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Essentials of Environmental Sciences and Hygiene

for Nursing and Pharmacy Students

As per INC Syllabus/PCI (Pharmacy Council of India)



HCL Rawat
Satinder Kaur

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CHAPTER 3

Environmental Pollution

Learning Objectives

After study this unit students will be able to:

- Define water and sources of water.
- Discuss water pollution and control of water pollution.
- Discuss waterborne diseases and prevention.
- Describe various methods of water harvesting.
- Define air and composition of air.
- Describe air pollution and its ill effects on health.
- Give detail about management of air pollution.
- Enlist diseases caused by air pollution.
- Define noise.
- Describe sources of noise.
- Define noise pollution.
- Enumerate effects on human health of noise pollution.
- Describe about control measures of noise pollution.
- Define soil pollution.
- Describe causes and types of soil pollution.
- Explain different control measures for soil pollution.
- Define marine and marine pollution.
- Describe causes and effects of marine pollution.
- Describe control measures of marine pollution.
- Define radioactivity and radioactive pollution.
- Enlist sources of radioactive pollution.
- Describe causes of radioactive pollution.
- Describe effects of radioactive pollution.
- Enumerate control measures of radioactive pollution.
- Define housing.
- Describe housing standards and accurate location for housing.
- Describe construction of healthy house.
- Define ventilation.
- Enumerate type of ventilation.

WATER POLLUTION

Water is a transparent and nearly colorless chemical substance with chemical formula H_2O and is the main constituent of earth's streams, lakes, and oceans, and the fluids of most living organisms. Water strictly refers to the liquid state of that substance, that prevails at standard ambient temperature and pressure but it is also abundant in solid form as ice and gaseous form as vapors. In natural state it occurs as snow, glaciers, clouds, fog dew, etc. in solid and gaseous form.

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Definition

Water is a colorless, odorless and tasteless liquid, which plays vital role in animal and human life. This is important solvent to maintain normal physiological processes of life.

Major Physical Characteristics of Water

- Water is non-expensive and easily available molecule
- Water is a polar molecule
- Water can form hydrogen bond with other polar compound
- Freezing point of water is 0°C (32°F)
- Boiling point of water is 100°C
- Normal specific gravity of water is 1.0000 (4°C).

Sources of Water

Life is possible on earth due to the presence of water. Nearly three-fourths of the earth's surface is covered with water. About 70% of the human body is water. The bodies of all plants and animals contain water. Thus water is available in natural sources and manmade sources on earth like—rainwater, oceans, rivers, lakes, streams, ponds and springs are natural sources of water whereas wells, dams, hand pumps, canals etc. are manmade sources of water.

Rainwater

Rainwater collects on the earth in the form of surface water which is present on the surface of earth in oceans, rivers, lakes and underground water is present below soil and rocks. Basically underground water is the rainwater which seeped through soil and collects under the surface which can be obtained by digging wells, sinking tubes and through springs. The collection of rainwater is known as rainwater harvesting. On the surface of earth 94% of water is in oceans and 4% covered by groundwater whereas rivers and other sources cover < 0.01% and 2% is covered by glaciers.

Rainwater Harvesting

Rainwater harvesting is the activity of direct collection or storage of rainwater into dugs, wells etc. Rainwater can be stored for direct use or can be recharged into the groundwater aquifer. It helps to overcome water scarcity.

Purposes of rainwater harvesting:

- To conserve and encourage the storage of groundwater
- To reduce water table depletion
- To improve the quality of groundwater
- To arrest sea water intrusion in coastal areas
- To avoid flood and water stagnation in urban areas
- To meet increasing demand of water.

Methods of Rainwater Harvesting

There are two important methods for rainwater harvesting:

1. ***Surface runoff harvesting:*** In urban areas, during rain surface water flows off. This water can be stored and conserved and can be used to recharge aquifers by using appropriate methods.

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2. ***Rooftop rainwater harvesting:*** It is another method of conserving rainwater. In this method the rainwater is collected from roof of house/ building, surface of ground or pavement and stored in either a tank or diverted to artificial recharge system. This is less expensive, effective method to raise the groundwater level.

