health of women and children
- Advising the employer or management for improving working conditions, and placement of hazards.
- Monitoring of working environment for assessment and control of hazards.
- Supervision over sanitation, hygiene and canteen facilities.
- Liaison and cooperation with the safety committees
- Liaison and cooperation with the safety committees
- Maintenance of medical records for medical check-up and follow-up for maintaining health standards and also for evaluation.
- To carry out other parallel activities such as nutrition programme, family planning, social services recreation etc., Concerning the health and welfare of the workers.

1.5.4. Components of occupational health services

- ✓ Medical treatment, First aid treatment in emergency.
- ✓ Health education, First aid education.
- ✓ Medical examination
- ✓ Pre-employment examination
- ✓ Medical treatment, First aid treatment in emergency.
- ✓ Health education, First aid education.
- ✓ Medical examination
    - Pre-employment examination
    - Periodic medical examination
    - Special medical examination
- ✓ Health counseling
    - Stress management
    - Mental health and Physical health
    - Rehabilitation programme
    - Medical rehabilitation
    - Social rehabilitation
    - Educational rehabilitation
    - Vocational rehabilitation
- ✓ Family welfare program
- ✓ To take care of employee and dependents
- ✓ Disaster management
- ✓ Health records maintenance

1.5.5. **Factors for effectiveness of Occupational Health services:**

- The nature of industry or organization: small, medium or large and its location.
- Existing infrastructure of health services.
- Trained manpower.
- Workers involvement and employers commitment.
- Surveillance of the working environment by means of epidemiological studies and testing.

CHAPTER TWO: HYGIENE AND SANITATION

2.1. Importance of Hygiene and Sanitation

Hygiene means what people do to stay clean and prevent the spread of germs. Hygiene includes washing hands and bathing, storing and preparing food, and keeping the home clean.

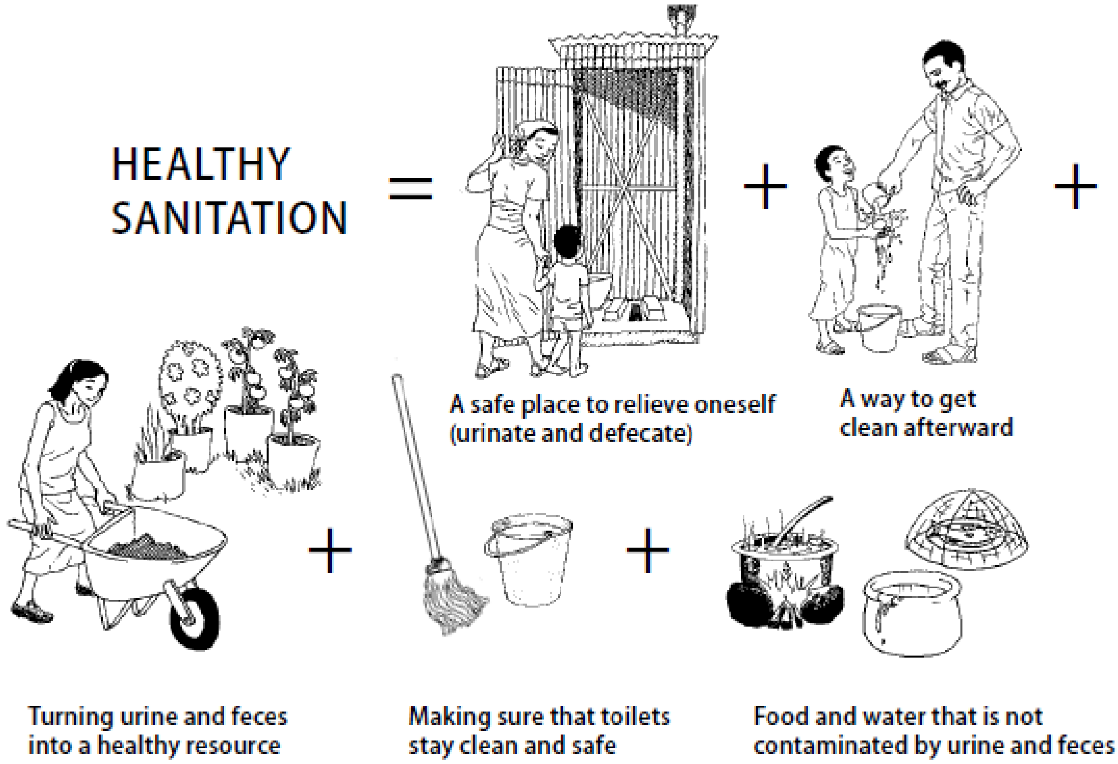
The scope of the science of Hygiene is the preservation and promotion of human health; its task consists therefore first of all in the prevention, restriction and removal of sicknesses and diseases; in the conservation and prolongation of the power of earning money, and of the prolongation of man's life itself.

Sanitation is a process where people demand, develop and sustain a hygienic and healthy environment for themselves by erecting barriers to prevent the transmission of disease. Sanitation is the hygienic means of promoting health through prevention of human contact with the hazards of wastes.

The World Health Organization states that: "Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal. Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities.

Some health workers believe health problems and death from poor sanitation can be prevented only if people change their personal habits, or “change their behaviors,” for staying clean. But promoting behavior change often fails because the conditions people face in their daily lives, such as poverty, or a lack of clean water or decent toilets, do not change. And when their behavior does not change, the people themselves are blamed for their own poor health.

Diseases caused by poor sanitation will continue if people are blamed for their own poor health or if technical solutions that ignore local conditions are promoted. To improve health in a lasting way, health promoters must listen carefully and work with people in the community to develop solutions based on their needs, abilities, and desire for change.



2.2. Good personal hygiene

The human body can provide places for disease-causing germs and parasites to grow and multiply. These places include the skin and in and around the openings to the body. It is less likely that germs and parasites will get inside the body if people have good personal hygiene habits.

Personal hygiene activities are all the things done to keep the body clean. Some of these activities are showering, washing hair, cleaning teeth and changing into clean clothes when necessary. Good personal hygiene habits include:

- washing the body often. If possible, everybody should have a shower or a bath every day. However, there may be times when this is not possible, for example, when people are out camping or there is a shortage of water
- If this happens, a swim or a wash all over the body with a wet sponge or cloth will do

- cleaning the teeth at least once a day. Brushing the teeth after each meal is the best way of making sure that gum disease and tooth decay are avoided. It is very important to clean teeth after breakfast and immediately before going to bed
- washing the hair with soap or shampoo at least once a week
- washing hands with soap after going to the toilet
- washing hands with soap before preparing and/or eating food. During normal daily activities, such as working and playing, disease causing germs may get onto the hands and under the nails. If the germs are not washed off before preparing food or eating, they may get onto the food
- changing into clean clothes. Dirty clothes should be washed with laundry soap before wearing them again
- hanging clothes in the sun to dry. The sun's rays will kill some disease-causing germs and parasites
- turning away from other people and covering the nose and mouth with a tissue or the hand when coughing or sneezing. If this is not done, droplets of liquid containing germs from the nose and mouth will be spread in the air and other people can breathe them in, or the droplets can get onto food

2.3. Domestic hygiene

It is important that the house be kept clean so that it is a healthy place. If the house and everything in it are not cleaned often, moisture and dirt gather and it becomes an ideal place for germs, parasites and vectors (disease-carrying animals) to breed and multiply. These germs can cause the people living in the house to get sick.

2.3.1. Domestic hygiene activities

Domestic activities include all the jobs which are done to keep the house and people's clothes and bedding clean. These jobs include sweeping and washing floors, cleaning the toilet, washing clothes and bedding, and washing dishes and cooking utensils after meals.

As well as making sure that the house is a clean and healthy place, it is important for good health to keep our bodies clean. If our bodies become dirty and sweaty and stay that way for a while, the skin and hair become ideal places for disease-causing germs to grow and multiply. The teeth and gums also need to be kept clean to stop them from becoming diseased.

2.3.2. Challenges to domestic hygiene

Overcrowding

When there are too many people in any house, the likelihood of them getting disease is greater than if the house is not overcrowded. This is because people in an overcrowded house will be much closer to each other and it is therefore easier for any germs to spread from one to another. For example:

- sneezing and coughing in crowded rooms makes it easier to spread cold and flu germs
- sharing towels can spread trachoma germs and other germs which cause eye infections (runny or sore eyes)
- several children sleeping in the same bed makes it easier to spread a scabies infection

Each house is designed to allow a particular number of people to live there comfortably. This number will depend upon the number and size of the rooms, especially bedrooms, and the size of other facilities such as the sewage system and washing and cooking areas. If the number of people living in the house is greater than the number it was designed for, these facilities will not be able to cope properly. For example, large numbers of people using the toilet may mean that the septic tank will not be big enough to take and treat the additional load of sewage.

In many communities, overcrowding in houses occurs for a number of reasons, such as:

- there not being enough houses for the number of people who live in the community
- families not being able to afford to pay rent on a house of their own and needing to live with relatives to share the cost
- people visiting relatives and staying for a long time
- visitors coming to stay so that they can attend special events such as wedding and funerals

It is important that environmental health professionals remember that overcrowding is a significant environmental health problem in many communities.

For good health and comfort, the number of people who should live in a house depends upon the factors outlined below.

The number and size of bedrooms

While most people who live permanently in a house will have a bedroom to themselves or share one with one or two other people, other rooms are often used as bedrooms. The number of people who should sleep in a room will depend upon the amount of air which is available to each person. The standards require that each adult person has at least 13 cubic metres of air and each child has at least 10 cubic metres of air in a sleeping area.

The type and size of the sewage system

Usually, a household septic tank system with 2 round tanks caters for a maximum of ten people.

The size and availability of other facilities

The facilities within the house may not be able to handle all of the demands placed on them by the occupants. For example, the hot water system may not be able to produce enough hot water, or the amount of food to be chilled is too great for the refrigerator to hold.

2.4. Poor hygiene and disease

There are many sicknesses which can be caused by inadequate (poor) domestic or personal hygiene. Signs of poor personal hygiene include:

- not washing hands
- not showering
- not washing hair

Signs of poor domestic hygiene include:

- not cleaning the toilet
- not getting rid of rubbish

- not washing clothes and bedding frequently
- not storing food properly

Diseases caused by germs and parasites resulting from inadequate domestic and personal hygiene

Bacterial: Food poisoning, gastroenteritis, diarrhea caused by Campylobacter, pneumonia, trachoma and skin infections

Viral: hepatitis A, gastroenteritis, colds, flu...

Parasitic: giardiasis, scabies infection, pediculosis (head lice infection), hookworm infection, threadworm infection, roundworm infection (strongyloides), flea infections (amavunja), lice infections (indâ)…

Poor domestic and personal hygiene practices can help the transmission of disease-causing germs **directly** by the faecal-oral route, or by person to person or pet to person contact or **indirectly** by vectors coming into contact with people or their food, people breathing in airborne droplets of moisture which contain germs or eating contaminated food.

2.5. House design and health

It is important that houses are pleasant and healthy places in which to live. There are many factors to be considered in a house design to make it a healthy place.

2.5.1. Protection from the weather

A house should keep out the rain and strong winds. It should keep out as much heat as possible in hot weather and keep in the warmth during cold weather. If the house meets all these requirements it lowers the chances of people getting sick from too much heat, cold or dampness.

2.5.2. Size of rooms

Each room in the house should be large enough to allow the people living there to have enough space to live comfortably. Rooms that are too small can lead to overcrowding and this can make it easier for diseases to be spread from person to person. Overcrowding can make people annoyed and depressed (downhearted). Rooms that are too small can result in the people using them not getting enough air. Even a large house can become overcrowded if too many people live in it.

2.5.3. Ventilation

All rooms should be well **ventilated**. This means that air should be able to flow into and out of each of the rooms. This is important so that fresh air can get inside all the rooms and stale air can get out. Ventilation also allows heat, steam and odours (smells) to escape, particularly from the kitchen, bathroom, laundry and toilet. This is important for the good health of the people living there. Open windows and doors allow the house to be well ventilated. Sometimes air vents are placed in the walls or the corners of the ceiling to provide ventilation when doors and windows are closed.

Toilets usually have a window with one part always fixed open, or have an air vent in the ceiling which opens to the outside air. Cooking areas also should be well ventilated so that any cooking smells are blown or sucked out of the house. Sometimes houses do have plenty of windows but the people living in the house rarely or never open them. These people should be encouraged to open their windows, especially on days when a breeze is blowing. Fly screens allow for windows to be open while protecting people inside from flying insects (flies and mosquitoes).

2.5.4. Lighting

As well as providing ventilation, windows also let natural light into the house. There should be enough windows to let in plenty of light. It is difficult for germs and insects to live and breed in light, airy rooms. When plenty of light can get into the house, it helps to make the home a cheery place to live in. Where possible, electric lights also should be positioned outside to light up areas such as verandahs and outside toilet blocks at night.

2.5.5. Water supply

Every house should have clean drinking water supplied to it. Plumbing carries the water to taps in different parts of the house. Water must also be supplied to the toilet if it has a flushing mechanism. Outside the house, water can be used on gardens and trees. Care should be taken to avoid wasting water.

2.5.6. Kitchen

If possible, the kitchen should have: a window or vent to let in fresh air and to allow cooking odors to escape. Sometimes a mechanical fan will ventilate the room, screens covering the windows to stop flies from coming in, a sink with water supplied to wash food and dishes, if possible, hot as well as cold water should be available to the sink, a workbench area which can be used to prepare food, a ventilated storage cupboard in which to keep dry and canned foods, storage areas for crockery (cups, saucers, plates, glasses), cutlery (knives and forks), kitchen utensils (saucepans, frying pans, billies) and cleaning equipment, a stove for cooking, a refrigerator for keeping foods cold to stop them from going bad too quickly

2.5.7. Bathroom

Every house should have an area where people can clean their bodies. The bathroom should have a basin and a shower or bath with water supplied directly to each of them. If possible, hot as well as cold water should be available at these places.

2.5.8. Toilet

Every house or other type of dwelling (place in which people live) must have some type of toilet provided or at least there should be one close to the house. Modern houses have toilets under the main roof, while older houses may have them in a small separate building located nearby. Human waste (feces and urine) can pollute water, food, and soil with germs and worms, leading to serious health problems. The safe disposal of human waste (sanitation) by building and maintaining toilets and washing hands prevents the spread of germs and is necessary for good health.

Whether your community uses pit toilets, toilets that turn human waste into fertilizer **(ecological sanitation),** toilets that flush human wastes and water **(sewage),** or another type of toilet, the main goal is to prevent human waste from contaminating drinking water, food, and our hands. Just as important as a safe and comfortable toilet is a way to wash hands after using it. Safe toilets and hand washing together can prevent most of the illnesses that come from germs in human waste.

Poorly built toilets and sewage systems are a major cause of illness and groundwater contamination. As clean water becomes scarcer, disposing of human waste in ways that do not cause more water contamination becomes increasingly important. It is important that water and soap are nearby so that people can wash their hands after going to the toilet. This water may be provided by a tap connected to a house water supply or a sealed container with a tap.

What People Want from Toilets

Health is not always the main reason why people want improved sanitation.

People also want:

• **privacy:** A toilet can be as simple as a deep hole in the ground. But the need for privacy makes it important for a toilet to have a good shelter with a door. The best shelters are simple and are built from local materials.

• **safety:** For a toilet to be safe it must be built well and in a safe place. If a toilet is badly built it can be dangerous to use. And if the toilet is far from the home, or in an isolated place, women may be in danger of sexual violence when they use it.

• **comfort:** People will more likely use a toilet with a comfortable place to sit or squat, and a shelter large enough to stand up in. They will also be more likely to use a toilet that is close to the house and is sheltered from wind, rain, or snow.

• **cleanliness:** If a toilet is dirty and smelly, no one will want to use it. Traditionally the job of low status people in the community, sharing the task of cleaning will help make sure that toilets are properly used and cared for.

• **respect:** A well-kept toilet brings status and respect to its owner. This can be an important reason people spend the money and effort to build one.

2.6. Sewage disposal

There must be a way of removing the sewage produced in a house. The sewage comes from the toilet, bathroom, kitchen and laundry.

Sewage systems use water to carry waste away in pipes. They can improve community health, especially in crowded urban areas. But to prevent health problems, sewage must be treated to make the water safe to return into waterways and for reuse.

Sewage treatment is costly, and more often than not, sewage is dumped without being treated. This spreads waste and all the germs, worms, and toxic chemicals it may contain, causing health problems such as hepatitis, cholera, and typhoid in places where sewage is dumped.

Even with costly sewage treatment, using water to carry away waste is often not sustainable and can lead to problems such as:

• contamination of drinking water sources downstream.

• contamination of land where people live and farm.

• loss of nutrient resources (fertilizer) for farming.

• contamination of water sources used for drinking, bathing, and farming.

• bad smells.

Sewage systems also cause health problems when different kinds of waste are mixed together, such as when factories dump toxic chemicals into sewers. This contamination makes the treatment and safe reuse of wastewater very difficult. The safest low cost way to manage sewage is to treat it close to where it is produced, and then to allow the water to absorb into the soil and nourish plants.

The most common way to do this is to use a **septic tank** (a large container underground where solids collect and decompose) and a **leach field** (where liquid flows out and into the soil).

This method, however, requires technical planning beyond the scope of this guide.

Sewage systems use a lot of water to do a job that can often be done with very little or no water.

Communities with little water, or that cannot afford a sewage system, will benefit from other types of toilets.

2.7. Rubbish disposal

Each house should have a way of properly disposing of the **solid waste** produced by the people living in the house. This solid waste is called **rubbish** and includes things such as food scraps, tin cans, plastic containers, glass bottles and jars, papers, cardboard and disposable nappies. If this rubbish is not properly disposed of it will quickly attract pests and germs. Solid waste disposal for a house should include: a small bin inside the house for daily use, a large bin in the yard into which all the household rubbish is placed. This rubbish should be collected and taken away at least once a week by a rubbish collector.

2.8. Protection from pests

There are many pests which carry disease-causing germs and parasites and are therefore a danger to health. Such pests include flies, mosquitoes, cockroaches and rodents. Houses can be made safe from these pests by:

- putting flyscreens on all windows and vents, and fitting doorways with flywire doors or hanging strip barriers
- sealing (closing) all gaps where pipes pass through walls
- sealing all gaps, such as cracks and crevices, around food storage cupboards which allow entry to the cupboard

2.9. House cleaning—tidying and maintaining the yard

The outside of the house is also an area where disease-causing germs can grow and multiply or where vectors can live and breed. For example, germs can live in rubbish and faeces, and mosquitoes can breed in water in old pots and containers. Grass is effective at reducing dust levels in the yard. Long grass is attractive to snakes so, where grass grows, it should be kept short.

