Health and Environment: Action-*based* Learning

(HEAL)

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Acknowledgements:

Students represent a large body of workforce, which can perform many useful tasks. In the international educational project, GLOBE, students from all over the world are collecting data about different environmental parameters. These data are being sent to a large team of American scientists in different disciplines, which analyse and use these data to predict climatic changes and other related issues. We have been guided and inspired by several Globe experiments and methodology.

The Centre for Science and Environment, New Delhi, with its fortnightly publication, *Down to Earth*, is playing an important role in raising environment-based issues in the country. We have greatly benefited by the different issues raised in the publication.

The different resource persons, teachers, scientists associated with BARC and other scientific Institutions, medical doctors with Brihan Mumbai Municipal Hospital and BARC hospital, retired scientists and Navi Mumbai Municipal Corporation (NMMC) have provided us complete support at all stages. The public health department and other departments of NMMC have co-operated with great enthusiasm.

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The Centre Director, Dean and colleagues in the scientific and administrative streams, have all encouraged us in this new initiative.

We are grateful to all.

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INTRODUCTION

Health and environment are intricately linked, but few among us seem to realize this. Rapid urbanization and industrialization has deteriorated our environment considerably, leading to a heavy burden of environment-related diseases. These range from the fatal cancers to chronic problems of cough, asthma and cold to a variety of gastro-intestinal problems and vector-borne diseases, to eye and skin irritations. Our burden of diseases is going to increase in the next decade or two, as more and more people from villages with shrinking agriculture and new world trade norms, migrate to towns and cities.

In a new initiative, Health and Environment: Action-*based* Learning of Homi Bhabha Centre for Science Education (TIFR) attempts to bring health and environment on a common platform. Students, under the supervision of oriented and trained teachers, will be carrying out surveys, collecting data and performing experiments to bring out the quality of the environment and health (in selected site areas). Besides leading to a culture of scientific data collection and analysis, this methodology has the potential of creating mass awareness and sensitizing our young students (and adults) about these important issues.

Both environment and health are complex concepts with many dimensions. Environment of an individual includes: (**a**) internal environment, incorporating the indoor environment of home and work places, and (**b**) external environment, consisting of air, water and soil and related dimensions in public domain. In the first part of this program, the external environment -- air, water and soil --- will be studied. Several physical and chemical parameters under each head, in addition to solid waste management, green cover, and noise and traffic pollution are included. These combined, could give information about the quality of our environment.

In the second part of the program, environment related diseases, largely communicable diseases caused by pathogens, would be monitored in terms of morbidity and mortality caused by them. These include, diseases of the upper, middle and lower respiratory tract, gastro intestinal diseases, vector-borne diseases, noise induced hearing loss, and others like skin and eye irritations. For

establishing correlations between diseases and pollution, the exposure time and dose of the pollutants received by individuals needs to be considered.

This will be a long-term, open-ended programme, involving HBCSE and other resource persons, teachers and students of schools and colleges. In this three-tier program, teachers will be oriented at HBCSE, who, in turn, will train/motivate their students in carrying out experiments and data-collection about different parameters of environment and health. Students will be collecting and filling in data according to protocols prepared by HBCSE. Simple activities are included so that later school students also could monitor their environment and health.

The protocol developed by HBCSE and tested in the pilot study has given us confidence to launch the programme on a larger scale, when in this academic year, more students, especially those associated with the National Social Service of the University of Mumbai, will participate. The methodology of the programme will remain the same and we expect to cover additional nodes of Navi Mumbai in this phase. All studies and surveys will be carried out during vacations (April-May; October-Nov.; Dec.-Jan), or seasonally, or even on a monthly basis if there is enough motivation among students and their teachers.

The Health Department of Navi Mumbai Municipal Corporation has offered its co-operation in this programme: An electronic air monitor is already installed at Vashi, health-related and water quality data will be provided to teachers and HBCSE for validation. High volume air samplers will be made available to students/teachers.

This programme provides a platform to students and teachers to introduce novel experiments/projects. Other elements of the programme are:

- Association with prestigious scientific institutions in the city.
- Interactions with scientists from India and abroad.
- The project will help participants to explore their organizational skills and creativity in this scientific endeavour of vital importance to the nation.