Components of Rooftop Rainwater Harvesting

- ***Catchment:*** The surface of roof of building, ground, courtyard etc. which receives rainfall directly is called catchment.
- ***Transportation:*** From the surface of catchment rainwater is carried to tank or storage area through pipes or slopes.
- ***First flush:*** The first shower of rain is flush off to avoid contaminating impurities of catchment surface present in rainwater. Provisions of first rain separator should be made at outlet of each drain pipe.
- ***Filter:*** The rainwater should pass through filter to effectively remove turbidity, color, microorganisms and impurities before storage.

  There are various types of filters available which are used to filter rainwater before harvesting.

  - ***Sand gravel filter (Fig. 3.1):*** This is common method of filtration where water is filtered by using pebbles, gravel and sand layers. Each layer of material is separated by wire mesh trough which rainwater passes before storage to separate impurities.

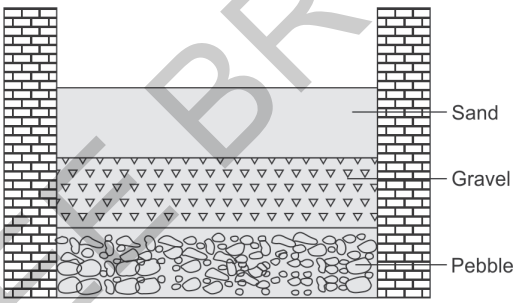


Fig. 3.1: Sand gravel filter

  - ***Charcoal filter (Fig. 3.2):*** Charcoal filter apparently work to sand gravel filter except by using another layer of charcoal in filter for cleaning and removing odor from rain water. This filter is also implanted in drums and each material layer is separated by wire mesh.

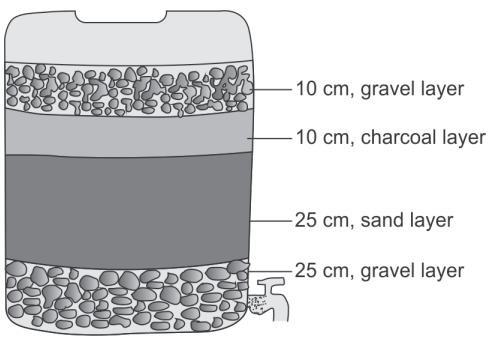


Fig. 3.2: Charcoal filter

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- ***PVC pipe filter (Fig. 3.3):*** In this filtration method PVC pipe is used to filter rain water with inlet at one end and outlet at another end. Pipe is divided into three compartments by using wire mesh and each compartment is filled with sand, gravel and charcoal, respectively. Use of charcoal is optional in this filter.

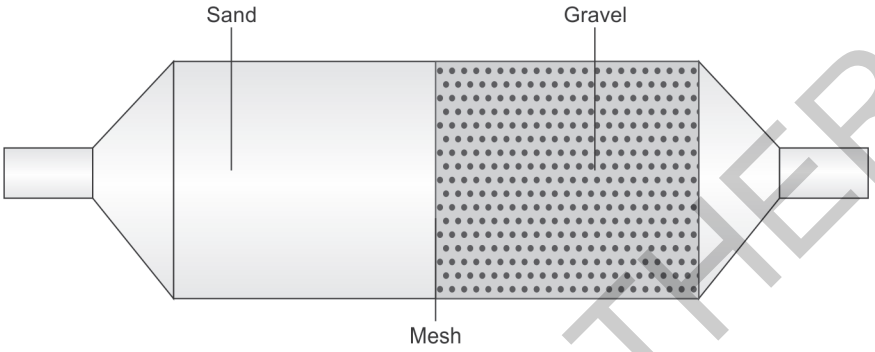


Fig. 3.3: PVC pipe filter

- ***Sponge filter (Fig. 3.4):*** This type of filtration is done by using PVC drum which have sponge in the middle of drum. This method of filtration is easy, less expensive and suitable for residential roof rainwater harvesting.