Yard tidying and maintenance tasks

The jobs which should be done to keep the yard tidy and well maintained include:

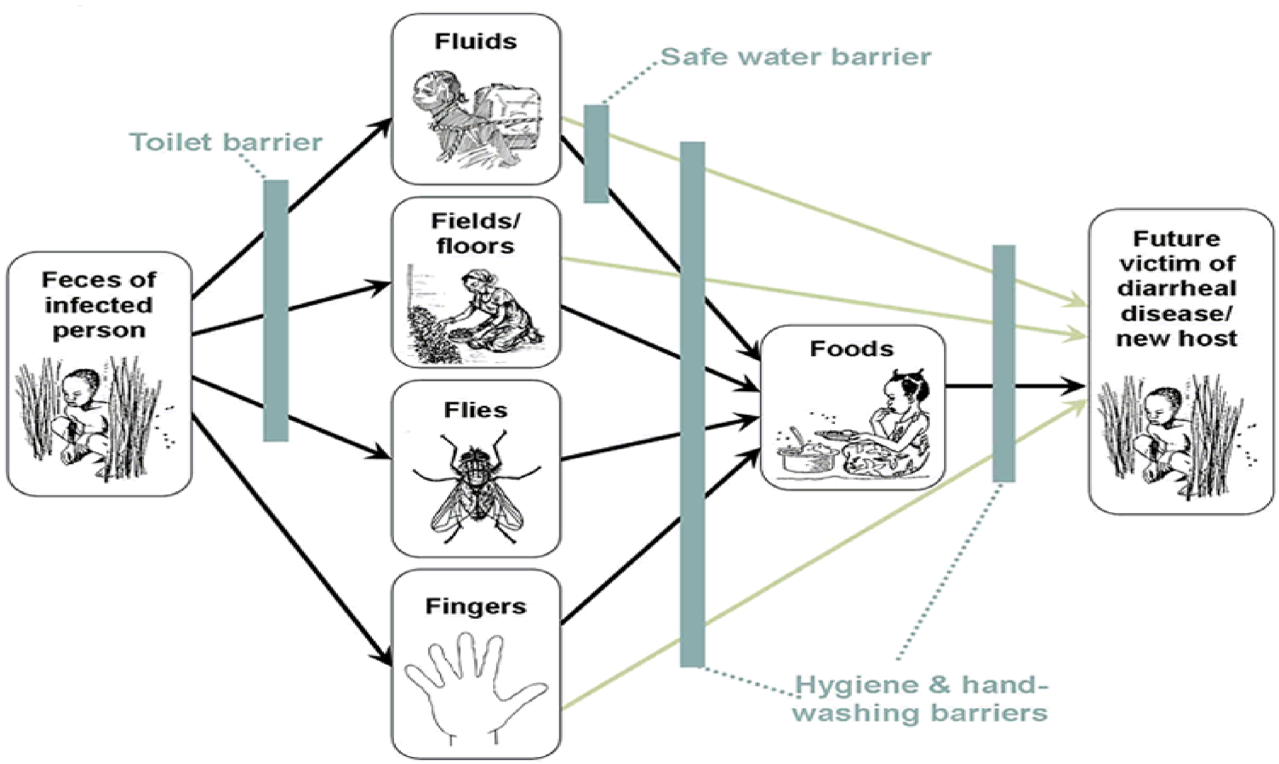
- raking up and disposing of rubbish (for example, cans, papers, plastic containers, bottles, broken glass), faeces and leaves
- mowing lawns, trimming edges and removing weeds
- pruning shrubs and trees
- cleaning out gutters if necessary
- removing bulky rubbish (for example, old pots, containers, …)
- watering lawn, shrubs or trees. This particular job maintains the garden. Lawns and shrubs help keep dust under control. Lawns need only be watered twice a week

Most yard tidying tasks are usually done once a week or less often. What needs to be done and how often depends upon one or more of the following:

- How many people use the yard and what they do there.
- The number and kind of pets that use the yard. For example, dogs are dirtier and more destructive than cats
- Weather factors. For example, rain collecting in containers can allow mosquitoes to breed and very strong winds blow objects, such as pieces of tin, around the community
- Other environmental factors such as the vegetation in the yard. For example, shrub types may differ as to how often they need to be cut back

2.10. How germs and worms spread disease

Sometimes it is easy to know where germs and worms are, especially on unclean things such as feces, rotting foods, dirty toilets, and so on. But sometimes they are in places that look clean, like clear water, or on our hands. Germs and worms can pass from person to person through touch, and through the air with dust or when people cough or sneeze. They can spread through food and drinking water, or be carried by flies, other insects, and animals. They may also live on uncooked or poorly cooked food. Some worms can be passed by drinking, stepping into, or washing with contaminated water, or eating uncooked shellfish or plants from contaminated water. Germs and worms that cause diarrhea travel on these paths:



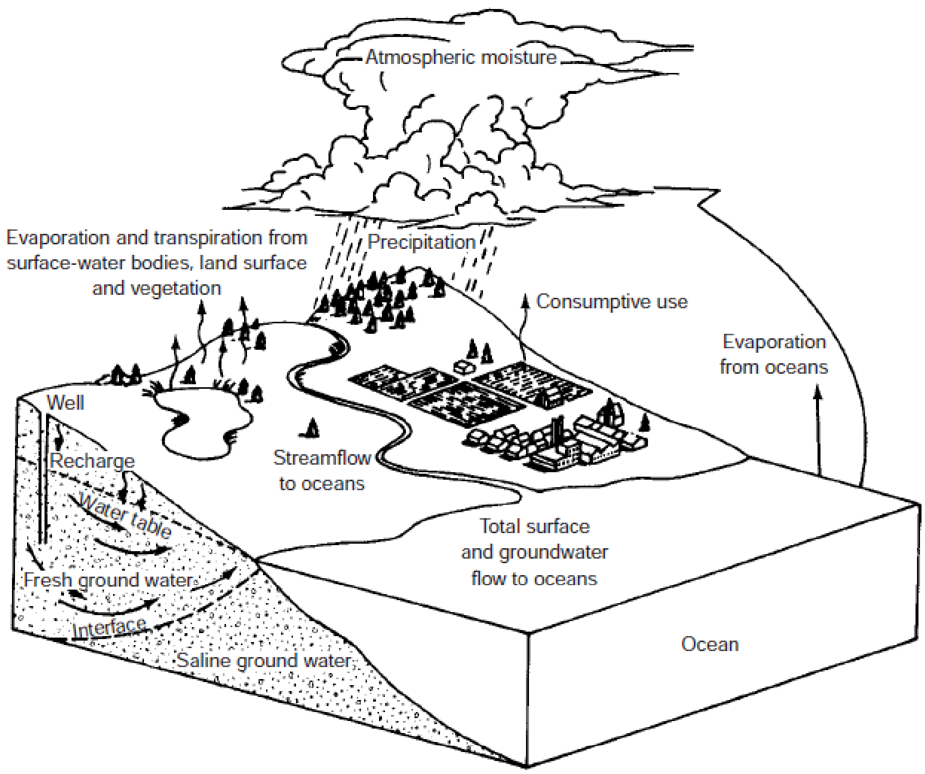
2.11. Drinking water

The quest for pure water dates back to prehistoric times. Information on methods for treating water has been found in Sanskrit medical lore, and pictures of apparatus to clarify water have been discovered on Egyptian walls dating back to the fifteenth century b.c. Treatment methods such as boiling, filtration through porous vessels, and even filtration through sand and gravel, have similarly been prescribed for thousands of years. In his writings on public hygiene, Hippocrates (approximately 460– 354 b.c.) directed attention to the importance of water in the maintenance of health. The Romans demonstrated a similar awareness of the merits of pure water, as is shown by the extensive aqueduct systems they developed, as well as their use of settling reservoirs to purify water, their rulings that unwholesome water should be used only for irrigation, and the passage of laws prohibiting the malicious polluting of waters.

The first positive evidence that public water supplies could be a source of infection for humans was based on epidemiological studies of cholera in the city of London by John Snow in 1854. His study is particularly impressive when one realizes that at the time he was working, the germ theory of disease had not yet been established. A similar study by Robert Koch in Germany in 1892 provided evidence of the importance of filtration as a mechanism for the removal from water of the bacteria that caused cholera. Subsequent experiments in the United States relative to the control of typhoid fever confirmed his observations and revealed the further benefit of the addition of chemicals to coagulate the water prior to filtration.

One of the most important technological developments in the treatment of water during the twentieth century was the introduction in 1908 of chlorination. This provided a cheap, reproducible method of ensuring the bacteriological quality of water. The dramatic impact of this development, combined with the filtration of water, in reducing deaths from typhoid fever in Philadelphia, Pennsylvania. Prior to that time, typhoid fever had been a major contributor to illness and death in the United States. The oceans, which are salty, cover about 70 percent of the Earth's surface and contain an estimated 96.5 percent of its water. Saline or brackish groundwater and saltwater lakes (including large inland seas) make up another 1 percent. The remaining 2.5 percent of the water on Earth is fresh and therefore potentially available for drinking, irrigation, and industrial use. Two-thirds of this, however, is frozen in the polar ice sheets and glaciers. The Antarctic and Greenland ice sheets contain a major portion of this fraction. The remaining 0.8 percent is held in aquifers, soil pores, lakes, swamps, rivers, plant life, and the atmosphere.

Much of this, however, is so deep beneath the Earth's surface that it is not readily accessible. As a result, only about 0.3 percent of the total water on Earth is available for human use. Even so, this small percentage represents a tremendous quantity. The Earth's freshwater lakes, for example, are estimated to contain nearly 125,000 cubic kilometers (30,000 cubic miles) of water, and its rivers and streams contain, on average, an additional 1,250 cubic kilometers (300 cubic miles) or more.



The hydrologic cycle

The basic source of all water on Earth is precipitation—rain, snow, and sleet. For the United States, the average annual amount is about 71–76 centimeters (28–30 inches). There are, however, significant geographic and seasonal variations in deposition in this country, as well as the rest of the world. For example, the area east of the Mississippi River typically receives more than twice as much precipitation as the area west of the Rocky Mountains. Because, as noted above, so much of the world is covered by oceans, only about 30 percent of the precipitation falls on land. Of this, about 70 percent is evaporated or transpired (through vegetation) directly back into the atmosphere; 10 percent soaks in and becomes groundwater; and 20 percent runs off into lakes, streams, and rivers. Most of this ultimately flows into the oceans. The overall movement of water from precipitation through various pathways on Earth and back into the atmosphere is called the hydrologic cycle.

2.11.1. Sources of Drinking Water

The primary sources of drinking water are groundwater and surface water. In addition, precipitation (rain and snow) can be collected and used. Water within the upper water table can be accessed through dug wells. Such wells generally extend 1.5–6 meters (5–20 feet) beneath the ground surface. Groundwater located in deeper reservoirs or aquifers can be accessed through wells that are driven or drilled. These may penetrate to depths of 450–600 meters (1,500–2,000 feet) (Figure 7.3). Springs, which are outcrops where the underground aquifer intersects the surface of the earth, represent another source of groundwater (Symons, 1992). Sources of surface water include lakes, reservoirs, and rivers. Surface water may also come from protected watersheds. Each of these sources has its advantages and disadvantages.

Groundwater

The widespread use of groundwater stems not only from its general availability but also from economic and public health considerations. Groundwater is commonly available at the point of need at relatively little cost, and reservoirs and long pipelines are not necessary. It is also normally free of suspended solids, bacteria, and other disease-causing organisms unless it contains contaminants introduced by human activities. Unfortunately, as of 1992 it was estimated that more than 10 percent of the community water-supply wells and almost 5 percent of the rural domestic wells in the United States contained detectable concentrations of one or more contaminants, primarily agricultural pesticides. About 1 percent contains one or more contaminants in excess of health-based limits. Accessible groundwater sources are limited in volume and, once depleted, are essentially irreplaceable. Yet farmers and municipalities throughout the world continue to pump water out of the ground faster than it is being replenished. Major portions of the Ogallala aquifer, which underlies the Great Plains section of the United States, have already been depleted. Aquifers in India have been depleted to such an extent that about half of the country now faces groundwater shortages. Similar conditions exist in the People's Republic of China. In fact, it is estimated that lack of water will reduce the production of grain in China and India by 10 to 20 percent within the next several decades (Montaigne, 2002).

Protected Runoff

Many homeowners have systems for collecting the rainfall from their roofs, storing it in a cistern, and using it as a source of drinking water. Such sources, however, are almost certain to have some degree of pollution. One step that can be taken to reduce contamination is to delay collecting the water until enough rain has fallen to cleanse the roof. Several types of diversion valves have been developed to accomplish this task. Some systems also incorporate units for filtering the water prior to use. Cisterns in which the water is collected should be watertight, and manholes or other ports of entry should be leakproof. Rainfall and accompanying runoff can also be collected on a wider scale to provide drinking water to large municipalities. Cities that employ this approach include New York, Boston, and Lisbon, where foresighted planners set aside large land areas for collecting precipitation and runoff in natural and human-made lakes.

Surface Supplies

Lakes, streams, and rivers are sources of drinking water for people in many areas. Water from such sources, however, usually requires extensive treatment before use. A further problem is that the adequacy of such supplies is in question in many parts of the world, especially in light of other demands for the water, such as irrigation, fisheries, and habitats for wildlife. Heated debates have ensued—for example, in the western United States—on how the limited surface-water supplies should be managed and allocated. In the final analysis, it will be necessary for all users to learn to accept limitations and to share responsibility for these resources.

2.11.2. Human Uses of Water

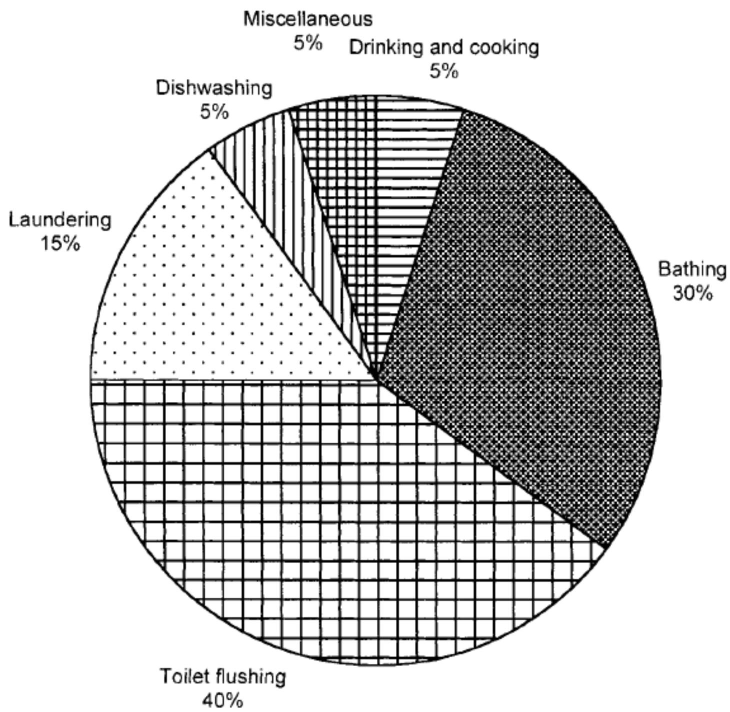
Water is absolutely essential to life. From 50 to 65 percent of the human body is composed of water, and variations of as little as 1–2 percent will cause thirst or pain. The loss of 5 percent of body water can cause hallucinations; a loss as large as 10–15 percent can be fatal. Although humans can live several months without food, under hot, dry conditions they can survive only a day or two without water.

In 1995, almost 400 billion gallons of water per day were withdrawn from aquifers and streams in the United States. This demand is equivalent to about 25 percent of the estimated renewable supply. Of this amount, about 75 percent (300 billion gallons) is eventually discharged into rivers and streams, and about 100 billion gallons are consumed and incorporated into manufactured products, agricultural crops, and animal tissue and hence are no longer available for immediate use. Although direct human consumption accounts for only about 150 million gallons per day, water that meets drinking-water standards is routinely used for irrigating lawns, fighting fires, washing cars, cleaning streets, and recreational and aesthetic purposes. With the increasing shortages of water in many areas of the world, however, this approach is rapidly changing. Dual water systems have been constructed in many arid areas, whereby separate plumbing systems deliver high-quality water for human consumption and less pure or reclaimed water for uses such as irrigation and waste disposal.

On a global basis, about 10 percent of the water is applied to household use, and about 70 percent is used for irrigation. The remaining 20 percent is used by industry. Details on some of the more prominent categories of use are summarized here.

Personal Use

Personal use includes drinking, cooking, bathing, laundering, and excreta disposal. On a daily basis, flushing the toilet consumes some 60–90 liters (15–25 gallons); bathing consumes another 60–80 liters (15–20 gallons). Total personal (domestic) water usage depends, of course, on whether a home contains a washing machine and dishwasher, whether it has a swimming pool, the extent to which water is employed to irrigate lawns, and other factors. Only about 2 liters (2 quarts) of the water in this category is actually consumed (for drinking and cooking).



Distribution of uses of water in home.

Waste disposal. As noted earlier, a major share of the water used by people for personal needs winds up as liquid waste. The water carriage method of excreta disposal, an outgrowth of the development of the flush toilet is particularly wasteful, using almost 250 gallons of purified water to transport a single pound of fecal material to a sewage-treatment plant for disposal.

Recreational and aesthetic use. Boating, sailing, water skiing, spray fountains, and the like fall in this category. Except for discharges of oil and gasoline from powerboats, few of these uses result in significant pollution.

Irrigation. The use of water for irrigation in the United States has increased by a factor of seven since 1900. A total of 55 million acres was being irrigated in 1997, and the amount of water lost through evaporation, transpiration, or incorporation into products or crops was estimated to total about 100 billion gallons per day (CEQ, 1998). About half of this comes from surface-water sources and about half from groundwater. Additional water is used to irrigate golf courses and parks, much of which is reclaimed. In fact, the amount of reclaimed wastewater used in the United States totals more than a billion gallons per day (CEQ, 1998).

Other. Other uses of water include providing supplies for farm animals and aquaculture, transportation (waterways and canals), and the generation of electricity. The last application includes the use of water as a coolant in fossil-fueled and nuclear-fueled electricity generating stations. For the United States, this accounts for almost 200 billion gallons per day, a portion of which is lost through evaporation. An even larger amount is used to generate electricity in hydroelectric power plants. Although the water is not "consumed," the volumes involved are enormous, amounting to some 3 trillion gallons per day.

Few people in industrialized nations are aware of the many ways in which water is used to support their accepted standard of living. Consider the following requirements: more than 50 glasses of water to grow the oranges to provide one glass of orange juice; 30 liters (8 gallons) to grow a single tomato; 450 liters (120 gallons) to produce one chicken egg; more than 13,000 liters (3,500 gallons) for a steak; and 225,000 liters (60,000 gallons) for one ton of steel, approximately the amount in an automobile.

2.11.3. Water: Pathways or Avenues of Human Exposure

Experience has shown that water can have effects on human health through four principal avenues.

Waterborne diseases. These result from the *ingestion* of water that contains the causative organisms for enteric diseases such as typhoid, cholera, and infective hepatitis. Prevention depends on avoiding the contamination of raw water sources by human and animal wastes or removing or destroying the contaminants prior to consumption.

Water-contact diseases. These can be transmitted through direct contact with organisms in water. The most common example is schistosomiasis, which can be transmitted to people who swim or wade in water that contains snails infected with the organism.

The larvae, which leave the snail and enter the water, can readily penetrate the skin. Prevention can be achieved through properly disposing human excreta and deterring people from contact with infested waters.

Water-insect-related diseases. Examples are malaria, yellow fever, and West Nile fever, encephalitis or rash, where water serves as a habitat for the disease transmitter, in this case the mosquito. Control requires eliminating mosquito-breeding areas, killing them, and/or preventing their contact with people.

Water-wash diseases. These result from lack of sufficient water for personal hygiene and washing. Shigellosis, trachoma, and conjunctivitis are among the diseases that may ensue. For purposes of assessing waterborne diseases in the United States, the impacts are divided into two basic avenues of exposure: (1) ingestion and (2) recreational exposures. Ingestion and most recreational exposures would be covered by waterborne diseases, as described earlier. Some recreational exposures, for example, dermatitis, would fall under watercontact diseases.

Impacts of Waterborne Diseases

Although the true magnitude is not known, it is estimated that waterborne bacteria, viruses, and parasites produce about 4 billion cases of diarrhea each year worldwide. In fact, water may serve as the vehicle for the transmission of as much as 80 percent of all illnesses. Groups at highest risk include the approximately 1 billion people who lack access to safe drinking water and the almost 2.5 billion without adequate sanitation facilities.

Worldwide, it is estimated that more than 2 million people, most of them infants and children under the age of five, die each year from waterborne diseases (Sawin, 2003). For the United States, the more common waterborne diseases that result from the ingestion of water are caused by bacteria, viruses, and parasites. Some health officials estimate that these agents may cause up to 1 million illnesses in this country each year.

Table 7.1 Diseases transmitted through contaminated drinking water

Disease	Causative agent	Source
Bacterial infections		
Salmonellosis	*Salmonella* sp.	Animal and human feces
Typhoid fever	*Salmonella typhi*	
Paratyphoid fever	*Salmonella paratyphi-A*	
Shigellosis (bacillic dysentery)	*Shigella* sp.	Human feces
Cholera	*Vibrio cholerae*	Human feces
Leptospirosis	*Leptospira* sp.	Human feces
Gastroenteritis	*Escherichia coli*	Animal and human feces
Diarrhea	*Campylobacter jejuni*	Human feces
Viral infections		
Viral hepatitis	Hepatitis A	Human feces
Acute gastronenteritis	Norwalk-like virus	Human feces
Waterborne parasites		
Amebiasis (amebic dysentery)	*Entamoeba histolytica*	Human feces
Diarrhea	*Cyclospora cayetanensis*	Human feces
Gastronenteritis	*Cryptosporidium parvum*	Animal and human feces
Giardiasis	*Giardia lamblia*	Animal and human feces

Bacterial diseases

A major outbreak of bacteria-related waterborne disease that occurred among attendees at a county fair in New York in 1999 affected almost 16,000 people, including 10 children who were hospitalized. Although most of the vendors at the fair were supplied with chlorinated water, several food vendors were supplied with water from a shallow well that was not chlorinated. Subsequent investigations indicated that the water was highly contaminated and that the causative agents were *Escherichia coli* O157:H7 and *Campylobacter*. An earlier waterborne bacteria-related disease outbreak, this time due to recreational exposure, occurred in Illinois in 1998. The causative organism was a member of the species Leptospira interrogans and the outbreak involved 375 persons who became ill after swimming in a lake. Twenty-eight of these people were hospitalized, making this the largest outbreak of leptospirosis ever reported in this country.