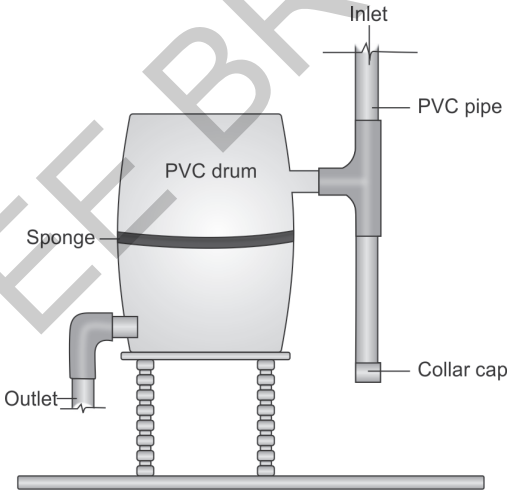


Fig. 3.4: Sponge filter

Types of Water

Water can be classified into two types:

1. ***Hard water:*** Hard water is enriched in minerals specifically in calcium and magnesium. If hard water is waste of industry become too dangerous. It has certain benefits because of enriched in minerals, it reduces solubility of potentially toxic metals such as lead, and copper. But it creates problem with use of detergent. It does not form leather when used with soap as well as leaves scales after wash.

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Hard water can be changed into soft water after treatment including exchange of ions.

2. ***Soft water:*** Water contains little or no dissolving salts of calcium or magnesium is considered to be soft and safe water.

   Soft water is the water which is used for drinking because it contains sodium or minerals and have good taste. It has no dangerous effects on health and does not leave any scales or deposits after wash. It forms good leather with use of detergent.

Physical Characteristics of Water

- ***Turbidity of water:*** Turbidity is measurement of amount of transparency which water has lost due to presence of suspended particles. Turbidity of water is measured by using turbid meter and units for turbidity are NTU (Nephelometric turbidity units).
- ***Color of water:*** Water is a transparent liquid but it reflects blue color because of scattered light absorbed by water is returned to surface and gives appearance of blue. If color of water changes to dull and dark color then it could be dangerous for flora and fauna. The color of water is determined by using tintometer.
- ***Taste and odor of water:*** In general good quality water is tasteless and odorless. The extent of taste and odor measured in water sample is known as odor intensity and is related with threshold odor number. In public supplies water should be odor free and minimum odor no. is 1 which should not exceed 3 for good quality of water.
- ***Temperature:*** For public supplies temperature of water 10°C is desirable which should not exceed 25°C.
- ***Specific conductivity:*** Specific conductivity indicates amount of ions dissolved in water and can be measured as how well water conducts electrical current. The electrical conductivity of deionizer water is 5.5 µs/m and for drinking water range of conductivity should be 5–50 mS/m.

Chemical Characteristics of Water

- ***Total solids and suspended solids:*** Total solids (suspended solids + dissolved solids) can be measured by residue after evaporation of water from sample. The permissible amount of total solids in good quality water is 500 ppm.
- ***pH value of water:*** pH of water indicates presence of H^+ ions in water sample. The normal pH value of water is between 6.6 and 8.4 and pH of water is measured by using potentiometer.
- ***Hardness of water:*** Hardness of water is caused by presence of sulfates, chlorides, nitrites, calcium and magnesium present in water. For public supply the desirable hardness of water is 75–115 ppm.
- ***Chloride content:*** The chloride content of water can be measured by titrating the water with standard silver nitrate solution using potassium chromate as indicator. The chloride content of treated water to be supplied to the public should not exceed a value of about 250 ppm.
- ***Nitrogen content:*** Nitrogen in water can be present in any form like free ammonia, nitrites, nitrates and organic matter, etc. The presence of high

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content of nitrogen in public supply can cause disease methemoglobinemia in infants. The desirable amount of nitrogen contents in public supply is 45 mg/ L.