Viral diseases

As noted previously, the Norwalk-like viruses (NLVs) can be readily transmitted through food. The same is true for drinking water, and the impacts are similar. Waters in which NLVs have proved to be a problem include municipal and groundwater supplies, streams, lakes, and swimming pools, as well as commercial ice. Since these viruses are an intestinal organism, the primary mode of transmission is the fecal-oral route. As was the case for food, the lack of a readily available analytical method for monitoring NLVs in water has hampered efforts to link NLV strains to specific sources of contaminated water. With the development of molecular diagnostics, this problem as well as the obtaining of data on the frequency of occurrence of waterborne outbreaks caused by NLVs should soon be solved.

Parasitic diseases

As is the case for food, one of the most common parasitic organisms present in drinking water in the United States is *Giardia*. Persons at highest risk are children in day care, their close contacts, backpackers and campers (via ingestion of unfiltered, untreated water), people who travel to disease-endemic areas, and those who drink water from shallow wells. From the standpoint of recreational exposures, the seasonal peak for young children coincides with the summer recreational season. This may reflect their increased use of communal swimming venues, for example, lakes, rivers, swimming pools, and water parks. Another parasitic organism for which water serves as a primary mode of transmission is *Cryptosporidium parvum.* A major outbreak involving this organism occurred in Milwaukee, Wisconsin, in 1993. In this case, the organism passed undetected through two water-treatment plants and caused more than 400,000 people to become ill with diarrhea. An estimated 50 to 100 of them died. In more recent years, multiple outbreaks in the United States have been found to be associated with swimming and wading pools, water parks, fountains, hot tubs, and spas. Although any event involving fecal contamination of swimming-pool water increases the probability of the transmission of infectious agents, the probability of the transmission of *Cryptosporidium* is especially high. The reasons are several: its oocysts are extremely resistant to chlorine; they are not efficiently removed by conventional pool filters; and the ingestion of only a few mouthfuls of water from a pool in which only a single fecal accident has occurred can result in infection. For these reasons, the Centers for Disease Control and Prevention has recommended that should a single release of solid fecal matter be observed within a swimming pool, everyone should be directed to leave immediately.

Another parasite, transmitted primarily through the ingestion of contaminated drinking water, is *Dracunculus medinensis*, a filarial worm. This can cause what is called Guinea worm disease, the course of which is as follows. Approximately one year after a person is infected by the consumption of water contaminated by copepods (water fleas) that contain immature forms of the parasite, one or more meter-long adult female worms begin to emerge through the skin. The net impact is that victims of this disease are essentially crippled, unable to work, attend school, care for their children, or harvest crops. Although a variety of methods have been used to control this disease, the approach being used in Sudan is clever, inexpensive, and effective. In this case, every person has been provided with a pipe similar to but larger than a straw that contains a nylon cloth filter capable of removing Guinea worms. Users are instructed to drink by sucking water through the pipe. Through this approach, the number of cases in that country was reduced by 98 percent between 1986 and 2000. The disease has been eliminated in Cameroon, Chad, India, Kenya, Pakistan, Senegal, and Yemen.

2.11.4. Drinking Water and Chemicals

One of the early scientists who studied the role of drinking water in health was H. A. Schroeder of Dartmouth College. One of the results of his studies was what appeared to be a clear correlation of heart disease and the "hardness," or mineral content, of water. His observations showed that people who drank "soft" water (containing few minerals) had a higher incidence of heart disease—apparently because soft water, being more corrosive, dissolves toxic substances (such as lead and cadmium) from plumbing systems. Although his work was pioneering, scientists in the U.S. Public Health Service had conducted related studies on the effects of fluoride in drinking water in the late 1920s. These studies were an outgrowth of the reports of mottled enamel on the teeth of people who drank water containing relatively high concentrations of this chemical.

One of the important ancillary observations was that people who lived in such areas had far less tooth decay than those who lived where mottling was nonexistent. Subsequent studies confirmed that modest intakes of fluoride prevented dental caries, the optimum concentration being about 1 part per million, far less than that which would cause mottling.

Although drinking water has not generally been considered a major source of toxic chemical intake, the discovery in the 1990s of high concentrations of arsenic in the groundwater being consumed by an estimated 35 million or more people living in Bangladesh and West India dramatically changed this assumption. Interestingly, the arsenic is of natural origin, occurring through the dissolution of arsenic from the rocks and soils through which the groundwater flows. The urgency of correcting the problem is heightened by the fact that the concentrations of arsenic range up to several thousand parts per billion (ppb), far in excess of the EPA/WHO standard of 10 ppb. In essence, millions of people have been, and are continuing to be, poisoned. Tragically, this situation occurred following a recommendation by international agencies that populations in these countries switch from surface to groundwater sources. The anticipated goal was to provide them a more protected and higher-quality supply. Follow-up studies have shown that an additional million people in Vietnam and Thailand are facing a similar problem. A further complication is that the consumption of food products, particularly rice, may represent a larger source of arsenic intake than drinking water.

2.11.5. Drinking-Water Standards, Implications, and Analyses

A series of primary standards should be designed to protect human health, and secondary standards, designed to assure that drinking water is aesthetically pleasing in terms of temperature, color, taste, and odor. The primary standards include maximum contaminant levels (MCLs) for selected inorganic contaminants, volatile organic chemicals (including pesticides and certain chlorinated hydrocarbons), and selected radioactive materials, as well as limits for the presence of coliform organisms. The secondary standards include limits for iron, which along with manganese can discolor clothes during laundering; sulfates and dissolved solids, which can have the same effect as a laxative; and minerals that can, for example, interfere with the taste of beverages. They also include limits for suspended solids (turbidity) both for aesthetic reasons and because the efficacy of disinfection is related to the clarity of the water.

One of the problems with contaminants, such as pesticides and related organic compounds, is that water-purification plant operators must anticipate which contaminant will be present and be ready to remove it. The use of multipurpose removal agents, such as activated carbon, is one approach for addressing these problems. Another very promising and rapidly developing approach is the use of membrane filtration technologies.

In the past, the measurement of biological contaminants on an individual basis in water was difficult and tedious. Since coliform organisms originate primarily in the intestinal tracts of warm-blooded animals, including humans, the accepted approach has been to test for these organisms and to use their presence, if confirmed, as an indication of fecal contamination. This situation is now changing. As a result of technological developments, test papers and/or strips, for example, are now available for diagnosing the presence of certain microorganisms on an individual basis. These include *Bacillus brevis* and *Escherichia coli.* A more sophisticated approach is the use of molecular probes, which can not only detect the presence of human feces, but also determine whether an organism, such as *Salmonella*, is present. In a related manner, test strips and/or sticks are available for the rapid determination of the presence of a wide range of individual chemical elements (for example, chromium and lead), as well as chemical compounds (for example, nitrates).

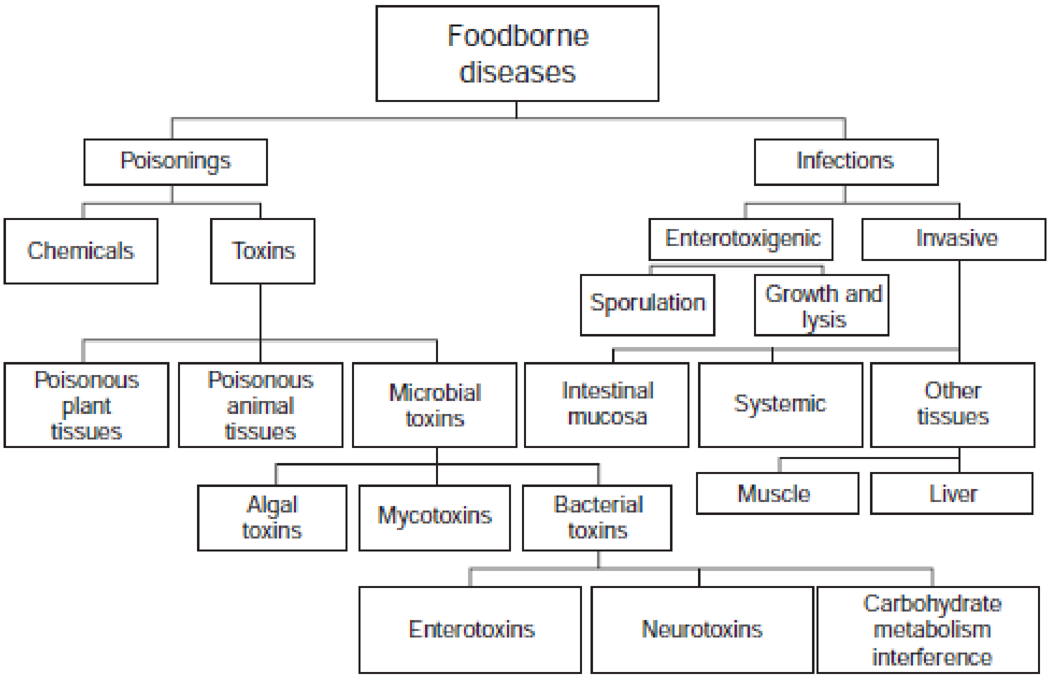
2.12. Food hygiene

2.12.1. Introduction

Given the central importance of food in our personal environment, one would expect it to be an aspect of our lives that we control. This is far from the case. The production, preparation, and handling of food continue to present new and novel challenges. These include the introduction of new agricultural and food technologies, such as genetically modified food crops; an increasing globalization of the food supply; changes in human demographics and food preferences; and intense public and media scrutiny of issues such as mad cow disease and biotech foods.

The focus in this section is on contaminants that are commonly found in food, their effects on health, and the steps that must be taken in the preservation and handling of food to assure its safety.

Aside from objectionable materials, such as rust, dirt, hair, machine parts, nails, and bolts, such contaminants fall into two broad categories: (1) biological agents, such as bacteria, viruses, molds, antibiotics, parasites, and their toxins, which can cause a wide range of illnesses; and (2) chemicals, such as lead, cadmium, mercury, nitrites nitrates, and organic compounds, which can have both acute and chronic health effects. Such contaminants can gain access to the food chain at any of a multitude of stages during growing, processing, preparation, or storage. Of the two, microbial sources account for upwards of 95 percent of all reported outbreaks (97 percent of all cases). Accordingly, most of the attention in this section is devoted to illnesses of this type.



Classification of foodborne diseases

2.12.2. Foodborne Illnesses and Their Causes

Table below summarizes the major foodborne illnesses, the causative agents, the food usually involved, and the incubation period. The illnesses described may be caused by parasites, bacterial infections, viral infections, or toxins.

2.12.2.1. Parasites

Two of the more common parasitic diseases are amebic dysentery (caused by *Entamoeba histolytica*) and giardiasis (caused by *Giardia lamblia*). *Entamoeba histolytica*, a parasitic organism, can exist as a hardy, infective cyst or a more fragile, potentially pathogenic trophozoite. The parasite can coexist with its host without injury to either, or it may invade the tissues of the host, giving rise to intestinal or extraintestinal disease. In these cases, the effects may range from acute dysentery, accompanied by fever, chills, and bloody diarrhea (amebic dysentery), to mild abdominal discomfort with diarrhea, alternating with periods of constipation or remission. Transmission occurs primarily through the ingestion of fecally contaminated food. Because amebic cysts are relatively resistant to chlorine, water can also be a source of intake. If the water is filtered through sand, most of the cysts will be removed. Diatomaceous earth filters will remove them completely. Individuals infected with *E. histolytica* should be excluded from handling food and from direct care of hospitalized and institutionalized patients.

Giardiasis is a gastrointestinal illness caused by the flagellated protozoan *Giardia intestinalis*, also known as *G. lamblia* or *G. duodenalis*. Symptoms include diarrhea, fever, or both—and flatulence, nausea, malaise, or abdominal cramps. *Giardia* organisms are present worldwide and infect both domestic and wild animals, including cats, dogs, cattle, deer, and beavers. Like *E. histolytica*, these organisms are spread from person to person and from animals to humans through fecal-oral transmission, with either food or water serving as a typical route of intake. Children are infected more frequently than adults. Although the infectious dose is low, the causative organism is only moderately resistant to chlorine. Because the symptoms may be mild, giardiasis is often regarded as a benign gastrointestinal illness. Nonetheless, chronic or debilitating giardiasis has been reported.

Table 6.1 Examples of important foodborne illnesses, United States

Illness	Causative agent	Food usually involved	Incubation period
Foodborne parasites			
Amebiasis (amebic dysentery)	*Entamoeba histolytica*	Food contaminated with fecal matter	2–3 days to 1–4 weeks
Cryptosporidiosis	*Cryptosporidium parvum*	Vegetables, unpasteurized milk, fruits	2–28 days, 7 days average
Cyclosporiasis	*Cyclospora cayetanensis*	Imported berries, lettuce	1–11 days
Giardiasis	*Giardia lamblia*	Raw salads and vegetables	1–4 weeks
Trichinosis	*Trichinella spiralis*	Raw or undercooked meat, usually pork or wild game	1–2 days to 2–8 weeks
Foodborne Bacteria			
Dysentery	*Shigella dysenteriae*	Food contaminated with fecal material, raw vegetables, egg salads	Up to 1 week
Gastroenteritis	*Shigella sonnei*	Food contaminated with fecal material, person-to-person contact, raw produce, parsley	2–4 days
Salmonellosis	*Salmonella* spp.	Eggs, poultry, unpasteurized milk or juice, cheese, raw fruits and vegetables	1–3 days
Foodborne Viruses			
Gastroenteritis	Norwalk-like viruses	Fecally contaminated food, salads, sandwiches, ice, cookies, fruit, poorly cooked shellfish	24–48 hours

Viral hepatitis	Hepatitis A virus	Shellfish from contaminated waters, raw produce, uncooked foods	15–50 days, 30 days average
Foodborne toxins			
Botulism (in infants)	*Clostridium botulinum*	Honey, home-canned fruits and vegetables	3–30 days
Brucellosis	*Brucella abortus, B. melitensis, and B. suis*	Raw milk, goat cheese from unpasteurized milk, meats	7–21 days
Diarrhea	*Escherichia coli* O157:H7, and other shiga-toxin producing *E. coli*	Undercooked beef, unpasteurized milk and juice, raw fruits and vegetables	1–8 days
Paralytic shellfish poisoning	Dinoflagellates (neurotoxins)	Scallops, mussels, clams, cockles	30 minutes–3 hours
Staphlococcal food poisoning	*Staphylococcus aureus*	Improperly refrigerated meats, potato and egg salads, pastries	1–6 hours

2.12.2.2. Bacterial Infections

Certain bacteria can gain access to foods and be ingested and transported to the digestive tract, where they can multiply and cause illnesses. Two common examples are discussed here. *Salmonella* infections occur in an estimated 1.4 million people in the United States each year. The majority suffer diarrhea, fever, and abdominal cramps one to three days after exposure. The illness usually lasts four to seven days, and the majority of those infected recover without treatment. The causative agent, the *Salmonella* organism, exists in the intestines of chickens, dogs, and rodents. It can also live in the ambient environment and can survive conditions that many other organisms cannot. This accounts for its transmission through food as well as drinking water. Common foods involved include chicken, pork, and beef, with eggs and poultry being primary sources of infection. In fact, about 12 percent of chickens marketed in U.S. supermarkets are estimated to contain this organism (Consumers Union, 2003). In the case of eggs, *Salmonella* transmission was originally primarily due to contamination on the outside of the shells. Today these organisms are often present inside the eggs because of infections in the ovaries of chickens. All protein foods requiring a large amount of handling are subject to contamination. Low-acid foods, such as meat pies, custard-filled bakery products, and improperly cooked sausages, are also common sources of outbreaks. *Salmonella* can also be transmitted to humans, especially children, through direct or indirect contact with reptiles, such as lizards, snakes, and turtles. *Shigella dysenteriae,* which causes bacillic dysentery, is another common source of foodborne illness. Two-thirds of all cases, and most deaths, occur in children under 10 years of age. Illness in infants less than 6 months old is unusual. Secondary attack rates in households can be as high as 40 percent. *Shigella sonnei,* another species, is a common cause of gastroenteritis.

In both cases, the organisms are present in human feces, and transmission is favored by crowded conditions where personal contact is unavoidable. Food handlers can readily spread the infection. Flies can also transfer the organisms to nonrefrigerated food, where they can multiply. In the case of *S. dysenteriae*, ingestion of a large number of organisms is required in order for a person to become infected; in the case of *S. sonnei,* as few as 10–100 organisms can cause infection. As a result, person to person is a viable method of transmission for this organism. The incubation period in the case of *S. dysenteriae* is up to a week, while the bacteria in the body multiply; in the case of *S. sonnei,* it is only two to four days.

2.12.2.3. Viral Infections

Prominent sources of viral infections are the Norwalk-like viruses (NLVs) and those that cause infectious hepatitis and bovine spongiform encephalopathy, so-called mad cow disease. NLVs annually cause an estimated 23 million episodes of gastroenteritis, 50,000 hospitalizations, and 300 deaths in the United States. These viruses can be transmitted by fecally contaminated food, such as salads, sandwiches, fruit, and improperly cooked shellfish, and by direct person-to-person contact. They are extremely contagious for two reasons: (1) the dose that will cause infection is low, and (2) patients continue to be infectious for up to two weeks after recovery. Exacerbating the situation is that the viruses are resistant to chlorination as well as to temperature variations ranging from $0^{o}C$ ($32^{o}F$) to $60^{o}C$ ($140^{o}F$). Outbreaks of gastroenteritis due to Norwalk-like viruses are common in settings in which people are crowded and sanitation facilities are inadequate, such as summer camps.

Infectious hepatitis (hepatitis A) is a highly contagious disease caused by a virus whose symptoms are fever and general discomfort. The disorder occurs most frequently among school-age children and young adults, and the infectious agent commonly is present in feces. Adults are usually immune. Common sources include foods, such as sandwiches and salads, that are not cooked or foods that are handled after cooking by infected handlers. Raw or undercooked mollusks harvested from contaminated waters, as well as contaminated produce, such as lettuce and straw berries, and contaminated drinking water, may also be sources of infection.

Still another virus-related disease that has gained prominence in recent years is the previously cited bovine spongiform encephalopathy, which leads to progressive neurological degeneration in cattle. There was a major outbreak of this disease, in the United Kingdom during the 1990s. The first cases were observed in 1986. As a consequence, about 100 people developed the variant Creutzfeldt-Jakob disease and died. It has been hypothesized that the source of their infections was the ingestion of beef from infected cattle. Fortunately, due to a well-organized program that included quarantining areas where infected cows were present and destroying diseased animals, the epidemic was brought under control, and possible transmission to other countries of the world was minimized. Nonetheless, a cow imported from Canada into the United States was discovered in 2003 to be infected with mad cow disease. Obviously, continuing vigilance will be required.

2.12.2.4. Toxins

In contrast to bacterial infections, which are caused directly by the organisms, some foodborne illnesses are caused by toxins produced by bacteria that are not in themselves harmful. Toxins can similarly be produced in food by viruses and fungi. Toxins can be introduced into food through improper handling, or they may be naturally present. In either case, the ingestion of the accompanying toxins can readily lead to illnesses and, in some cases, death. *Toxins resulting from improper handling.* The most common toxins introduced into food through improper handling are produced by bacteria.

Three of the more common such organisms are discussed here.

1. Under favorable conditions, *Staphylococcus aureus* can produce one or more enterotoxins that, if ingested, can abruptly (within one to six hours) lead to severe nausea, cramps, vomiting, and prostration, often accompanied by diarrhea and sometimes by subnormal temperature and reduced blood pressure. This organism can readily be transmitted to food from infected cuts, boils, sores, postnasal drip, or sprays expelled during coughing or sneezing. It is also present in air, water, milk, and sewage, and an estimated one-quarter of the population are carriers. Meat (especially ham), meat products, poultry, poultry products, and poultry dressing, as well as custards used for pastry fillings, are common sources.

Staphylococcus aureus grows rapidly, especially in food held at room temperature for several hours before being eaten (Chin, 2000).

2. Botulism is a paralytic illness caused by the neurotoxin produced by the bacterium *Clostridium botulinum.* Its spores are present in the soil throughout the world. Conditions that promote their germination and growth include the absence of oxygen (that is, anaerobic conditions), low acidity (pH approximately 4.6), temperatures higher than 4^{o}C (39^{o}F), and high moisture content. Although rare and sporadic, foodborne botulism is a persistent cause of morbidity and mortality in the United States. The source in this case was beaver meat that was being fermented in plastic or glass containers (CDC, 2001b). Most poisonings in the continental United States result from the consumption of vegetables and fruits that have been improperly canned at home. The toxins are extremely potent; a few nanograms (10^{-9}gram) can cause illness. While the toxins can exist for long periods, they can be destroyed by boiling. Inactivation of the spores, however, requires higher temperatures.

3. *Escherichia coli,* another toxin producer, is present in the lower intestinal tract of most warm-blooded animals and is the most prevalent oxygen-tolerant bacterium in the large intestine of humans. Foods of bovine origin, particularly ground beef, are common sources of sporadic infections and outbreaks. Unless care is exercised, it is relatively easy for *E. coli* to be transferred from feces and intestinal contents to carcasses and meat during processing. Symptoms of infection include bloody and nonbloody diarrhea, vomiting, and abdominal cramps, with onset ranging from one to eight days after ingestion. *Escherichia coli* can also be transmitted to

humans through the ingestion of shellfish and watercress that become contaminated while being grown in sewage-contaminated waters.

Naturally occurring toxins. Laboratory studies of foodstuffs and cooked food show that they contain a surprising array of naturally occurring toxins that would normally not be permitted as regulated additives. Carrots, for example, contain *carotatoxin,* a fairly potent nerve poison; *myristicin,* a hallucinogen; and *isoflavones,* which have an estrogenic effect similar to that of female hormones. Peanut butter contains *aflatoxins,* some of which (aflatoxin B, for instance) have been shown to be acutely poisonous and carcinogenic in animals. The common assumption that "natural" is safe and "human-made" is suspect is contrary to current scientific knowledge. In fact, a typical diet contains far more natural carcinogens than synthetic ones.

2.12.2.5. Inorganic and Organic Chemical Contaminants and Additives

Foods can contain a variety of inorganic and organic chemicals. Some of these are purposefully added, and others result from human actions. Heavy metals, such as lead, copper, tin, zinc, or cadmium, can leach from containers or utensils, particularly in cases in which acidic foods are being prepared or stored. Other chemicals can be introduced through accidental or inadvertent contamination with detergents or sanitizers. Pesticides, herbicides, fungicides, fertilizers, and veterinary drugs and antibiotics can be introduced into vegetables, poultry, and livestock as a result of the conditions under which they are grown.

Inorganic Chemicals

Mercury discharged into rivers, lakes, and oceans in the form of inorganic salt or as the metallic element (which is not harmful to humans) can be converted by microbes to methyl mercury. In this form, it can pose a significant health risk. Large-scale poisonings by these compounds have caused deaths and cases of permanent damage to the central nervous system. In a classic episode in Japan in the early 1950s, industrial wastes containing mercury were discharged into Minamata Bay. More than 100 people who ate contaminated fish were poisoned, and 46 died. Other sources of mercury include volcanic eruptions, which account for about one-third of worldwide releases, and airborne contaminants from coalfired electricity generating stations. If in a water-soluble form, the mercury is readily brought back to the ground by precipitation. Once the mercury reaches bodies of water, it is passed up the food chain into fish, notable examples being swordfish and tuna. The global aspects of this problem are demonstrated by the fact that about a fifth of that which deposits in the United States comes from facilities in Asian countries, such as China.

A variety of other inorganic chemicals are or can be introduced into foods during processing. One of the most common is sodium, one of the two ingredients (the other being chlorine) in salt. This compound primarily serves as a taste enhancer and preservative. Although the subject is controversial, data from some studies indicate that excessive salt intake is related to hypertension and gastric injury in some individuals. Also added to foods are sulfites and bisulfites, which, in aqueous solutions, form sulfurous acid, an antimicrobial agent. In addition, nitrites and nitrates serve as agents for curing and pickling meats and vegetables. These two substances can also gain access to some foods through uptake into agricultural crops that are produced using nitrogen fertilizers. One of the benefits of nitrates and nitrites is that they inhibit the growth of *C. botulinum* in foods that are vacuum packed. One of the risks is that high concentrations of nitrates in baby food, much of which is converted into nitrites, can cause methemoglobinemia in infants. Another risk is that during cooking, nitrites can react with secondary and tertiary amines to form nitrosamines, a potential carcinogen. Current formulations, however, significantly reduce this risk. To qualify for use, all such additives must be classified as GRAS, that is, they must be "generally recognized as safe".

Organic Chemicals

A number of organic acids and their salts are used as preservatives in foods. These include benzoates, which inhibit the growth of yeasts and molds; sorbate salts, which inhibit the growth of yeasts and molds; and propionic acid and propionate salts, which are active against molds. Other organic chemicals gain access to food through the use of pesticides and herbicides on agricultural crops.

Examples are chlorinated hydrocarbons, polychlorinated biphenyls (PCBs), chlorinated dibenzo-*p*-dioxins, and chlorinated dibenzofurans. Tests in animals show that PCBs can cause reductions in immune system function, behavioral alterations, and impaired reproduction. Organic contaminants can also be produced in foods, especially meat, through the cooking process.

Browned or burned portions of meats that have been charbroiled, whether fried or smoked, contain heterocyclic aromatic amines, many of which have been shown to be highly mutagenic.

Examples are benzo-a-pyrene and the polycyclic aromatic hydrocarbons, as well as numerous breakdown products of common dietary amino acids.

Measures that have been suggested to avoid the production of these compounds include using alternative processes such as stewing, poaching, or boiling to cook meat and employing a microwave oven to cook fish and poultry.

Another group of compounds that are present in commercially prepared foods are trans-fatty acids. It has been known for some years that saturated fats in red meat, butter, and cheese are contributors to coronary heart disease, epidemiological studies now show that the consumption of foods containing trans fatty acids plays a key role, particularly in relation to the types and quantities of cholesterol in the blood.

Still another is acrylamide, a compound that was identified years ago as a potential industrial hazard from the standpoint of causing certain neurological effects. This compound is present at relatively high concentrations in starch-based foods, such as biscuits, cereals, french fries, and potato chips, that are cooked or baked at temperatures in excess of 120^{o}C (248^{o}F). Laboratory studies show that it is capable of inducing cancer and heritable mutations in rats. The fact that acrylamide has probably been a component of human diets ever since cooking began makes these evaluations particularly interesting. In addition to these sources, abnormal and toxic metabolites are frequently produced when plants are subjected to stress. These include protease inhibitors, hemagglutinins, goitrogens, and allergens.

2.12.2.6. Antibiotic and Hormone Use in Farm Animals

About 50 years ago, farmers began feeding antibiotics to animals to prevent the spread of infections and to reduce the amount of feed required to fatten them. During the intervening decades, however, studies have increasingly confirmed that such practices have contributed to an alarming increase in the resistance of many human bacterial pathogens to antibiotics.

One example is the use of fluoroquinolones, which the FDA (contrary to the advice of the Centers for Disease Control and Prevention) approved in 1996 for feeding to chickens and turkeys, primarily to prevent mortality associated with infections by *Escherichia coli.* Within three years, more than 15 percent of *Campylobacter jejuni* and 30 percent of *Campylobacter coli* isolated from human patients showed resistance to this antibiotic.

2.12.2.7. Care in Food Preservation and Handling

A variety of methods are available for safely preserving wholesome food, preventing contamination, and destroying organisms or toxins that may have gained access to or been produced within the food. One of the prerequisites to ensuring that these methods are successful is to seek to maintain the food in a condition that is not favorable for bacterial growth. A major goal in this regard is to avoid conditions that provide warmth, moisture, and a medium that is neither highly acid nor alkaline. On the basis of these and other considerations, the primary methods that have proved to be effective for preserving food may be summarized as follows:

Cooking. Cooking renders food digestible and palatable. Although it also tends to kill many bacteria, this process alone will not preserve food. In fact, partial cooking may render protein foods (meat, eggs, milk, milk products) more susceptible to bacterial growth and permit active increases in the number of harmful organisms or the toxins they may produce. Even when food is heated thoroughly and to a sufficiently high temperature to kill any microorganisms present, it must be eaten promptly or protected from subsequent spoilage.

Canning. The process of canning involves heating food sufficiently to kill any microorganisms present and then sealing it in a container to keep it sterile. The combination of time and temperature required to preserve food by canning varies with the product and its likely contaminants. Acid foods—tomatoes and some fruits— need to be heated to the boiling point for only a few minutes. Nonacid foods—corn and beans—must be heated to higher temperatures (under pressure) for a longer time to prevent undesirable changes in appearance and flavor, as well as, for example, to destroy the anaerobic microorganisms that produce the botulism toxin.

Drying and dehydration. Air drying, one of the most economical and effective ways of preserving food, has been practiced for centuries. Today food can be dried in the sun or by artificial heating processes. Other methods include spray drying, freeze drying, vacuum drying, and hot-air drying. Once the food is reconstituted by the addition of water, bacterial activity resumes, and it is essential that sanitary controls be applied.

Preservatives. As described in the previous section "Inorganic and Organic Chemical Contaminants and Additives," a variety of chemicals are purposefully added to foods to inhibit the growth of microorganisms, to kill them, or to serve as flavor enhancers.

These include salt, sugar, sodium nitrate and nitrite, salicylic acid, and sodium benzoate, as well as propionates and sorbic acid. Each carries with it both risks and benefits. One additional method of preserving foods, especially meats, is smoking. This technique is often used since it improves flavor and retards microbial growth.

Refrigeration. Storing food at temperatures lower than 5^oC (40^oF) will retard the growth of pathogenic organisms and the more important spoilage organisms, but it does not prevent all changes. The level of humidity is also important: too little results in moisture loss; too much promotes the growth of spoilage organisms. Proper air circulation and regular cleaning and sanitizing of chill spaces are mandatory.

Freezing. Bacteria that cause food spoilage do not multiply at freezing temperatures, but once thawing begins, frozen food becomes vulnerable to bacteria and the associated toxins they may produce. Refreezing will not make the food safe, nor will freezing improve the original quality of the product. Thus the selection of appropriate products for freezing is essential. One variation is "dehydrofreezing," in which the food is partially dehydrated (but still perishable) and then frozen. This process provides the space and weight savings of dehydration without depriving the food of its fresh color, flavor, and palatability.

Pasteurization. Pasteurization is an excellent method of preserving food for a short time. Combined with refrigeration, it extends the useful shelf life of dairy products. Milk is generally heated to 63^oC (145^oF) for 30 minutes—or to 72^oC (161^oF) for 15 seconds— to kill the pathogenic organisms. Although some heat-resistant organisms will survive, subsequent refrigeration will preserve the milk for up to several weeks.

Irradiation. Through this process, food is exposed to ionizing radiation at sufficiently high doses to kill a large fraction of any microorganisms present. At the doses that are applied, meats and poultry, for example, are not sterilized; they still require refrigeration and proper handling. In this sense, irradiation is directly analogous to pasteurization. It is especially effective in destroying foodborne contaminants such as *Salmonella* and *Escherichia coli.* It also destroys *Trichinella spiralis* in pork. In some foods, however, irradiation produces unwanted changes in taste and palatability. Although fears have been expressed about other changes that take place during irradiation, especially the formation of radiolytic compounds, the types and quantities of these compounds in irradiated foods are no different than those in foods processed by other methods of preservation.

2.12.2.8. Components of an Effective Food Sanitation Program

In addition to exercising care in processing, the prevention of foodborne illnesses requires an effective sanitation program. A safe water supply, adequate garbage and refuse disposal, proper wastewater and sewage disposal, and effective insect and rodent control are also essential. Other factors involve equipment and facilities, personnel training and habits, standards and regulations, and enforcement and monitoring.

Equipment and facilities. Equipment used in the preparation or processing of food should be designed to facilitate cleaning. Cutting boards should be made of nonporous materials. Vehicles used to transport food products must be clean and should not carry other products. Refrigerated vehicles must be available for the transport of perishable foods. Facilities should be designed so that all foods, particularly vegetables, can be stored above the floor, where they will remain dry and will not come in contact with powders and sprays used to control insects and rodents.

Personnel training and habits. Personal hygiene is indispensable in the proper handling and preparation of food products. Antimicrobial cleaners should be used on the surfaces on which foods are prepared, and cleaning rags and sponges should be disinfected regularly or replaced. Food handlers must wash their hands after toilet use and before and after work; must avoid contact between open wounds and foodstuffs; must wear clean outer garments, including a cap over the hair; and must avoid using tobacco products while working. Food handlers should be trained in appropriate methods of food storage, garbage disposal, and insect and rodent control. The essential rules for safe food preparation and consumption are summarized in table below.

Standards and regulations. The basic requirements are that standards and regulations be national in scope and specify the proper methods of processing, preparing, and selling food products; limitations on the types and quantities of chemicals that can be added to foods; restrictions on the quantities, types, and manner in which pesticides can be used on agricultural food crops; and proper labeling requirements for commercial food products.

Enforcement and monitoring. authorities at the state and local levels have primary responsibility for the inspection of restaurants, retail food establishments, dairies, grain mills, and other food establishments. Their goals are to assure the safe handling, proper labeling, and fair marketing of food products.

Methods used to meet these responsibilities include inspection at the point of production or processing, examination of products at the retail or wholesale level of distribution, and licensing of establishments that manufacture or handle foods. Because it is impossible to inspect every food at every site of production, processing, and distribution, the incentives to comply with regulations depend primarily on the probability of detection and the penalties for noncompliance (which can include fines and legal proceedings).

In addition, compelling economic and business factors encourage food handlers, processors, and distributors to want to comply with the regulations. No food processor wants to suffer the loss of customer confidence that can accompany a highly publicized foodborne disease outbreak.

Ten rules for safe food preparation and consumption
1. Choose food processed for safety.
2. Cook food thoroughly.
3. Eat cooked food immediately.
4. Store cooked food immediately.
5. Reheat cooked foods thoroughly.
6. Avoid contact between raw and cooked foods.
7. Wash hands repeatedly.
8. Keep all kitchen surfaces meticulously clean.
9. Protect foods from insects, rodents, and other animals.
10. Use pure water.

2.12.2.9. Ways food can become contaminated through incorrect food handling

Food can become contaminated with disease-causing bacteria anywhere the food is handled or stored. These places include:

- factory where it is processed ready for sale
- truck in which it is taken from the factory to the shop
- shop
- food outlet such as a school canteen or take-away shop
- between the shop and home
- home

Most food has to be prepared in some way before it is eaten. During this preparation the food is handled by people. There are many ways in which unhygienic practices can cause food poisoning bacteria to be deposited on the food while it is being handled. Some examples are:

- Leaving food uncovered. Pets, flies, cockroaches and other insects carry germs, including food poisoning bacteria, which contaminate the food
- Touching parts of the body while handling food. While preparing food a food handler might scratch a pimple, touch a sore, push back hair, scratch an ear or rub or pick the nose. Every one of these activities contaminates the fingers with bacteria. If the person's hands are not washed before handling food again, these bacteria will be passed to the food.

Rubbing the nose while preparing food helps spread germs.

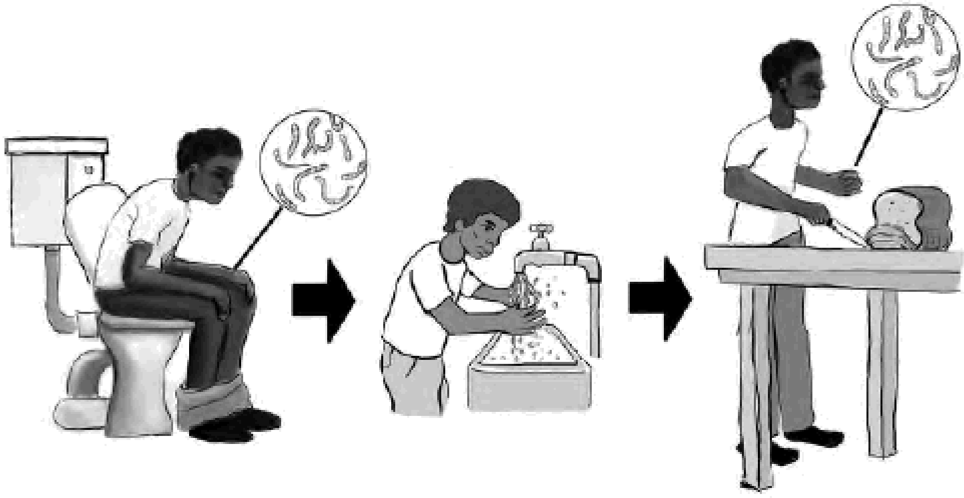
- Sneezing or coughing near food. If a food handler, or anyone else, sneezes or coughs near uncovered food, then the food almost will certainly be sprayed with bacteria laden droplets.

Sneezing over food spreads germs.

- Licking fingers while handling food. Human saliva carries staphylococcus bacteria and licking the fingers could result in these bacteria being passed to the food.

Licking fingers while handling food spreads germs.

- Not washing hands after going to the toilet during food handling. If a person goes to the toilet during food handling activities and does not wash his/her hands afterwards food poisoning bacteria may be passed onto the food.



Washing hands after going to the toilet helps stop the spread of germs.

- Poor handling of high risk foods. High risk foods are those which generally need refrigeration and have high moisture content. Poor handling of high risk foods is a common cause of food poisoning. High risk foods include:
  - chicken, duck and other poultry
  - fish and shellfish
  - raw meat products
  - dairy products (milk, cheese, cream)
  - unpasteurized cow or goats milk
  - eggs and egg products
  - gravies

Cross contamination. Certain foods will always contain some bacteria. Poor handling of these foods may result in **cross contamination**. Cross contamination is the passing of bacteria from contaminated food to uncontaminated food. Cross contamination can occur when storing or handling food.

An example of cross contamination during storage is:
A high risk food, such as a raw chicken thawing in a refrigerator, is placed in contact with cooked meat. The bacteria from the raw chicken contaminate the cooked meat. Since the cooked

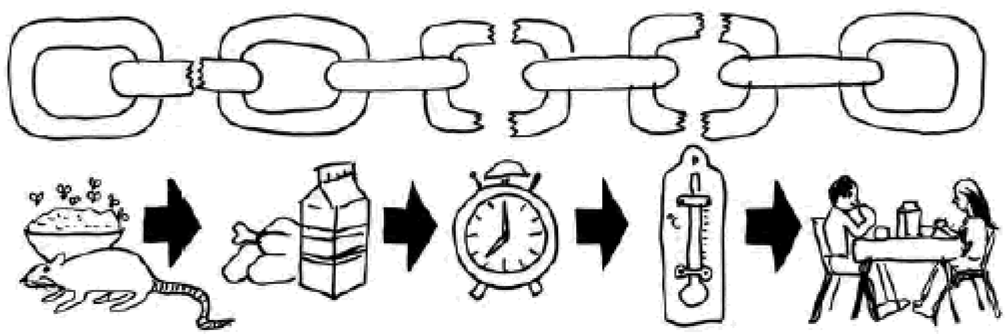
meat is not heated again before eating, the bacteria from the chicken pass to the person who eats the meat.

An example of cross contamination during handling is:
Before cooking a fish which is contaminated with salmonella bacteria, a person uses a knife and cutting board to cut it up. Bacteria from the fish will be left on the knife and cutting board. The person slices cooked ham using the same knife and board without washing them first. The bacteria are transferred to the ham.

Protecting food from contamination

Correct food handling practice and food storage helps prevent bacteria from contaminating and multiplying on foods. The following action needs to be taken to prevent bacterial contamination:

- Protect food from contamination – handle food properly
- Prevent bacteria from multiplying
- Destroy germs on/in food



The food contamination chain can be broken in several places.