Characteristics of Safe Drinking Water

The quality of drinking water can be measured by measuring following qualities of water:

- ***Contaminant free:*** The water is filtered of unhealthy toxins, including synthetic chemicals, toxic metals, bacteria and viruses, radioactive substances and other treatment additives such as chlorine and fluoride
- ***Mineral rich:*** The natural occurring minerals in the source water are not removed through purification processes, such as reverse osmosis and distillation.
- ***Alkaline pH:*** The drinking water has an alkaline pH between 7.0 and 9.5, which means that the water contains a healthy level of alkaline minerals such as calcium and magnesium.
- ***Micro-clustered:*** Water that is electrolyzed or 'reduced' will have smaller groupings of water molecules. Drinking reduced water can improve cellular hydration and cell-water turnover (i.e. nutrients into the cells and toxins out).
- ***Anti-oxidant:*** Water that is ionized has a negative oxidation reduction potential (-ORP) and thus acts to neutralize free radicals in the body and slows the oxidation (i.e. aging) process in the body.
- ***Good taste:*** The taste of water should be good to drink enough amount of water on regular basis to maintain normal health status.

Use of Water

Water is an important molecule for maintenance of life in biosphere. Water is a precious source of healthy life and for routine work. Humans, plants and animals are made up of mostly water.

Water is used for:

- For drinking purpose
- For household work like washing, bathing, cooking and cleaning etc.
- For building construction
- For the generation of steam for industrial use and electricity generation
- For the manufacture of hydrogen, oxygen and water gases
- For maintaninence of normal physiological processes of life
- For maintaninence of normal temperature in ecosystem
- For agriculture purposes
- For irrigation purposes
- For maintenance of aquatic life.

WATER POLLUTION

Water pollution refers to contamination of water sources natural and manmade which decreases quality of water and causes degradation of water for use. The contamination of water occurs when physical and chemical

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pollutants dissolved in water may be as a result of industrial waste or household waste.

Definition of Water Pollution

Water pollution can be defined as the addition of harmful chemicals and dissolvents in natural sources of water. This disturbs normal flora and fauna of water as well as put ill effects on health.

Or

A body of water, such as a lake, stream, river, pond, ocean and even the water underground in the soil, can become polluted when it is contaminated by sewage leaks, agricultural runoff or chemical spills and become unsafe for living organisms.

Sources of Water Pollution

Water pollution sources can be categorized into two parts:

1. ***Point sources:*** The point sources of water pollution are when pollutants leak from a discrete location like factory, sewage pipe and run off from single agriculture field which degraded quality of water in natural resources. The Bharat Petroleum oil spill in 2010 is an example of point source pollution, because the massive amount of oil leaked from a single point of origin.
2. ***Non-point sources:*** When water pollution occurs from addition of pollutants from various sources and contributes from a large area, e.g. one water source contaminated by multiple sources. The Mississippi river is at great risk for non-point source pollution because it is so large and is exposed to a variety of possible pollution sources. In Indian scenario The Ganga River is long and broad and is at great exposure for non-point pollution sources like industrial waste, residential waste, rain water ground surface waste, agriculture waste, etc.

Categories of Water Pollution

Surface Water Pollution

Surface water pollution is the pollution of water sources those are above the ground like rivers, lakes, streams, oceans etc. The pollution of these sources occurs when rain water runoff carrying pollutants of industrial waste, agriculture field chemicals, domestic waste etc.

Surface water can be classified into two categories:

1. ***Nutrient pollution:*** When pollution is caused by nutrients and fertilizers of agricultural field which leads to overproduction of algae on surface of water sources which inhibit the immersion of sunlight causes less production of oxygen by under water plants effects aerobic respiration of marine organisms leads to death of organisms under water.
2. ***Toxic chemical water pollution:*** When pollutants comes from waste of industries, agriculture pesticides, petroleum product wastes, car fluids etc which causes toxicity of natural water sources is called toxic chemical water pollution which effects aquatic life as well as life on earth.