Food can be protected from contamination by handling it with care. Food handlers should think about:

- where food poisoning bacteria come from. They can come from people's bodies, sneezes, coughs, high risk foods, insects, rodents, pets, toilets and dust particles in the air

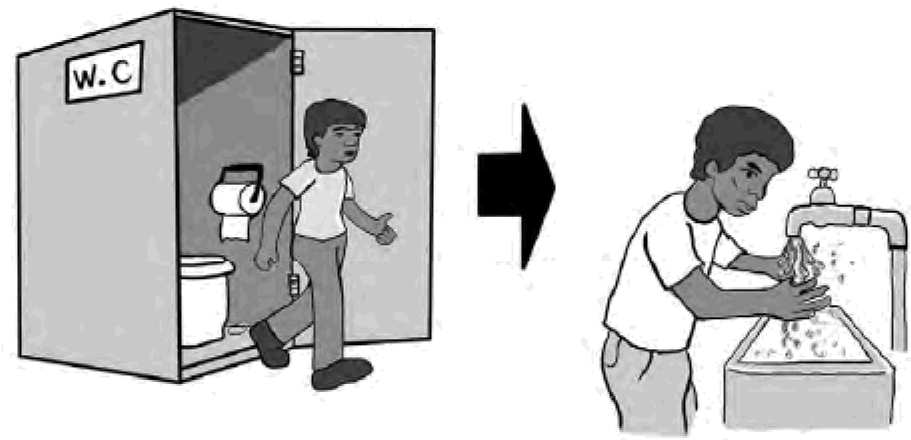
- the different ways bacteria can get on to the food they are handling, for example, from cross contamination and contaminated hands and clothing
- the correct cooking and storage temperatures which prevent bacteria multiplying

The number of people affected in an outbreak of food poisoning will depend on where the food contamination occurs. For example, contaminated food prepared and eaten in the home is only likely to affect a few people but contaminated food prepared in a fast food outlet or in a factory is likely to affect many people.

Correct food handling rules

Always wash hands with soap and warm water before handling food. Wet the hands before applying the soap. Make sure you rub in between fingers and on the front and backs of hands. Remember to clean under fingernails. Rubbing with soap loosens bacteria. They must be rinsed off with water. (When possible, use hot water for washing the hands.)

Wash hands before handling food and be sure to clean under the finger nails.
Always wash hands with soap and warm water after going to the toilet or touching any parts of the body, such as the skin or nose.



Wash hands after going to the toilet.

- Do not smoke while preparing food
- Handle food with tongs, a spoon or some other utensil which is clean
- When sneezing or coughing always cover the face with a tissue or the hands and turn away from the food. Wash hands immediately after as they may have been contaminated
- Avoid preparing food for others if you have diarrhea

If sneezing, turn away from the food and use a tissue.

- If food does have to be left standing in the open for a few minutes during preparation always cover it with a lid, clean cloth or cling wrap
- Do not let raw high risk foods touch other foods
- Always clean and sanitise utensils and benches/work surfaces used to prepare high risk foods immediately after the food has been prepared
- Work benches and cooking utensils should always be kept clean
- Make sure insects, rats, mice and other pests cannot get into the food preparation area
- Pets should also be discouraged from domestic kitchens and must never be allowed into a shop or community kitchen

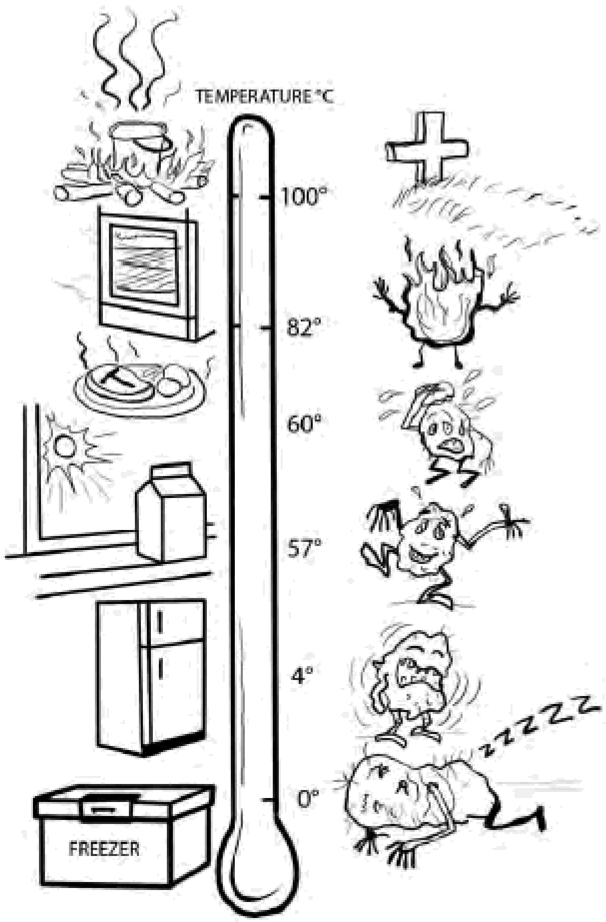
Keep all work benches clean.

- Dispose of rubbish regularly and correctly
- Make sure the floors, walls, window sills and all fixtures in the food preparation area are regularly and properly cleaned

Correct food storage

Food poisoning bacteria can only multiply in the temperature danger zone of between **5°C and 60°C**. However, food poisoning bacteria do not multiply at the same rate throughout this temperature range. They multiply most quickly between 36°C and 38°C, which is around human body temperature.

Above 60°C nearly all food poisoning germs are killed. Below 5°C the germs stay alive but they do not multiply. Keeping food out of the temperature danger zone helps stop the multiplication and growth of bacteria.



The food temperature danger zone.

Food should be stored according to its food type. For example:

- high risk foods such as milk and milk products and fish should be stored in a refrigerator or freezer. They should never be left in the food temperature danger zone
- foods such as fresh fruit and vegetables last longer when they are kept cold, and should be stored in a refrigerator
- dry foods such as flour, breakfast cereals and rice are likely to be attacked by pests and need to be stored in sealed containers

Storing foods in refrigerators and freezers

Freezers, including the freezer section in household refrigerators, will keep foods frozen. Frozen foods can last many months depending on the food type. However, some foods are unsuitable for freezing. For example, cheese and processed foods will lose food quality when frozen. Frozen foods taken from the freezer and allowed to thaw must be cooked or eaten straight away. Thawing means returning the frozen food to its normal soft state by increasing its temperature. It is safest to do this by putting the frozen food into the normal refrigerator compartment, or by defrosting in a microwave oven on the defrost setting.
Once food has been thawed it should never be frozen again. This is because bacteria will grow and multiply in the food during the freezing and defrosting process. Refrigerators chill foods. Foods which are to be eaten cold should be kept in the refrigerator until they are ready to be served. These foods include milk, cheese, custards, salads and cold meats. Many of these foods will deteriorate (break down) after several days in refrigerator storage and will not be fit to eat.

Storing foods which do not need to be frozen or chilled

These foods include cereals, flour, sugar, unopened canned goods, dried products, sauces and spices. They do not support the growth of bacteria like the high risk/high moisture foods. They can lose quality from being kept too long in storage and their major source of contaminants is pests.
Some bacterial contamination can occur when canned high risk/high moisture foods are kept too long in storage or when containers become broken or damaged during production, transport or storage. Other foods may suffer bacterial contamination from exposure to pests, especially insects and rodents.

Care should always be taken when purchasing tinned foods. Do not buy dented or blown cans. A blown can occurs when gas forms from the action of bacteria in the product. It is easy to tell a blown can because the lid and base will pop when pressed.

When dealing with foods that are normally stored at room temperature, remember:

- canned or packaged foods should be used in rotation, with the oldest used first

- cereals, flour, sugar and other dried foods should be stored in sealed containers to stop the access of pests
- Clean up any spilled food as soon as possible, for example spills in cupboards, open shelves, the fridge or freezer.

Correct cooking temperatures

Food poisoning bacteria do not grow at temperatures above 60°C. If the temperature falls into the danger zone between 5°C and 60°C, the bacteria will be able to grow and multiply rapidly. Before some frozen foods are eaten they will need to be thawed. Foods which are to be eaten hot should be cooked and served immediately while they are still hot. If they are not to be eaten straight away they should be placed in the refrigerator or freezer immediately after cooking. Cooked foods which have been stored in the refrigerator or freezer must be thawed if necessary and reheated quickly and thoroughly to a temperature of at least 75°C. No high risk food should be left standing in the danger zone for more than a few minutes.

Food shops and stores

There are laws which strictly control food handling practices in places where food is prepared ready for sale to the public. This is because there is usually a lot more food involved and more people could be affected by food contamination. Environmental Health Practitioners employed by the Department of Health and local government have responsibility for routinely inspecting shops and making sure that these regulations are followed. These inspections are very specialized, but sometimes the EHP can make occasional visits.
One task that the community can ask the EHP to do is a frequent routine inspection of any food shops and stores in the community. Before doing them alone, it would be necessary for the EHP to learn to do them properly. These inspections will include checking:

- date codes on foods ('best before' or 'use by' date). Some foods display a date by which they should be used. It is for the information of buyers and is called the date code. When this date has been passed the food is said to be out of code

- It is not illegal to sell foods after the 'best before' date, but buyers should be careful because such foods could be stale or have lost some of their quality, such as loss of nutrients or taste. It is illegal to sell foods after the 'use by' date for food contamination.

Signs of food contamination include:

- broken packets
- blown cans (the lid or base will 'pop' when pressed)
- weevils in packaged dried goods, such as plastic bags of rice. Weevils are a type of insect, and leave webs which can be seen through clear plastic packaging
- meat in shrink-sealed plastic bags will develop gas when contaminated with bacteria.
- discolouration and mould on chilled goods
- food storage in freezers, chillers and refrigerators. Raw and cooked foods must be stored separately in freezers, chillers and refrigerators and the cabinets of these storage facilities must be kept very clean

Storage of dry foods

It is important that dry foods, such as flour, breakfast cereals and sugar, are stored safely. Storage areas for dry goods, including dry foods, are favourite places for rats and mice and checks should be made for signs of these pests. Dry foods should always be separated from household cleaning and other products which may be poisonous or which could spoil the food in other ways. The EHP can also provide advice on cleaning programs and education on correct food handling and storage practices.

2.12.2.10. Food and Health

For well over a decade, the primary source of dietary guidance has been the "food pyramid," developed in 1992 by the U.S. Department of Agriculture (USDA). Basic to this guidance is the recommendation that certain food groups, such as grains, vegetables, and fruit, be consumed in larger quantities than others, such as meat and dairy products, fats, oils, and sweets. In recent years, this guidance has been subjected to increasing criticism. A common complaint is that in discouraging the consumption of fats, the USDA appeared to convey a sense that all carbohydrates were harmless. As nutritionists and health experts gained new information and insights, it became increasingly clear that the USDA pyramid had become obsolete. One deficiency is that it fails to point out that there are good sources of dietary intake in all food groups.

Examples are grain foods that are good sources of carbohydrates, plant oils that are good sources of fats, and nuts and legumes, followed by fish, poultry, and eggs, that are good sources of protein. For this reason, a revised pyramid is now being proposed. One of the primary goals of its developers is to provide dietary guidance that is designed not for short-term weight loss but for lifelong health. Therefore, they emphasize that any dietary program should be accompanied by daily exercise and weight control. Numerous epidemiological studies support the changes that are being suggested. Such studies have confirmed, for example, that the consumption of fruits, vegetables, and fiber protects the heart, and that the consumption of whole grains reduces the risk of stroke and diabetes.

CHAPTER THREE: ENVIRONMENTAL POLLUTION

3.1. DEFINITION OF COMMON TERMINOLOGIES

Pollution may be defined as addition of undesirable material into the environment as a result of human activities. The agents which cause environmental pollution are called **pollutants**.
Pollutant may be defined as a physical, chemical or biological substance unintentionally released into the environment which is directly or indirectly harmful to humans and other living organisms.

Developmental activities such as construction, transportation and manufacturing not only deplete the natural resources but also produce large amount of wastes that leads to pollution of air, water, soil, and oceans; global warming and acid rains. Untreated or improperly treated waste is a major cause of pollution of rivers and environmental degradation causing ill health and loss of crop productivity. In this section you will study about the major causes of pollution, their effects on our environment and the various measures that can be taken to control such pollutions.

Human activities directly or indirectly affect the environment adversely. A stone crusher adds a lot of suspended particulate matter and noise into the atmosphere. Automobiles emit from their tail pipes oxides of nitrogen, sulphur dioxide, carbon dioxide, carbon monoxide and a complex mixture of unburnt hydrocarbons and black soot which pollute the atmosphere. Domestic sewage and run off from agricultural fields, laden with pesticides and fertilizers, pollute water bodies. Effluents from tanneries contain many harmful chemicals and emit foul smell. These are only a few examples which show how human activities pollute the environment.

3.2. TYPES OF POLLUTION

Pollution may be of the following types: Air pollution, water pollution, soil pollution, noise pollution, thermal pollution and Radiation pollution.

3.2.1. AIR POLLUTION

Air pollution is a result of industrial and certain domestic activity. An ever increasing use of fossil fuels in power plants, industries, transportation, mining, construction of buildings, stone quarries had led to air pollution.

Air pollution may be defined as the presence of any solid, liquid or gaseous substance including noise and radioactive radiation in the atmosphere in such concentration that may be directly and indirectly injurious to humans or other living organisms, plants, property or interferes with the normal environmental processes.

Gaseous air pollutants: their sources and effects

Pollutant	Source	Harmful effect
Carbon compound (CO and CO_2)	Automobile exhaust burning of wood and coal	• Respiratory problems • Green house effect
Sulphur compounds (SO_2 and H_2S)	Power plants and refineries volcanic eruptions	• Respiratory problems in humans • Loss of chlorophyll in plants (chlorosis) • Acid rain
Nitrogen Compound (NO and N_2O)	Motor vehicle exhaust atmospheric reaction	• Irritation in eyes and lungs • Low productivity in plants • Acid rain damages material (metals and stone)
Hydrocarbons (benzene, ethylene)	Automobiles and petroleum industries	• Respiratory problem • Cancer causing properties
SPM (Suspended Particulate Matter) (Any soild and liquid) particles suspended in the air, (flush, dust, lead)	Thermal power plants, Construction activities, metalurgical processes and automobiles	• Poor visibility, breathing problems • Lead interfers with the development of red blood diseases and cancer. • Smoge (skoke & fog) formation leads to poor visibility and aggravates asthma in patients
Fibres (Cotton, wool)	Textiles and carpet weaving industries	• Lung disorders

Prevention and control of air pollution

(i) Prevention and control of indoor air pollution

Poor ventilation due to faulty design of buildings leads to pollution of the confined space. Paints, carpets, furniture, etc. in rooms may give out volatile organic compounds (VOCs). Use of disinfectants, fumigants, etc. may release hazardous gases. In hospitals, pathogens present in waste remain in the air in the form of spores. This can result in hospital acquired infections and is an occupational health hazard. In congested areas, slums and rural areas burning of firewood and biomass results in lot of smoke. Children and ladies exposed to smoke may suffer from acute respiratory problems which include running nose, cough, sore throat, lung infection, asthma, difficulty in breathing, noisy respiration and wheezing.

Use of wood and dung cakes should be replaced by cleaner fuels such as biogas, kerosene or electricity. But supply of electricity is limited. Similarly kerosene is also limited. The house designs should incorporate a well ventilated kitchen. Use of biogas and CNG (Compressed Natural Gas) need to be encouraged. Those species of trees such as baval (*Acacia nilotica*) which are least smoky should be planted and used. Indoor pollution due to decay of exposed kitchen waste can be reduced by covering the waste properly. Segregation of waste, pretreatment at source, sterilization of rooms will help in checking indoor air pollution.

(ii) Prevention and control of industrial pollution

Industrial pollution can be greatly reduced by:

(a) use of cleaner fuels such as liquefied natural gas (LNG) in power plants, fertilizer plants etc. which is cheaper in addition to being environmentally friendly.

(b) employing environment friendly industrial processes so that emission of pollutants and hazardous waste is minimized.

(c) installing devices which reduce release of pollutants: filters, electrostatic precipitators, inertial collectors, scrubbers, gravel bed filters or dry scrubbers .

Apart from the use of above mentioned devices, other control measures are:

• increasing the height of chimneys.

• closing industries which pollute the environment.

• shifting of polluting industries away from cities and heavily populated areas.

• development and maintenance of green belt of adequate width.

(iii) Control of vehicular pollution

• The emission standards for automobiles have been set which if followed will reduce the pollution. Standards have been set for the durability of catalytic converters which reduce vehicular emission.

• Emissions inspection is mandatory to all vehicles operating in Rwanda (twice a year for all commercial and public transport vehicles and once a year for other vehicles (private, public and even utilities).

• In cities like Delhi, motor vehicles need to obtain Pollution Under Control (PUC) certificate at regular intervals. This ensures that levels of pollutants emitted from vehicle exhaust are not beyond the prescribed legal limits.

• The price of diesel is much cheaper than petrol which promotes use of diesel. To reduce emission of sulphur dioxide, sulphur content in diesel has been reduced to 0.05%.

• Earlier lead in the form of tetraethyl lead was added in the petrol to raise octane level for smooth running of engines. Addition of lead in petrol has been banned to prevent emission of lead particles with the vehicular emission.

Air pollution, greenhouse gases and climate Change

Climate change is one component of global environmental change that poses widespread risks to human health and wellbeing. Climate change, whether resulting from natural variability or from human activity, depends on the overall energy budget of the planet, the balance between incoming (solar) shortwave radiation and outgoing longwave radiation. Among the other aspects of global environmental change are ecosystem degradation and land use change, petroleum depletion, urban sprawl, and water scarcity.

- **Greenhouse gases and greenhouse effect**

A greenhouse gas (GHG) is a gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

The greenhouse effect is a process by which thermal radiation from a planetary surface is absorbed by atmospheric greenhouse gases, and is re-radiated in all directions. Since part of this re-radiation is back towards the surface and the lower atmosphere, it results in an elevation of the average surface temperature above what it would be in the absence of the gases.

Over the last 50 years, human activities, particularly the burning of fossil fuels, have released sufficient quantities of carbon dioxide and other greenhouse gases to trap additional heat in the lower atmosphere and affect the global climate.

In the last 100 years, the world has warmed by approximately 0.75^oC. Over the last 25 years, the rate of global warming has accelerated, at over 0.18^oC per decade. Sea levels are rising, glaciers are melting and precipitation patterns are changing. Extreme weather events are becoming more intense and frequent.

- **Impact of climate change on health**

Although global warming may bring some localized benefits, such as fewer winter deaths in temperate climates and increased food production in certain areas, the overall health effects of a changing climate are likely to be overwhelmingly negative. Climate change affects social and environmental determinants of health: clean air, safe drinking water, sufficient food and secure shelter. Extreme high air temperatures contribute directly to deaths from cardiovascular and respiratory disease, particularly among elderly people. In the heat wave of summer 2003 in Europe for example, more than 70 000 excess deaths were recorded. High temperatures also raise the levels of ozone and other pollutants in the air that exacerbate cardiovascular and respiratory disease. Urban air pollution causes about 1.2 million deaths every year. Pollen and other aeroallergen levels are also higher in extreme heat. These can trigger asthma, which affects around 300 million people. Ongoing temperature increases are expected to increase this burden. Globally, the number of reported weather-related natural disasters has more than tripled since the 1960s. Every year, these disasters result in over 60 000 deaths, mainly in developing countries. Increasingly variable rainfall patterns are likely to affect the supply of fresh water. A lack of safe water can compromise hygiene and increase the risk of diarrheal disease, which kills 2.2 million people every year. In extreme cases, water scarcity leads to drought and famine. By the 2090s, climate change is likely to widen the area affected by drought, double the frequency of extreme droughts. Climatic conditions strongly affect water-borne diseases and diseases transmitted through insects, snails or other cold blooded animals.

3.2.2. NOISE POLLUTION

Noise is one of the most pervasive pollutants. A musical clock may be nice to listen during the day, but may be an irritant during sleep at night. Noise by definition is “sound without value” or “any noise that is unwanted by the recipient”. Noise in industries such as stone cutting and crushing, steel forgings , loudspeakers, shouting by hawkers selling their wares, movement of heavy transport vehicles, railways and airports leads to irritation and an increased blood pressure, loss of temper, decrease in work efficiency, loss of hearing which may be first temporary but can become permanent in the noise stress continues. It is therefore of utmost importance that excessive noise is controlled. Noise level is measured in terms of decibels (dB). W.H.O. (World Health Organization) has prescribed optimum noise level as 45 dB by day and 35 dB by night.

Anything above 80 dB is hazardous. The table below gives the noise intensity in some of the common activities.

Sources of some noises and their intensity

Source	Intensity	Source	Intensity
Quiet Conversation	20-30dB	Radio Music	50-60 dB
Loud Conversation	60 dB	Traffic Noise	60-90 dB
Lawn Mower	60-80 dB	Heavy Truck	90-100 dB
Aircraft Noise	90-120 dB	Space Vehicle	140-179 dB
Beat Music	120 dB	Launch	
Motor Cycle	105 dB	Jet Engine	140 dB

3.2.2.1. Sources of noise pollution

Noise pollution is a growing problem. All human activities contribute to noise pollution to varying extent. Sources of noise pollution are many and may be located indoors or outdoors.