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Groundwater Pollution

When water which is present below layers of earth gets contaminated is called groundwater pollution. There are various sources given below which causes groundwater pollution:

- ***Storage tanks:*** When leakage of storage tanks of gasoline, oil, chemicals or other liquids occurs this mix with water present below the layers of earth and cause serious contamination of groundwater results in ill effects of health on and below ground life.
- ***Septic systems:*** If septic tanks collecting excreta and organic waste of houses, building and offices is not properly constructed or attached with city sewerage system it seeped out and mix with groundwater causes organic contamination of ground water i.e. causes increase in number of bacteria, viruses or other microorganisms in ground water.
- ***Landfills:*** These are the places to dump waste material in huge amount or where garbage is to be buried. If surface of landfill is not solid and having cracks then unwanted material and microorganisms will seep in ground-water through soil causes contamination of groundwater.
- ***Chemicals and road salts:*** Chemicals, fertilizers, pesticides and salts used in making road seeped in soil with rainwater causes contamination of groundwater.
- ***Atmospheric contaminants:*** Since groundwater is the part of hydrologic cycle, contaminants in other parts of the cycle, such as the atmosphere or bodies of surface water can eventually be transferred into our groundwater supplies.

■ WATER CONSERVATION AND WATER SOURCES PURIFICATION

Water Conservation

Water conservation is a term used to save most important and vital inorganic molecule, i.e. water, required saving life on planet. Water conservation includes all the policies, strategies and activities made to sustainably manage the natural resources of fresh water and to protect water environment to save and meet the demand of present and future.

Definition of Water Conservation

Water conservation refers to the preservation, control and development of water resources, both surface water and groundwater and to prevent pollution of natural water resources.

Methods of Water Conservation

Water conservation becomes the need of the day to save present and future life on planet. Various efforts have been taken by governments of countries to save or conserve water by building dams, reservoirs, digging wells and by initiating recycling and desalination (removing salts) of water.

The most important and favorable methods are to conserve rainwater and to increase groundwater level by using various methods in India:

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- House in part of western Rajasthan is built in such a way that each has rooftop harvesting system and water is stored in tank and utilized for daily life activities.
- Nowadays it became mandatory in urban areas to leave little exposed earth during construction of houses, roads and pathways for soakage of water in ground which will help in increasing water table and will recharge the groundwater supply.
- Town planners and civic authority in many cities in India are introducing bylaws making rainwater harvesting compulsory in all new structures. No water or sewage connection would be given if a new building did not have provisions for rainwater harvesting.

Easy Steps to Conserve Water

- Turning the water off when brushing your teeth or washing your hair can save a lot of water.

  Purchase water-efficient products and appliances for your home. This includes dishwashers, sink systems, bathtubs and more.
- Plant your garden in the spring and you can save since water requirement levels are less during this season.
- Do not use water to defrost foods. Although many people do use this method it requires a lot of water consumption to do this.
- Check for leaks. This includes the toilet and the sinks in the home.
- Cut off the water supply to any areas in the home that you are not using.
- Do not throw away water that has been used for washing vegetables, rice or dals use it to water plants or to clean the floors, etc.
- Do not use unnecessary water flow for washing of vehicles instead prefer to dry cleaning of vehicles.
- Judicious use of water for agriculture and gardening.

■ WATERBORNE DISEASES

Waterborne diseases caused by consuming contaminated contain algae and pathogenic microorganisms. Outbreaks of waterborne diseases often occur after a severe precipitation event (rainfall, snowfall). Any disease that can spread through contaminated water. The contamination can involve bacterial, viral or protozoa organisms.

Definition: Waterborne diseases are caused by pathogenic microorganisms that most commonly are transmitted in contaminated fresh water. Infection commonly results during bathing, washing, drinking, in the preparation of food, or the consumption of food thus infected.

Risk Factors

- Droughts can cause increased concentrations of effluent pathogens, overwhelming water treatment plants and contaminating surface water. Older water treatment plants are particularly at risk.
- Changes in ocean and coastal ecosystems, including changes in pH, nutrient and contaminant runoff, salinity, and water security that can

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cause degradation of fresh water, particularly in areas where much of the population uses untreated surface water for daily consumption and activities.

- Increased frequency of intense extreme weather events can cause flooding of water and sewage treatment facilities, increasing the risk of waterborne diseases.
- Indirectly, the lack of water can cause pressure on agricultural productivity, crop failure, malnutrition, starvation, population displacement, and resource conflict.
- Changes can occur in the distribution and concentrations of chemical contaminants in coastal and ocean waters through the release of contaminants previously locked in polar ice sheets, or in runoff from coastal and watershed development.