Indoor sources include noise produced by radio, television, generators, electric fans, air coolers, air conditioners, different home appliances, and family conflict. Noise pollution is more in cities due to a higher concentration of population and industries and activities such as transportation. Noise like other pollutants is a byproduct of industrialization, urbanization and modern civilization.

Outdoor sources of noise pollution include indiscriminate use of loudspeakers, industrial activities, automobiles, rail traffic, aeroplanes and activities such as those at market place, religious, social, and cultural functions, sports and political rallies. In rural areas farm machines, pump sets are main sources of noise pollution. During festivals, marriage and many other occasions, use of fire crackers contribute to noise pollution.

3.2.2.2. Effects of noise pollution

Noise pollution is highly annoying and irritating. Noise disturbs sleep, causes hypertension (high blood pressure), emotional problems such as aggression, mental depression and annoyance. Noise pollution adversely affects efficiency and performance of individuals.

3.2.2.3. Prevention and control of noise pollution

Following steps can be taken to control or minimize noise pollution:

• Road traffic noise can be reduced by better designing and proper maintenance of vehicles.

• Noise abatement measures include creating noise mounds, noise attenuation walls and well maintained roads and smooth surfacing of roads.

• Retrofitting of locomotives, continuously welded rail track, use of electric locomotives or deployment of quieter rolling stock will reduce noises emanating from trains.

• Air traffic noise can be reduced by appropriate insulation and introduction of noise regulations for takeoff and landing of aircrafts at the airport.

• Industrial noises can be reduced by sound proofing equipment like generators and areas producing lot of noise.

• Power tools, very loud music and land movers, public functions using loudspeakers, etc should not be permitted at night. Use of horns, alarms, refrigeration units, etc. is to be restricted. Use of fire crackers which are noisy and cause air pollution should be restricted.

3.2.3. WATER POLLUTION

Addition or presence of undesirable substances in water is called **water pollution**. Water pollution is one of the most serious environmental problems. Water pollution is caused by a variety of human activities such as industrial, agricultural and domestic. Agricultural runoff laden with excess fertilizers and pesticides, industrial effluents with toxic substances and sewage water with human and animal wastes pollute our water thoroughly. Natural sources of pollution of water are soil erosion, leaching of minerals from rocks and decaying of organic matter. Rivers, lakes, seas, oceans, estuaries and ground water sources may be polluted by point or non-point sources. When pollutants are discharged from a specific location such as a drain pipe carrying industrial effluents discharged directly into a water body it represents **point source pollution.** In contrast **non-point sources** include discharge of pollutants from diffused sources or from a larger area such as runoff from agricultural fields, grazing lands, construction sites, abandoned mines and pits, roads and streets.

3.2.3.1. Sources of water pollution

Water pollution is the major source of water born diseases and other health problems.

Sediments brought by runoff water from agricultural fields and discharge of untreated or partially treated sewage and industrial effluents, disposal of fly ash or solid waste into or close to a water body cause severe problems of water pollution. Increased turbidity of water because of sediments reduces penetration of light in water that reduces photosynthesis by aquatic plants.

(i) Pollution due to pesticides and inorganic chemicals

• Pesticides like DDT and others used in agriculture may contaminate water bodies.

Aquatic organisms take up pesticides from water get into the food chain (aquatic in this case) and move up the food chain. At higher trophic level they get concentrated and may reach the upper end of the food chain.

• Metals like lead, zinc, arsenic, copper, mercury and cadmium in industrial waste waters adversely affect humans and other animals. Arsenic pollution of ground water has been reported from West Bengal, Orissa, Bihar, Western U.P. Consumption of such arsenic polluted water leads to accumulation of arsenic in the body parts like blood, nails and hairs causing skin lesions, rough skin, dry and thickening of skin and ultimately skin cancer.

• Pollution of water bodies by mercury causes **Minamata disease** in humans and **dropsy** in fishes. Lead causes **displexia**, cadmium poisoning causes **Itai – Itai disease** etc.

• Oil pollution of sea occurs from leakage from ships, oil tankers, rigs and pipelines.

Accidents of oil tankers spill large quantity of oil in seas which kills marine birds and adversely affects other marine life and beaches.

(ii) Thermal pollution

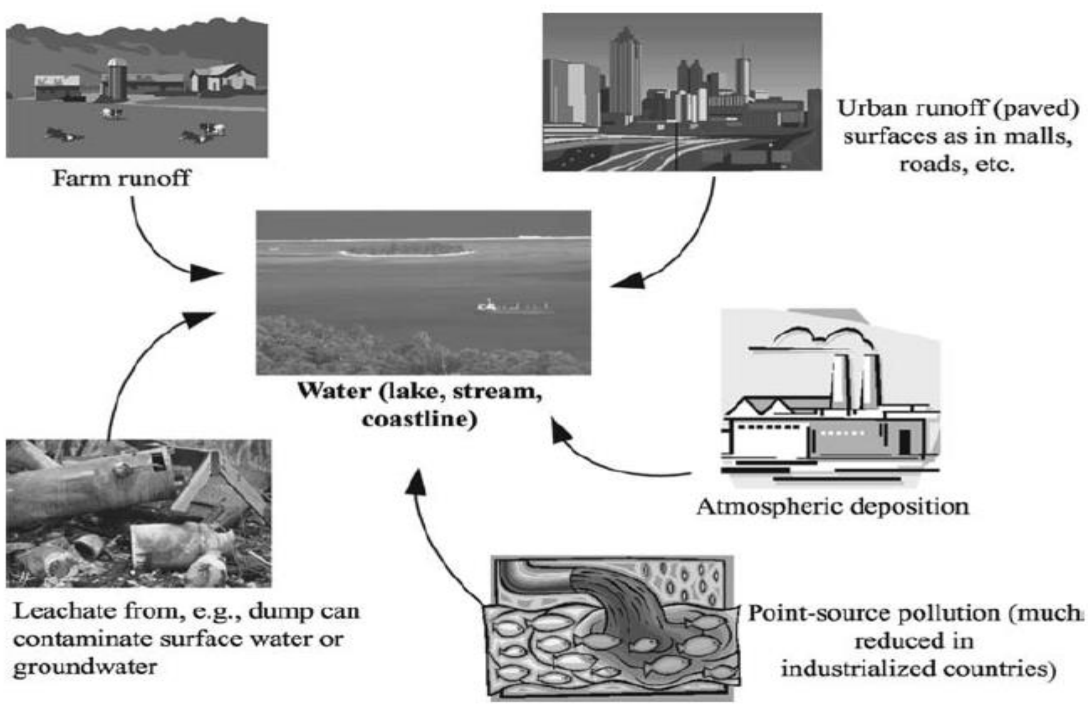
Power plants- thermal and nuclear, chemical and other industries use lot of water (about 30 % of all abstracted water) for cooling purposes and the used hot water is discharged into rivers, streams or oceans. The waste heat from the boilers and heating processes increases the temperature of the cooling water. Discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature.

This is **thermal pollution**. Increase in water temperature decreases dissolved oxygen in water which adversely affects aquatic life. Unlike terrestrial ecosystems, the temperature of water bodies remains steady and does not change very much. Accordingly, aquatic organisms are adopted to a uniform steady temperature of environment and any fluctuation in water temperature severely affects aquatic plants and animals. Hence discharge of hot water from power plants adversely affects aquatic organisms. Aquatic plants and animals in the warm tropical water live dangerously close to their upper limit of temperature, particularly during the warm summer months. It requires only a slight deviation from this limit to cause a thermal stress to these organisms. Discharge of hot water in water body affects feeding in fishes, increases their metabolism and affects their growth. Their swimming efficiency declines. Running away from predators or chasing prey becomes difficult. Their resistance to diseases and parasites decreases.

Due to thermal pollution biological diversity is reduced. One of the best methods of reducing thermal pollution is to store the hot water in cooling ponds, allow the water to cool before releasing into any receiving water body

Ground water pollution

Lot of people around the world depend on ground water for drinking, domestic, industrial and agricultural uses. Generally groundwater is a clean source of water. However, human activities such as improper sewage disposal, dumping of farm yard manures and agricultural chemicals, industrial effluents are causing pollution of ground water.



Sources of pollution to water bodies

Eutrophication

'Eu' means well or healthy and 'trophy' means nutrition. The enrichment of water bodies with nutrients causes eutrophication of the water body.

Discharge of domestic waste, agricultural surface runoff, land drainage and industrial effluents in a water body leads to rapid nutrients enrichment in a water body. The excessive nutrient enrichment in a water body encourages the growth of algae duckweed, water hyacinth, phytoplankton and other aquatic plants. The biological demand for oxygen (BOD) increases with the increase in aquatic organisms. As more plants grow and die, the dead and decaying plants and organic matter acted upon by heterotrophic protozoans and bacteria, deplete the water of dissolved oxygen (DO). Decrease in DO result in sudden death of large population of fish and other aquatic organisms including plants, releasing offensive smell and makes the water unfit for human use. The sudden and explosive growth of phytoplankton and algae impart green colour to the water is known as water bloom, or "algal blooms". These phytoplankton release toxic substances in water that causes sudden death of large population of fishes. This phenomenon of nutrient enrichment of a water body is called **eutrophication**. Human activities are mainly responsible for the eutrophication of a growing number of lakes and water bodies in the country.

3.2. 3.2. Methods for control of water pollution and water recycling

Control water pollution

Waste water from domestic or industrial sources or from garbage dumps is generally known as **sewage.** It may also contain rain water and surface runoff. The sewage water can be treated to make it safe for disposal into water bodies like rivers, lakes etc. The treatment involves three stages: primary, secondary and tertiary.

This includes:

1. Sedimentation, 2. Coagulation/flocculation, 3. Filtration, 4. Disinfection, 5. Softening and
6. Aeration. The first three steps are involved in primary treatment remove suspended particulate matter. Secondary treatment removes organic solids, left out after primary treatment, through their microbial decomposition.

Effluents after secondary treatment may be clean but contain large amounts of nitrogen, in form of ammonia, nitrates and phosphorous which can cause problem of eutrophication upon their discharge into a receiving water body such as river, lake or pond. The tertiary treatment is meant to remove nutrients, disinfect for removing pathogenic bacteria, and aeration removes hydrogen sulfide and reduce the amount of carbon dioxide and make water healthy and fit for aquatic organisms. This treatment of waste water or sewage is carried out in effluent treatment plants especially built for this purpose. The residue obtained from primary treatment one known as sludge.

3.2.3.3. Water recycling

With increasing population the requirement for water is increasing rapidly. However, the availability of water is limited but an ever increasing water withdrawal from different sources such as rivers, lakes and ground water is depleting these sources and deteriorating their water quality. Therefore, it is essential to utilize the available water with maximum economy.

While recycling is a term generally applied to aluminum cans, glass bottles, and newspapers, water can be recycled as well. Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing... Wastewater treatment can be tailored to meet the water quality requirements of a planned reuse. Recycled water for landscape irrigation requires less treatment than recycled water for drinking water. Water recycling offers resource and financial savings.

3.2.3.4. Control of water pollution

The following measures can be adopted to control water pollution:

(a) The water requirement should be minimized by altering the techniques involved.

(b) Water should be reused with or without treatment.

(c) Recycling of water after treatment should be practiced to the maximum extent possible.

(d) The quantity of waste water discharge should be minimized.

3.2.4. SOIL POLLUTION

Addition of substances which adversely affect the quality of soil or its fertility is known **as soil pollution.** Generally polluted water also pollutes soil. Solid waste is a mixture of plastics, cloth, glass, metal and organic matter, sewage, sewage sludge, building debris, generated from households, commercial and industries establishments add to soil pollution. Fly ash, iron and steel slag, medical and industrial wastes disposed on land are important sources of soil pollution.

In addition, fertilizers and pesticides from agricultural use which reach soil as run-off and land filling by municipal waste are growing cause of soil pollution. Acid rain and dry deposition of pollutants on land surface also contribute to soil pollution.

3.2.4.1. Sources of soil pollution

Plastic bags: Plastic bags made from low density polyethylene (LDPE), is virtually indestructible, create colossal environmental hazard. The discarded bags block drains and sewage systems. Leftover food, vegetable waste etc. on which cows and dogs feed may die due to the choking by plastic bags. Plastic is non biodegradable and burning of plastic in garbage dumps release highly toxic and poisonous gases like carbon monoxide, carbon dioxide, phosgene, dioxine and other poisonous chlorinated compounds.

Industrial sources – It includes fly ash, chemical residues, metallic and nuclear wastes. Large number of industrial chemicals, dyes, acids, etc. find their way into the soil and are known to create many health hazards including cancer.

Agricultural sources – Agricultural chemicals especially fertilizers and pesticides pollute the soil. Fertilizers in the run off water from these fields can cause eutrophication in water bodies. Pesticides are highly toxic chemicals which affect humans and other animals adversely causing respiratory problems, cancer and death.

3.2.4.2. Control of soil pollution

Indiscriminate disposal of solid waste should be avoided. To control soil pollution, it is essential to stop the use of plastic bags and instead use bags of degradable materials like paper and cloth. Sewage should be treated properly before using as fertilizer and as landfills. The organic matter from domestic, agricultural and other waste should be segregated and subjected to vermicomposting which generates useful manure as a by product. The industrial wastes prior to disposal should be properly treated for removing hazardous materials. Biomedical waste should be separately collected and incinerated in proper incinerators.

3.2.5. RADIATION POLLUTION

Radiation is a form of energy travelling through space. Radiation pollution is the increase in over the natural background radiation.

3.2.5.1. Sources and Hazards

There are many sources of radiation pollution such as nuclear wastes from nuclear power plants, mining and processing of nuclear material etc. The worst case of nuclear pollution was the Cherndoyl disaster in Russia occured in 1986 but the effects still longer today.

The radiation emanating from the decay of radioactive nuclides is a major source of radiation pollution. Radiations can be categorized into two groups namely the non-ionizing radiations and the ionizing radiations.

Non-ionizing radiations are constituted by the electromagnetic waves at the longer wavelength of the spectrum ranging from near infra-red rays to radio waves. These waves have energies enough to excite the atoms and molecules of the medium through which they pass, causing them to vibrate faster but not strong enough to ionize them. In a microwave oven the radiation causes water molecules in the cooking medium to vibrate faster and thus raising its temperature.

Ionizing radiations cause ionization of atoms and molecules of the medium through which they pass. Electromagnetic radiations such as short wavelength ultra violet radiations (UV), X-rays and gamma rays and energetic particles produced in nuclear processes, electrically charged particles like alpha and beta particles produced in radioactive decay and neutrons produced in nuclear fission, are highly damaging to living organisms. Electrically charged particles produced in the nuclear processes can have sufficient energy to knock electrons out of the atoms or molecules of the medium, thereby producing *ions*. The ions produced in water molecules, for example, can induce reactions that can break bonds in proteins and other important molecules. An example of this would be when a gamma ray passes through a cell, the water molecules near the DNA might be ionized and the ions might react with the DNA causing it to break. They can also cause chemical changes by breaking the chemical bonds, which can damage living tissues. The ionizing radiations cause damage to biological systems and are, therefore, pollutants.

3.2.5.2. Radiation damage

The biological damage resulting from ionizing radiations is generally termed as **radiation damage**. Large amounts of radiation can kill cells that can dramatically affect the exposed organism as well as possibly its offspring. Affected cells can mutate and result in cancer. A large enough dose of radiation can kill the organism.

Radiation damage can be divided into two types: (a) **somatic damage** (also called *radiation sickness*) and (b) **genetic damage.** Somatic damage refers to damage to cells that are not associated with reproduction. Effects of somatic radiation damage include reddening of the skin, loss of hair, ulceration, fibrosis of the lungs, the formation of holes in tissue, a reduction of white blood cells, and the induction of cataract in the eyes. This damage can also result in cancer and death. Genetic damage refers to damage to cells associated with reproduction. This damage can subsequently cause genetic damage from gene mutation resulting in abnormalities. Genetic damages are passed on to next generation.

3.2.5.3. Radiation dose

The biological damage caused by the radiation is determined by the intensity of radiation and duration of the exposure. It depends on the amount of energy deposited by the radiation in the biological system. In studying the effects of radiation exposure in *humans*, it is important to realize that the biological damage caused by a particle depends not only on the total energy deposited but also on the rate of energy loss per unit distance traversed by the particle (or "linear energy transfer"). For example, alpha particles do much more damage per unit energy deposited than do electrons.

3.2.5.4. Radiation effects and radiation doses

A traditional unit of human-equivalent dose is the ***rem***, which stands for ***r**adiation **e**quivalen**t** in **m**an*. At low doses, such as what we receive every day from background radiation (< 1 *m rem*), the cells repair the damage rapidly. At higher doses (up to 100 *rem*), the cells might not be able to repair the damage, and the cells may either be changed permanently or die. Cells changed permanently may go on to produce abnormal cells when they divide and may become cancerous.

At even higher doses, the cells cannot be replaced fast enough and tissues fail to function. An example of this would be "radiation sickness." This is a condition that results after high doses is given to the whole body (>100 *rem*). Nuclear explosions and accidents in nuclear reactors are a serious source of radiation hazard. The effects of atomic explosions in Nagasaki and Hiroshima are still not forgotten.

The nuclear reactor accident at Chernobyl in 1986 led to deaths of many reactor personnel and a very large release of radionuclide to the environment causing a long term radiation damage to the people living in the neighboring regions.

3.2.5.5. Accidents at nuclear power plants

Nuclear fission in the reactor core produces lot of heat which if not controlled can lead to a meltdown of fuel rods in the reactor core. If a meltdown happens by accident, it will release large quantities of highly dangerous radioactive materials in the environment with disastrous consequences to the humans, animals and plants.

To prevent this type of accidents and reactor blow up, the reactors are designed to have a number of safety features. Inspite of these safety measures two disasters in the nuclear power plants are noteworthy- namely at ‘Three Mile Island’ in Middletown (U.S.A.) in 1979, at Chernobyl (U.S.S.R.) in 1986. In both these cases a series of mishaps and errors resulted in over heating of the reactor core and lot of radiation was released into the environment. The leakage from Three Mile Island reactor was apparently low and no one was injured immediately. However, in case of Chernobyl the leakage was very heavy causing death of some workers and radiation spread over large areas scattered all over Europe. People of the city had to be evacuated to safer places and the plant had to be closed down. These two disasters are a reminder that nuclear power reactors require a constant up gradation of safety measures.

CHAPTER FOUR: WASTE MANAGEMENT

Waste is any material which is discarded by somebody (although it may be useful for somebody else). Wastes are categorized as Solid, Liquid, Sludgy or Gaseous depending on their physical properties.