Types

- ***Waterborne diseases:*** Diseases where water act as passive vehicle for microorganisms to reach out in agent and causes infection.
- ***Water washed diseases:*** Disease which occur due to less availability of water, poor personal hygiene and infections occur due to improper waste disposal.
- ***Water-based diseases:*** Infections occur due to ingestion of water containing hazardous microorganisms.
- ***Water-related diseases:*** Infections transmitted by insects living close to water.

The diseases related to water supply and consumption of contaminated water.

Biological

Common biological diseases are:

- ***Diarrhea and dysentery:*** Diarrhea is a disease caused by consuming contaminated water and very common in under five years age children. This causes about 2 million deaths every year among children with age under five.
- ***Intestinal worms:*** Intestinal worm ingestion occurs due to poor sanitation and consuming contaminated water and food. This can lead to malnutrition anemia and retarded growth depending upon the severity of infection.
- ***Trachoma:*** Trachoma is infection of eye caused by bacterium *Chlamydia trachomatis* caused by poor sanitation and contaminated water use. Trachoma can cause trichiasis leads to irreversible blindness.
- ***Schistosomiasis:*** Schistosomiasis is chronic waterborne disease caused by worm schistosoma also known as bilharzias disease. This occurs due to infestation of fresh water containing cercariae of parasites released by snails. Schistosoma causes hypersensitivity and bladder infections.

Chemical

- Common chemical diseases caused by water are acute toxic effects and fluorosis which may cause methemoglobinemia in infants.

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- Cancer widespread life threatening diseases outbreak occurs due to chemical pollution of water by industrial waste and agriculture pesticides mixing in groundwater.
- Chemical like mercury, cyanide, sulfuric acid, arsenic and methyl mercury used for mining are mix with water sources and cause water pollution results in various human health diseases as well as marine death.

Classification of waterborne diseases are given in Table 3.1.

Table 3.1: Classification of waterborne diseases as per infective agent

S. no.	*Infective agent*	*Disease*
1	Viral	Viral hepatitis A, hepatitis E, poliomyelitis, rotavirus diarrhea in infants
2	Bacterial	Typhoid and paratyphoid fever, bacillary dysentery, *E coli,* diarrhea, cholera
3	Protozoal	Amebiasis, Giardiasis
4	Helminthic	Roundworm, threadworm, hydatid disease
5	Leptospiral	Weil's disease
6	Snail (aquatic host)	Schistosomiasis
7	Cyclops (aquatic host)	Guinea worm, fish tape worm

WATER PURIFICATION

Water purification is the removal of contaminants and microorganisms from raw water to water quality and to make water safe for consumption for human beings. Substances that are removed during the process include parasites (such as *Giardia* or *Cryptosporidium*), bacteria, algae, viruses, fungi, minerals (including toxic metals such as lead, copper etc.), and man-made chemical pollutants.

Water purification can be done at small scale and large scale.

Small Scale Water Purification

1. Household purification of water
2. Disinfection of wells

Household Methods for Purification of Water

Boiling

- Easy and less expensive method of water purification at home.
- Water must be brought to 'rolling boil' for 5–10 minutes.
- Removes temporary hardness of water.
- It kills all microorganisms like bacteria, spores, cysts and ova present in raw water.
- Taste is altered with boiling but it is harmless.

Chemical Disinfection

Bleaching Powder (Chlorinated Lime)

- Bleaching powder ($CaOCl_2$) contains chlorine with pungent smell
- Chlorine is very effective against bacteria, viruses and fungi which are pathogenic for human health.

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- Removes chemical compounds that have unpleasant tastes and hinder disinfection.
- Principle in chlorination is to remove a free residual chlorine of 0.5 mL/lit at the end of 1 hour of contact.

Chlorine Solution

- Chlorine is prepared from bleaching powder.
- Chlorine is applied on massive scale.
- Chlorine is very reactive element and forms compound with other elements of water.
- Chlorine levels up to 4 milligrams per liter are safe amount to mix in drinking water.

High Test Hypochlorite

- Hypochlorite is a calcium compound which contains 60–70% of chlorine.
- More stable compound than bleaching powder.
- 1 g of HTH with 70% strength is required to disinfect 1 liter of water.