4.1. LIQUID WASTE

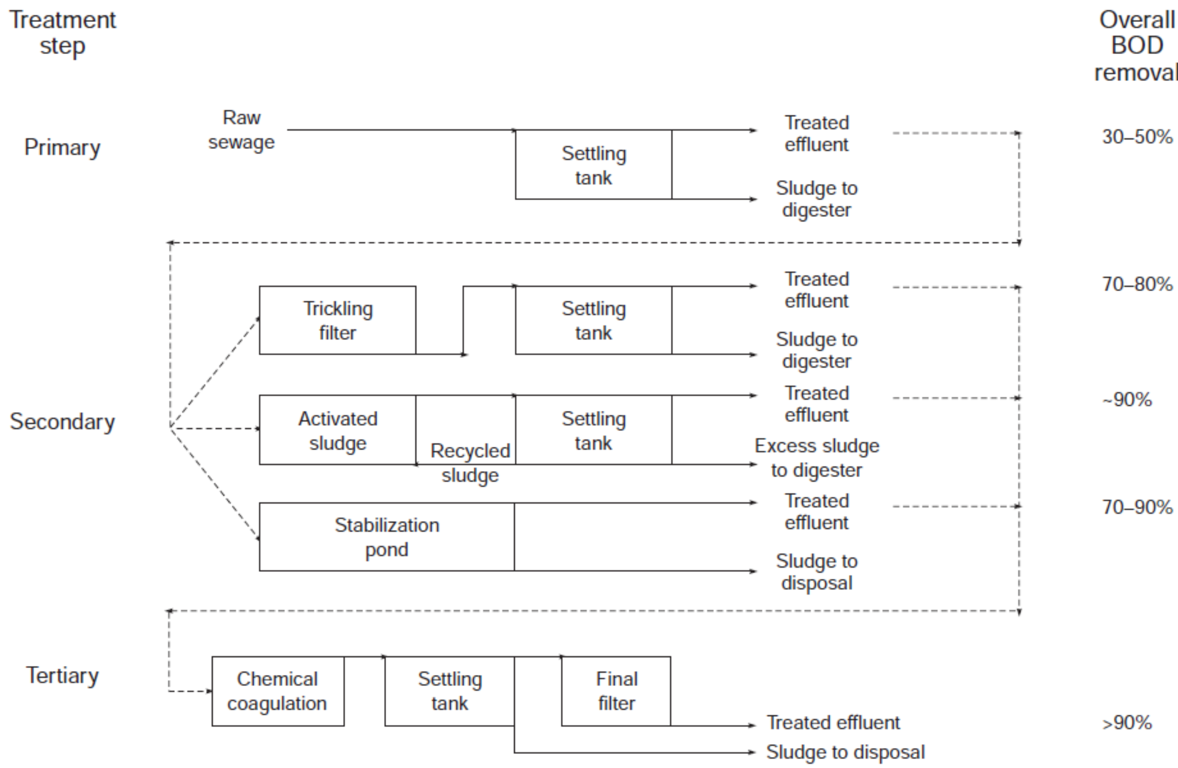
One of the most common types of liquid waste is human sewage. Basic guidance on its disposal can be found in verses 13 and 14 of the twenty-third chapter of Deuteronomy, where God provided the following instructions to Moses: "You shall have a place outside the camp and you shall go out to it; and you shall have a stick with your weapons and when you sit down outside, you shall dig a hole with it, and turn back and cover up your excrement." An early and simple method for disposing of human excreta follows this guidance almost to the letter: the pit privy, a hole in the ground with a small closed shelter and toilet built above it.

4.1.1. Treatment of Liquid Waste

As implied by the previous discussion, methods for treating liquid wastes, particularly domestic sewage, are designed to stabilize or oxidize, through biological processes, the organic matter they contain. This can be most effectively achieved by providing conditions that will optimize the ability of natural biological processes to accomplish this task. This is one of the primary goals in the design and operation of a sewage-treatment plant.

4.1.1.1.Municipal waste

Overall, the methods for the treatment of municipal sewage and other types of nontoxic liquid wastes are divided into three stages: primary, secondary, and tertiary. Primary treatment consists of holding the wastes undisturbed in a tank for a sufficient period of time to permit the solids within the waste to settle and be removed. Secondary treatment is the use of the previously discussed biological processes for oxidizing the organic matter in the waste. Tertiary treatment involves a variety of processes tailored to the intended uses of the finished product. One of the more common tertiary or advanced methods for treating liquid wastes is very similar to the coagulation, settling, and filtration processes used in treating surface waters to make them acceptable for drinking. Each of these processes represents a progressive level of purification, and the number of stages applied depends on the degree of treatment required. With modifications, however, higher removals are possible.



Primary, secondary, and tertiary stages in the treatment of municipal sewage

Primary treatment, as noted earlier, involves holding the sewage in a settling tank to permit the removal of solids by sedimentation. Before the sewage enters the settling tank, it is commonly sent through a chamber or collector to remove sand, grit, and small rocks that might damage pumps or other equipment. The settling tanks are operated on a flow through basis and are large enough to hold the material for several hours.

During that time, approximately half the suspended solids settle out, providing a BOD reduction of 30–50 percent. Grease and light solids that float are removed from the settling tank by a scraper and are pumped along with the settled solids to a large closed tank called a digester, where they are held for anaerobic digestion. Digestion is most effective when the biosolids are heated to 32^{o}C (90^{o}F) or more. At 32^{o}C the biosolids are digested in about 24 days; at 54^{o}C

(130^{o}F), in about 12 days. The methane gas produced in the process provides fuel for heating the digester and other applications within the treatment plant.

Secondary (or biological) treatment is accomplished through use of a trickling filter, the activated sludge process, or a waste stabilization pond. The first two methods are aerobic; the last combines aerobic and anaerobic systems. As previously noted, the overall objective is to make conditions ideal for biological stabilization. No special organisms are added; those that are necessary develop and flourish naturally. The *activated sludge process* is another form of aerobic secondary treatment for municipal sewage. Sewage is sent into a large open tank, where it is held for several hours and its oxygen content maintained by means of aerators (air diffusers) or mechanical agitators (paddles or brushes). Rather than growing on the surfaces of stones as in the trickling filter, the microorganisms float as suspended particles in the aerated sewage. The effluent is sent to a secondary settling tank, where the microorganisms settle out, and the settled sewage is the treated product. The overall reduction in BOD is about 90 percent. Some of the microorganisms that have settled out in the secondary tank are pumped back into the aerated tank to maintain an adequate population of microbial growth. The rest of the growth is treated as biosolids and sent to a digester.

Most methods for *tertiary treatment* of sewage are modeled on those used in the purification of drinking water. For wastes that contain unusual amounts of organic compounds, or heavy metals and viruses, additional steps may be required. Excess organic compounds are commonly removed by passing the treated waste through two granular carbon beds, each of which provides 30 minutes of contact time. Ozone may be used to disinfect the waste as it passes from the first carbon bed to the second. Heavy metals and viruses can be removed by coagulating the waste, for example, with lime, followed by sedimentation. This process, however, creates large volumes of highly toxic sludge that must be handled and disposed of carefully.

4.1.1.2. Industrial wastes

As might be anticipated, wastewaters from industrial operations contain a wide range of pollutants. As a result, the treatment of industrial wastes requires not only an expansion in the number of methods applied but also a change in their sophistication. Methods that can be applied, either singly or in combination, include the following:

Physical processes include those designed to remove suspended solids through filtration, centrifugation, or the previously described settling tanks; oils, greases, and emulsified organics through aeration, which causes such materials to float to the surface, where they can be removed by skimming devices; and dissolved materials, such as organic chemicals, which can be accomplished by passing the water through a semipermeable membrane or, as noted earlier, through beds of activated carbon.

Chemical processes include the addition of acids to neutralize wastes that are alkaline; bases to neutralize wastes that are acid; and chemicals to coagulate and precipitate suspended solids (as, for example, in tertiary treatment systems applied to the effluents from municipal sewage-treatment plants).

Biological processes include the predigestion of brewery, winery, and meat-packing wastes under anaerobic conditions, often at elevated temperatures to accelerate the process, and the oxidation of certain types of industrial wastes, such as petroleum constituents, under aerobic conditions similar to those applied in the treatment of domestic sewage.

4.2. SOLID WASTE

Solid waste was a problem even before water and air pollution issues attracted the notice of human civilization. Problems associated with solid wastes can be dated back to prehistoric days. Due to the invention of new products, technologies and services, the quantity and quality of waste have changed over the years. Now, the waste characteristics depend not only on people's income, culture and geography but also on the economy a society undergoes and situations like disasters to which the society may be subjected to.

The twentieth century is recognized as the American Century and the twenty first century is recognized as the Asian Century and, it seems everybody wants to earn 'as much as possible' After Asia the developing Africa could take the central stage of development in the coming years. Development does not come without environmental burdens and generation of waste is one among them. Waste in recent times has become a topic of extensive attention in academic and popular literature.

Waste is conventionally defined as unwanted material at the point of generation which does not have immediate use.

Some of the wastes are usually solid, and they are considered as useless and unwanted. But many of these waste substances can be reused and can be a resource for an industry. Indeed waste management is one of the most important problems of our time as development and subsequent use of materials generates enormous quantity of wastes.

Under the Environmental Public Health Act (EPHA) passed in 1968 in Singapore,''waste'' includes:

(a) Any substance which constitutes a scrap material or an effluent or other unwanted surplus substance arising from the application of any process; and

(b) Any substance or article which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled, and

(c) Anything which is discarded or otherwise dealt with as if it were waste shall be presumed to be waste unless the contrary is proved.

''Municipal solid waste'' is a term usually applied to a collection of wastes produced in urban areas. It includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated biomedical wastes.

Integrated Solid-Waste Management

Integrated solid waste management (ISWM) is comprehensive waste management which includes prevention, recycling, treatment, and disposal program. It considers how to manage solid waste most effectively to the environment and human health.

4.2.1. Solid Waste Management Strategies

Because solid and hazardous wastes may affect human health, **waste management** is a fundamental part of environmental public health. Waste management is best accomplished through a multitiered approach. The first tier is primary waste stream reduction. Materials recycling, substitution of materials, and changes in consumer habits, among other methods, can help industries, communities, and other groups achieve waste stream reduction. All sectors of a modern society, when approached with effective informational campaigns and incentives, can practice waste reduction.

The second tier of solid waste management involves proper handling and disposal of waste, that is, in a manner that protects the public health and the environment. Although complete avoidance of solid waste generation is the ideal, it is likely that there will always be some residual of mankind's activities requiring disposal.

4.2.1.1. Primary Prevention of Waste

The ideal waste management strategy is not to produce the waste in the first place. This goal can be approached in several ways, that is, through efforts to **reduce, reuse, and recycle.** In an industrial setting this goal might be achieved by altering production processes to avoid or reduce the use of a hazardous chemical. For example, in some electroplating operations, less toxic alternatives can replace highly toxic cyanide salts. In office settings, converting to electronic commerce and records management can reduce waste paper production.

Waste reduction also applies to municipal wastes. The quantity of raw materials in food and beverage containers is being reduced because of economic pressures. In the past few decades, manufacturers have reduced the amount of steel and aluminum in cans and the amount of plastic in milk jugs and plastic bags.

These efforts have reduced the cost of these containers and decreased the amount of wastes to be disposed. Further reductions in packaging could be achieved if consumers carried reusable canvas shopping bags instead of expecting plastic or paper bags with each purchase.

If the generation of waste cannot be abated or reduced, then the next best alternative is to recycle the waste. Recycling can refer to using waste material to produce more of the original product or to using waste material in something else.

Examples of the first kind of recycling include making glass or paper from used glass or paper and making new lead batteries from old lead batteries.

4.2.1.2. Waste Treatment and Disposal

As discussed earlier, it would be ideal if all solid and hazardous or special waste could be recycled, reused, or avoided. Unfortunately, this ideal goal may not be attained. As a result, society should strive to dispose of all such wastes in a manner that minimizes harm to human health and the environment. Both budgetary limitations and the need to comply with applicable regulations influence selection of the most practical option.

In years past it was common to burn wastes in backyard barrels, open dumps, and crude incinerators. All these methods had undesirable environmental and health impacts. During the second half of the twentieth century, public demand and governmental regulations led to improved waste treatment and disposal methods. Controlled or sanitary landfills replaced dumps. More sophisticated and controlled combustion systems replace crude incinerators. Newer incinerators were specifically designed for the type of wastes burned, such as medical waste, industrial waste, or municipal solid waste. Some industrial wastes, such as liquid brines, were discharged far beneath the Earth's surface, through deep well injection. Potentially harmful industrial wastes that had been previously discarded haphazardly in dumps or burial pits were also treated with remedial technologies designed to reduce or limit harmful impacts.

4.2.1.3. Sanitary Landfill

Open - burning municipal waste dumps, which were once prevalent throughout the United States, were the source of many environmental and public health problems. These problems included air pollution; groundwater pollution; and rats, flies and other disease - carrying vectors, as well as nuisance odors and unsightly conditions.

The creation of the EPA in 1970 prompted a major move in the United States to eliminate open dumps and replace them with the improved **sanitary landfill**. Careful site selection and preparation, the application of a daily covering of earth for each day ' s accumulation of waste, and other procedural provisions eliminated most of the problems with open dumping. Between 1996 and 2006, the number of operating municipal sanitary landfills in the United States decreased from about 3,100 to 1,754.

Sanitary landfills vary in design, depending on local site considerations. However, by definition, all sanitary landfills share certain design features and operating principles, as discussed here:

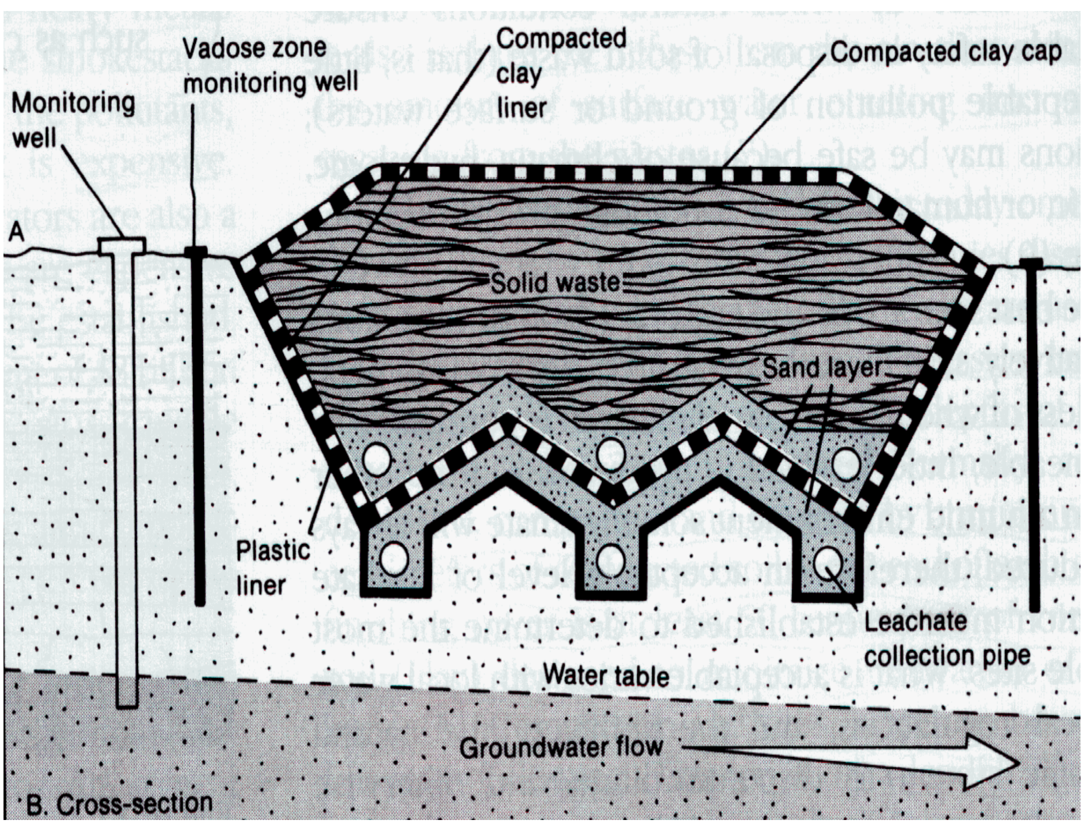
Site Selection and Preparation: many technical and social factors go into selecting a site for a municipal sanitary landfill. Technical considerations include the cost of the land and ensuring

- An adequate area to provide waste disposal capacity for a reasonable time period.
- An adequate elevation or separation to protect regional ground water
- Available or appropriate soil for daily soil cover requirements
- An adequate buffer from surrounding populations

Normally, several candidate sites will be identified and evaluated using these criteria. In addition to these technical requirements, the selected site must also meet with community acceptance or, at least, attempt to minimize community outrage.

Once a landfill site has been selected, site preparation can begin. In addition to grading and installing sediment and erosion controls to protect local surface waters, provisions must also be made to protect groundwater from leachate.

Leachate, a liquid, organic waste decomposition product sometimes contaminated with chemicals, can migrate down and into the local aquifer. In the absence of a natural barrier, installing an underlying man - made impervious barrier can provide protection. Where significant amounts of leachate are anticipated, some landfills have systems to collect and treat the leachate. Similarly, provisions are often made for collecting and controlling gaseous products of waste decomposition, consisting mainly of methane. In some cases the methane is cleaned and used as fuel for local energy production. Other site preparations can include aesthetic screening of the site, scales for weighing incoming trash trucks, maintenance facilities, flares or gas vents, security arrangements, and monitoring wells to sample leachate.



4.2.1.4. Incineration

Broadly defined, **incineration** is the controlled combustion of a waste. Incineration has been used for all types of wastes, including municipal solid wastes, sewage sludge, industrial and hazardous waste, and medical wastes. Some large municipal and industrial incinerators are designed to capture energy for reuse.

The goal of incineration is to reduce the volume of the waste being processed or to reduce the hazardous characteristics of a particular waste stream, or both.

All incineration attempts to control several variables in an effort to maximize the completeness of combustion. The classic 3 T s of combustion are:

1. Time: the length of time that solids and combustion gases are in the ignition and burn zones of the incinerator
2. Temperature: an indication of the amount of heat energy in the combustion chambers available to break molecular bonds and facilitate oxidation toward the desired end products of combustion (carbon dioxide, water vapor, inorganic ash)
3. Turbulence: the agitation of both solids and the combustible by – products needed to provide opportunity for complete oxidation to take place.

The other major factor in fundamental combustion control is the provision of adequate oxygen, usually in the form of combustion air, to complete all oxidation reactions. The theoretically required amount of air for complete combustion of a given waste stream is known as the *stoichiometric air requirement*. In actual incineration systems, air in excess of this requirement is provided to force the reaction toward complete oxidation of the organic wastes. This excess air is usually reported as a percentage of stoichiometric air.

Early incinerators were noted for smoke, odors, and sometimes even live embers coming out of the exhaust stacks. Because of these unacceptable conditions, regulations now require strict air pollution control technology. Now, devices such as wet or caustic scrubbers control acid gas. Electrostatic precipitators, venture scrubbers, and bag houses capture fine particulates. Some of the newest hazardous waste incinerators have a final activated - carbon filtration system. This polishing device minimizes emission of low - level products of incomplete combustion (PICs), such as dioxins and polycyclic aromatic hydrocarbons (PAHs). Inorganic waste contaminants, such as heavy metals (mercury, lead, and chromium, for example) can be difficult to control and can require special pollution control systems or elimination from the waste being fed to the incinerator. Because of increased traffic from trucks hauling in wastes and also because of odors and aesthetic objections, communities rarely welcome incinerators or waste landfills.

4.3. HEALTH CARE WASTE

Health workers do their best to help people stay healthy. But if waste from health care is not handled safely, it can spread illness to the health workers and the surrounding community.

Health care waste includes waste from clinics, hospitals, laboratories, blood banks, dental clinics, birth centers and animal hospitals. It also includes waste from **vaccination programs** (also called immunization campaigns) and medical aid missions, and waste produced from caring for the sick at home.

Most waste from health care is ordinary waste like paper, cardboard, and food scraps. But some health care waste is contaminated with blood or body fluids that may carry harmful germs and spread disease. Used needles and other sharp tools **(sharps)** can cause injury and spread disease. Some health care waste, such as plastics, contains toxic chemicals. When waste that carries harmful germs or toxic chemicals is mixed with ordinary waste, the mixed waste becomes a threat to all who handle it. That is why separation of waste is so important.

Safe handling of health care waste uses the same basic methods used to dispose of other solid wastes. But wastes contaminated with body fluids and germs must be **disinfected** and disposed of in ways that protect the health of people and the environment.

4.3.1. Health Problems from Health Care Waste

Any waste can cause health problems if not carefully disposed of. But health care waste can cause particular health problems such as:

- hepatitis B and C, tetanus, HIV/AIDS, and serious skin infections from used needles and sharp instruments.
- allergies, skin rashes, eye irritations, asthma and other breathing difficulties from breathing in disinfectants, detergents, medicines, and laboratory chemicals.

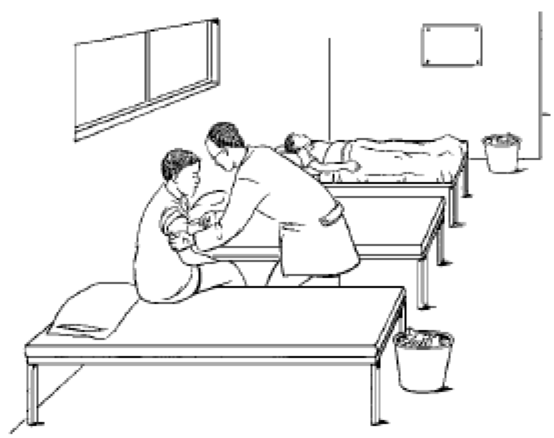
• antibiotic resistance. When a person handles antibiotic medicines often, they may no longer work for her.

• cancer, respiratory problems, and other illnesses from wastes that release toxic chemicals such as dioxins into the environment when they are burned.

People most at risk of harm from health care waste are:

people who live near where health care waste is dumped or burned

people who remove trash from health centers and those who collect, recycle, or sell trash from dump sites and landfills



workers and patients in health centers

4.3.2. Preventing Harm from Health Care Waste

Whether in a small health post, a larger clinic, or in the home, medical tools and health care waste must be managed safely to prevent harm.

• **Reduce** the amount of waste by choosing medical supplies carefully.

• **Separate** wastes where they are created.

• **Disinfect** wastes that carry germs.

• **Treat** chemical wastes to make them less harmful.

• **Safely store and transport** waste.

• **Dispose** of health care wastes in the least harmful way possible.

• **Train** everyone who handles health care waste about safe methods.

No matter what methods your clinic, center, or hospital uses, make sure everyone who handles health care waste, especially new people, understands what needs to be done and why. Often, people will bring up new ideas that can make work easier and safer for everyone. Some clinics have a team of people who are responsible for training and checking safe practices.

Reducing waste

Using fewer and less harmful materials will reduce the amount of harmful health care waste.

When choosing materials for your clinic, think about what kind of waste will be produced, how harmful it will be, and how you will dispose of it.

To reduce the amount of harmful waste:

• Avoid using disposable items if a reusable choice is available and safe to use.

• Use non-mercury thermometers if they are available. They cost more but are more durable and less dangerous if they break.

• Do not buy more medicines than you need, and use them only when necessary.

• Use pills instead of injections.

• Use non-plastic items when possible.

• Use the least toxic products to clean and disinfect whenever possible.

Separating waste

Separating waste where it is created is another important step in safe handling of health care waste. Separating wastes greatly reduces risks to health center workers and to people who collect, sell, and recycle waste. Separation also reduces the amount of waste that must be treated or buried later and reduces the cost of waste management.

Separating waste into colored containers

Many health centers separate wastes into different colored containers at the places where waste is created. For this to be a useful method, everyone in the health center needs to understand which waste goes into which color container. Different countries use different colors for each type of waste. For example, in some countries the color red means "danger." So containers for used needles and other sharp tools, and other harmful or toxic wastes are red or marked with red paint, marker, or tape.

More than half of all waste from health centers is just like household waste: paper, cardboard, bottles, cans, and kitchen scraps. When this waste is separated out, it is much easier to manage the harmful waste.

Containers should be:

• placed close to where waste is created.

• clearly marked with colors and symbols.

• strong enough so they do not leak or break.

• easy to seal and transport without risk of spills, leaks, or breaks.

• big enough to hold a full day's waste when only 3⁄4full.

It is best to use containers and bags that are the same color for the same kind of waste. If this is not possible, mark them with colored tape or paint. Always using the same colors can help workers who do not read — and even those who do — remember which containers are for regular waste and which are for harmful wastes.

Storing and transporting waste

Health care waste needs to be stored carefully until it can be safely taken to its final disposal site. Health care waste containers should be placed where waste is created and disinfected, never in hallways, bathrooms, or other places where people might spill them or fill them with mixed waste. Seal waste bins and bags when they are 3/4 full. Bins and bags 3/4 full are less likely to spill or break, and will reduce the chances of injury to a worker picking them up. Never put used needles and other sharp instruments in bags. If a bag breaks or leaks, put it inside another bag. Store sealed bags in a closed room until they can be removed from the site. The room should be secure so people who collect trash to sell it cannot get to it. Health care waste can be stored safely only for a short time. Soon it begins to smell bad and can spread infection as it decays. It is best to remove waste daily. Never store waste for more than 3 days. Your nose will tell you when you have waited too long!

Prevent harm when handling waste:

•Wear protective clothing to reduce risks from needles or other sharp tools, germs, or splashes from blood, other liquids or chemicals.

• Immediately after they are used, put used needles and other sharp tools in sharps boxes. Do not put sharp things in bags or with other waste.

• Wash hands after handling waste, and before and after working with every patient.

• Never carry uncovered (uncapped) needles.

• Do not let waste touch your skin. If protective clothing gets soaked through with contaminated wastes, take it off immediately, and wash yourself with lots of soap and water.

• Protective clothing only protects if it is clean. After each use or at the end of each shift, wash or disinfect gloves, aprons, glasses, and masks. This will protect the next person who uses them.

Disinfecting Waste

Disinfection means killing germs that cause infection. As much as possible, health care waste should be disinfected in the same place where it is created. The most common ways to disinfect are to use chemicals (such as **chlorine bleach**, **hydrogen peroxide**, or other chemicals) or heat (boiling, steaming, **pressure steaming**, **autoclave**, or **microwave**).

What wastes need to be disinfected?

Any materials in a health center that are contaminated with blood, body fluids, or feces, or that have been in close contact with a person with a contagious disease, need to be disinfected to prevent the spread of infection and disease.

Disinfecting with Chemicals

All chemicals used to disinfect can be harmful and need to be used with great care. Some chemicals commonly used to disinfect include hydrogen peroxide (6%), chlorine bleach, ethanol (70%), and isopropyl alcohol (70% to 90%). Many common cleaning and disinfecting products contain **glutaraldehyde** or **formaldehyde**.

Regular exposure to glutaraldehyde and formaldehyde can cause cancer and death. These chemicals should not be used. Many health centers use these guidelines for safety when using chemicals:

• Use chemical disinfectants outside, or in well ventilated rooms where there is a good exhaust fan.

• Use only the amount of chemical disinfectant needed to do the job.

• Wear gloves, safety glasses, a mask, and protective clothing to protect your skin, eyes, and breathing when using or disposing of chemicals.

• Store disinfecting chemicals in their proper containers. Label the containers. Do not reuse those containers for anything else.

• Do not store or mix chemicals in water buckets, or containers or bottles that may be used for food or drinks.
• Keep chemical containers tightly closed and stored upright. Check them for breaks, leaks, and weak spots.

Disinfecting with Heat

Many health centers use autoclaves or microwaves to disinfect syringes, other medical tools, and some waste. If you have no autoclave or microwave, then boiling, steaming, or pressure steaming materials for at least 20 minutes will disinfect them. Disposable wastes should **not** be disinfected with tools that will be used again, because it is difficult to keep the reusable tools clean when you separate them after disinfection.

After Disinfection

No matter what kind of disinfection you use (chemical or heat), disinfected waste should be safely stored in bags or disposed of right after disinfection. Keep waste away from patients, and make sure that infected waste does not get mixed with disinfected waste.

Disposing of Infectious Waste

The chart on this page shows when and how to disinfect and dispose of infectious wastes in small health centers. Some health centers may not be able to use all of these methods, or may have their own, better ways to treat wastes. The important thing to prevent infection is to use a system that everyone in the health center understands and follows.

Separate by type	SHARPS Needles, blades, lancets, broken glass, other sharp objects	ITEMS CONTAMINATED WITH BLOOD OR BODY FLUIDS Blood bags, dialysis kits, syringe barrels, gloves, masks, bandages, cotton swabs, other wastes	BLOOD, BODY FLUIDS, FECES Liquid blood, fluids from suction canisters, feces, and other contaminated body wastes	BODY PARTS Amputated limbs, tissues, skin tags
Separate using colored containers	 put in sharps container	 put in colored bag or container or  carefully cut or shred waste and put in bleach bucket	 put in colored bag or container	 put in colored bag or container with tight-fitting cover
Seal containers	when ¾ full, seal container with tape	when ¾ full, seal bag or container or keep tight-fitting cover on bleach bucket	seal bag or cover container with tight-fitting cover	when ¾ full, seal bag or container
Disinfection or safe burial	drop into a sharps pit or put container into a drum	disinfect using a heat method or leave in bleach bucket for at least 10 minutes, then drain	wearing protective clothing, carefully add bleach to container and let stand for 10 minutes	put in safe burial pit, add lime, and cover with soil
Final disposal	when almost full, seal the pit with concrete or when ¾ full, fill drum with concrete and bury drum in a landfill	put in safe burial pit, cover with soil. When pit is almost full, cover with soil and seal with concrete. or dry and reuse or recycle glass, metals, and plastics or discard with other solid waste	put liquid waste into safe leaching pit or into sanitary sewer or septic tank	when pit is almost full, cover with soil and seal with concrete

4.4. HEALTH CONCERNS FROM POOR WASTE MANAGEMENT

Exposure to solid and hazardous wastes can adversely affect human health in several ways. The aesthetic impact of poor waste management — trash piling up in streets and vacant lots — can undermine the livability and even the safety of a community. At least five kinds of health hazards are well recognized:

1. Infectious disease risks from poorly managed solid waste
2. Contamination of drinking water and soil by biological, chemical, and mining wastes
3. Gas migration and leachate discharges from landfills

4. Emissions of air pollutants from incinerators
5. Contamination of food by waste chemicals that escape into the environment

Poorly operated landfills can be havens for flies, mosquitoes, rats, and mice.

Uncovered garbage and trash provide them with food, shelter, and a breeding ground. These insects and animals can be vectors for disease by carrying pathogenic microbes into the surrounding community. Rats and mice can spread many diseases to humans, including leptospirosis, hantavirus pulmonary syndrome, and lymphocytic choriomeningitis virus. Furthermore, rats can carry many kinds of mites, lice, fleas, and ticks that act as disease vectors. Modern landfills, which require wastes to be covered daily with clean soil, have greatly reduced the spread of disease by these vectors.

Improper disposal of solid and hazardous wastes can contaminate drinking water. Both groundwater and surface water can be affected. Most old landfills or dumps lack liners, which allows chemicals buried in the landfill to leach down into the underlying aquifer. Volatile organic compounds (VOCs), such as trichloroethylene and tetrachloroethylene, and petroleum distillates are common contaminants in municipal and industrial landfills.

CHAPTER FIVE: ENVIRONMENTAL HEALTH EDUCATION AND PROMOTION

5.1. Health education and hygiene education

Health education is one important activity that is commonly undertaken to promote health. It is the communication of information that enables people to make informed decisions about health-related activities. Hygiene education is concerned specifically with communicating on those areas of health that are related to water supply, sanitation, vector-borne disease control, and hygiene practice and risk of communicable disease and its transmission.

5.2. Environmental Health promotion

Health promotion was defined in the Ottawa Charter as "the process of enabling people to increase control over, and to improve, their health. To reach a state of complete physical, mental and social well-being, an individual or group must be able to identify and to realize aspirations, to satisfy needs, and to change or cope with the environment.

Health is, therefore, seen as a resource for everyday life, not the objective of living. Health is a positive concept emphasizing social and personal resources, as well as physical capacities. Therefore, health promotion is not just the responsibility of the health sector, but goes beyond healthy life-styles to well-being". (World Health Organization 1986)

Environmental health promotion can be defined as "any planned process employing comprehensive health promotion approaches to assess, correct, control, and prevent those factors in the environment that can potentially harm the health and quality of life of present and future generations."

5.2.1. Hygiene promotion

Hygiene promotion follows the same approach as health promotion, in that it is concerned not only with the transmission of information, but with understanding and promoting the capacities of people to improve their own health, chiefly through their ability to: make best use of prevailing environmental-health conditions and existing services and facilities; act to improve environmental-health conditions; and make behavioural changes to reduce certain environmental risks at the household level. Hygiene promotion is concerned with achieving improvements in health through the joint efforts of individuals, families and communities on one hand, and external agencies, health authorities, etc. on the other. It is a process in which environmental-health conditions and hygiene-related behaviours are assessed, and changes in conditions, services and behaviours are achieved. A key feature of hygiene promotion is that it depends for its success on the careful analysis of people's constraints, opportunities and strengths in any situation, to seek solutions to hygiene problems that are realistic and appropriate to people's desires and ways of living. Recent work on hygiene promotion in development and emergency situations has underlined the advantages of hygiene promotion over the more traditional and narrower approach of hygiene education and health education (United Nations Children's Fund, 1999; Ferron, Morgan & O'Reilly, 2000).

5.2.2. Principles of community participation

Community participation means the involvement of people from the earliest stages of the development process, as opposed to simply asking their opinion of project proposals that have already been developed, or for their contribution to the implementation of projects imposed from outside. Participatory approaches have been widely tested in the fields of water, sanitation and hygiene, and experience has shown that involvement of the community can produce wide-ranging benefits.

The main principles are:

- Communities can and should determine their own priorities in dealing with the problems that they face.
- The enormous depth and breadth of collective experience and knowledge in a community can be built on to bring about change and improvements.
- When people understand a problem, they will more readily act to solve it.
- People solve their own problems best in a participatory group process.

Community-focused programmes therefore aim to involve all members of a society in a participatory process of: assessing their own knowledge; investigating their own environmental situation; visualizing a different future; analyzing constraints to change; planning for change; and implementing change.

The success of participatory action depends on a continuous community dialogue, where provisional goals are set and tested, subsequent action is based on analysis, research, and education, and experience is fed back into the process.

5.2.3. Obstacles to community participation

While past experience has taught the value of community participation, it has also highlighted the difficulties of mobilizing people. These difficulties are summarized here:

Apathy and disempowerment

There are real difficulties in involving people who are not used to making decisions, who feel powerless, who are apathetic or who are dependent on others. Those in authority may be unwilling to allow people to participate in decision-making. Political, religious and commercial interests may discourage participation.

Conflicts and divisions

Most communities include people from a wide range of social and economic backgrounds, with different needs and interests: rich and poor, young and old, men and women, people from different ethnic or religious groups. A community project designed for the common good may in fact be divisive if it is seen as benefiting one section of the society more than another. Where paid employment is involved, jealousies and conflicts can ensue. There may also be conflict between individual and group interests.

For example, in a densely-populated urban slum, discussions might reveal the need to relocate some houses to make fire breaks or drainage channels that would benefit everyone. But the questions “Whose house?” and “How will the owner be compensated?” may give rise to conflicts and divisions.

Poverty

Lack of resources, ill-health and poverty prevent people from participating. Many people work seven days a week for long hours just to be able to feed their families, and may not have the time to participate. As the poorest members of the community, these are often the most vulnerable people and their opinions are most valuable. Special efforts must be made to enable them to participate.

5.2.4. Overcoming obstacles and reaching the community

Methods of overcoming obstacles to community participation include the following:

Finding an entry point to the community

It is essential to find an appropriate entry point to the community. This will most often be an existing community-based organization with its roots in the community.

Where a primary health-care system exists, a community-health worker may provide the necessary entry point. Much of what the community-health worker tries to do is highly relevant to risk reduction, especially education on oral rehydration therapy, food and water hygiene, water-supply protection, vector-borne disease control, and disposal of wastes. When the health worker is supported by a community-health committee, this can provide a useful core structure for efforts to prevent or mitigate hazards (such as contamination of drinking-water sources, landslides due to poor building practices, etc.).

Care must be taken, however, not to delegate too many additional tasks to community health workers without providing the necessary extra support in the form of materials, transport and finances.

It is also possible to use existing local health programmes as the starting point. Thus, in Indonesia, a system called local area monitoring has been successful in achieving high childhood immunization coverage. As a result, there were plans for other health programmes, including an environmental health programme, to take advantage of this community-based system (S. Nugroho, personal communication, 1992).

Working with community leaders

A proven method for achieving community participation is to work through individuals who are able to bring people together and promote action. Political and religious leaders must be involved in their official capacity, but selecting other types of leaders may provide a useful balance.

Different leaders will need to be identified to reflect the ethnic, caste and religious diversity of the population. Women leaders are particularly important for their ability to represent and articulate women's interests and needs.

Once interested leaders have been identified, they may require training, not only in health matters, but also in skills in dealing with people, listening, encouraging and sharing responsibilities and power in emergencies. They must also be supported and their credibility within the community maintained by ensuring that they participate in emergency-planning processes. It is often important to work with people with strong political, religious and commercial influence, to encourage participation, or at least to overcome obstacles to participation.

Ensuring official support for community-led projects

Any community-based programme will need support from health workers and educators. These in turn will need the full support of their managers and of municipal, ministerial and other officials. People's investment of their own time in discussing risk and vulnerability reduction should be seen to produce visible results.

Understanding the socioeconomic make-up of the community

To overcome conflicts of interest, environmental-health personnel must take care to understand the socioeconomic make-up of the community, its divisions, and its past history of self-help community projects (especially if these have failed).

Making special arrangements to encourage participation

Special arrangements should be made to encourage the participation of all members of the community, for example providing free child care to allow parents of young children to participate.

5.2.5. Communication methods

Communication of health information is most effective when a variety of methods, approaches and materials are used. Broadly speaking, there are three main approaches:

Person-to-person contact

Captive audiences may be found at clinics, feeding centres, food-distribution centres, water-collection points and so on, where health workers and trained volunteers will be able to give advice. In nonemergency periods, health clinics, schools and workplaces may provide similar audiences. Meetings may be called for specific groups, or selected individuals may be brought together for focus group discussions on specific topics, and individual families may also be visited. The influence of existing local groups or social organizations can be very useful in increasing the impact of the information.

This direct approach, particularly if it involves some interaction between health workers and individuals, is most effective in tackling specific issues and encouraging particular changes in behaviour, and in checking that messages are seen as relevant and useful by the people concerned.

Activities suitable for person-to-person exchanges or for small groups include the discussion of personal feelings and experiences, demonstrations, story-telling, role-playing, case studies and educational games (particularly in nonemergency situations).

Teaching aids

Suitable teaching aids include printed materials, posters, films, slides, videos, murals, flannel graphs and flip charts. These are useful for transmitting information and as support to the spoken word, but must be reinforced by interaction and personal contact with members of the target audience.

Using mass communication

Radio, audiocassettes, television, video, newspapers, placards, plays, puppet shows and megaphones are effective means of communicating information quickly to a large number of people and creating awareness of a problem or idea. The relevance and impact of messages, and the effectiveness with which they are communicated, need to be evaluated by discussion with a sample of people.

5.2.6. Choosing an approach

When deciding on the message and the communication methods to use, it is essential to:

- establish the need for, and relevance of, the hygiene education activity through an assessment that is as participatory as possible, given the nature and urgency of the situation;
- be aware that a hygiene education campaign may be aimed at some people who are not literate: in such circumstances, participatory learning techniques are the most appropriate;
- select and adapt methods to suit the characteristics and interests of the particular target group—young/old, male/female, membership of a religious group, etc. (e.g. fables about animals may be more suitable for children than adults);
- establish procedures at the outset for evaluating the effectiveness of the health promotion campaign, by selecting appropriate indicators for measuring changes in people's health status, behaviour and environment;
- reinforce existing health practices that are beneficial and discourage those that are harmful;
- choose messages that are positive, attractive and based on what people already know, what they want and what they consider to be achievable;
- involve people in the community in the production of their own teaching materials (this is educational in itself and will ensure that such materials are relevant and culturally appropriate);
- use the effectiveness of young people and children in teaching and mobilizing others;
- avoid messages that imply that people are to blame for their own or their children's ill-health: messages and methods must not be judgmental.

REFERENCES

Aron, J. L., and Patz, J. A. (eds.). *Ecosystem Change and Public Health: A Global Perspective* . Baltimore, Md.: Johns Hopkins University Press, 2001.

Athanasiou, T. *Divided Planet: The Ecology of Rich and Poor*. Boston: Little, Brown, 1996.

Ayres, J., Maynard, R.L., and Richards, R. *Air Pollution and Health* . Hackensack, N.J.: World Scientific, 2006.

Emmelin , A. , and Wall , S. " Indoor Air Pollution: A Poverty - Related Cause of Mortality Among the Children of the World . " *Chest* , 2007 , *132* (5), 1615 – 1623 .

Koren , H. , and Bisesi , M. *H andbook of Environmental Health and Safety: Principles and Practices* . *2* vols. (3rd ed.) Boca Raton, Fla. : CRC Press , 1996 .

Kovats , R. S. , and others. " The Effect of Temperature on Food Poisoning: A Time - Series Analysis of Salmonellosis in Ten European Countries . " *Epidemiology and Infection* , 2004 , *132* (3), 443 – 453 .

Loretti , A. , and Tegegn , Y. " Disasters in Africa: Old and New Hazards and Growing Vulnerability . " *World Health Statistics Quarterly* , 1996 , *49* , 179 – 184 .

Newton, L. *Ethics and Sustainability: Sustainable Development and the Moral Life*. Upper Saddle River, N.J.: Prentice Hall, 2003.

Passchier-Vermeer, W, and Passchier, W. F."Noise Exposure and Public Health." *Environmental Health Perspectives,* 2000, *108* (suppl. l), 123 – 131 .

Prüss-Üstün , A., and Corvalán, C. *Preventing Disease Through Healthy Environments* . Geneva: World Health Organization, 2006.