Chlorine Tablets

- Chlorine tablets are extremely cheap method to purify household water.
- These tablets generate chlorine dioxide after coming in contact with water.
- 10 g chlorine tab generate 1 ppm of chlorine dioxide in 1000 L of water.
- It needs 4 hour treatment period for water before use.
- Chlorine tablets are used to purify drinking water in outdoor activities and emergency situations like disaster management sites.
- It changes after taste of water.

Iodine

- Available in the form of tablets.
- Can be used as an emergency disinfectant of water.
- When you are using iodine tablets you must be aware about water temperature.
- For purification of water within 30 minutes temperature of water should be 75°F and if need one hour then temperature should be 40°.
- Iodine effect persists longer than chlorine tablets.
- These tablets can be used only for persons with standard thyroid function.
- Each tablet contains tetraglycine hydroperiodide, which releases 8 ppm of titrable iodine.
- Two tablets treat one quart of water.
- Iodine tablets kill bacteria, viruses and giardia present in water.

Potassium Permanganate

- It is no longer recommended.
- It is a powerful oxidizing agent but not a satisfactory agent for disinfection of water.
- It may kill vibrio cholerae but not other types of bacteria.
- It alters the color, odor and taste of water.

Filtration of Water

- Filtration is an easy method used at small scale to purify water.
- Water filter which can be used are Pasteur Chamberland, Berkefeld filter and Katadyn filter.

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Essentials of Environmental Sciences and Hygiene for Nursing and Pharmacy Students

This textbook is a comprehensive module to learn about environmental sciences and hygiene for Nursing and Pharmacy students. A concise text about environment, pollution and health hazards is tailored to suit the Pharmacy Council of India (PCI) requirements for General Nursing and Midwifery, BSc Nursing and Pharmacy students comprises of latest information about environmental problems, conservation projects and health problems coming up with day-to-day changes in natural climate for life on earth. The book context is simple, clear and understandable for students. The first edition of book impressively contains all information about ongoing and recent projects of environmental conservation at national and global level to increase awareness about importance of environmental protection and conservation. The students will realize that this book as helping hand in understanding fundamentals of environmental sciences and hygiene as well as acquiring recommended knowledge for preparation to qualify examination.

Highlights

- The textbook covers the curriculum recommended by regulators for both Nursing and Pharmacy students
- Thorough information related to environmental sciences and hygiene
- Detailed context related to natural resources and their conservation
- The government as well as community role in prevention of pollution, health hazards and climate preservation
- Educate people and patients about the importance of environmental hygiene and protection of natural environment
- Detailed information related to disaster management.



HCL Rawat is a postgraduate of Delhi University (1995) and currently pursuing PhD from Baba Farid University of Health Sciences (BFUHS), Faridkot, Punjab, India. Presently, he is Professor and Principal at University College of Nursing, a constituent college of BFUHS and Editor-in-Chief of Baba Farid University Nursing Journal (BFUNJ) and Journal of Nursing Research Society of India (NRSI). He acted as Dean, Faculty of Nursing Sciences, BFUHS and also Active Member of board of studies of various universities. He is also member of selection committee for nursing faculty of various institutions and universities. He is an Active Member and President of NRSI (North zone), National Neonatology Forum (NNF), Indian Association of Neonatal Nurses (IANN), and Trained Nurses Association of India (TNAI). He has published many papers, chapters in books, conducted and chaired sessions in various National and International conferences, organized more than 65 various National and International conferences and workshops. He acted as a Supervisor for more than 50 thesis projects of PG students and significantly contributed in establishing center for excellence in collaboration with University of British Columbia, Canada and visited the same universities.



Satinder Kaur is a postgraduate from Baba Farid University of Health Sciences (BFUHS), Faridkot, Punjab, India. Presently, she is working as Faculty at University College of Nursing, a constituent college of BFUHS and Associate Editor of Baba Farid University Nursing Journal (BFUNJ). She has conducted various research projects. She has published and presented various award winning papers in National and International conferences. She is an Active Member in organizing committees of National and International conferences and workshops. She is Member of Foreign Affairs committee of BFUHS.

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