Suma Nair
Bakhtaver S. Mahajan
(Programme co-coordinators)

‘Air’ watch…

for good health

INTRODUCTION:

The surrounding -- ambient -- air, generally termed as atmosphere, has been taken for granted by humans. Breathing in and out, billions of time from birth till our death, the quality of air has a direct impact on our health, and on other life forms on this planet. The air quality keeps on changing on a daily and even on an hourly basis. The ‘development’ process and increasing industrialization has led to considerable damage and pollution of the atmospheric layer. To improve air quality, it is important that we have a scientific understanding about the atmosphere and take steps to prevent its further deterioration**.**

Earth’s atmosphere is composed of many layers, based on the changes in the vertical temperatures as follows:

- **Troposphere** - It is the lowest layer (up to 10 km) of the atmosphere nearest to earth. It is the storehouse of all major air pollutants, in particular the mixing layer, 1-2 kms height from the earth’s surface.
- **Stratosphere** - It ‘extends’ from the troposphere to about 50 km. Being less dense than the troposphere, there is less mixing of molecules here. Pollutants in this layer reside for extended periods, leading to long-term global hazards. Stratosphere also contains the ozone layer, which absorbs the UV radiation, thus protecting life on the earth. Exposure to UV is known to cause skin cancer in humans.
- **Mesosphere** - It occurs above the stratosphere extending to a height of 80 km. Low temperatures (often as low as –100 ^{0}C) are observed here.
- **Thermosphere** – It occurs above the mesosphere. Here temperature increases with height. The atomic oxygen present in the upper part of this layer filters ultraviolet (UV) radiation. This is important as the harmful UV rays could otherwise enter into the inner layers of the atmosphere.

The atmosphere comprises of a mixture of, gases held to the earth by gravity. A sample of dry air from any region at ground level shows the following major constituent gases: about 79% nitrogen, 20% oxygen and 1% of other gases, including water vapour and carbon dioxide.

Besides these gases, the natural atmosphere also contains gases (water vapour, carbon dioxide and ozone) whose concentrations keep on varying due to various processes, both natural and due to human activities (anthropogenic). In addition, non-gaseous constituents like smoke, dust and sea salt particles are also present.

Atmosphere is a finite, non-renewable resource that has to be conserved and treated with care. Unfortunately, today it is being used as a dumping place for several gases, endangering our health and existence on this earth.

WHAT IS AIR POLLUTION?

Atmosphere is a dynamic system that continuously absorbs a wide range of solids, liquids and gases from both natural and various anthropogenic sources. These substances are often dispersed and transported over long distances through air. They react with one another and with other substances at both physical and chemical levels. Most of these substances eventually find their way into a sink, such as oceans and soil, or to a receptor, such as man, other life forms and vegetation, depending on their residence time.

Air pollution is the presence of foreign substances in air. Contaminants, which interact with the environment to cause toxicity, disease, physiological defects and environmental degradation, are labeled as pollutants. In fact, some scientists consider any phenomenon (even fog) or substance causing inconvenience to humans as a pollutant. The various sources of pollutants can be broadly classified as:

- Natural sources: forest fires, sea spray, volcanic eruptions, and from the earth crust. Here the pollutants are: fog, mist, pollens and bacteria.

- Anthropogenic sources: emissions from industry, automobiles, power stations and smelters, waste incineration, biomass burning, etc.
    - Combustion sources: stationary (industry) or mobile (vehicle).

  Here the pollutants are: aerosols (particulates), dust, smoke, and fumes and gases and vapors of sulphur dioxide, carbon monoxide, nitrogen oxide and volatile organic compounds (VOC).

ANALYSIS OF AIR:

Attempts will be made here to find out the quality of air in specific locations by studying some physical and chemical properties. Analysis of the chemical composition of air requires sophisticated instruments, not easily available in schools and colleges. Hence, the students may have to approach the appropriate authorities of their local municipalities or study air monitoring indicators/stations to obtain relevant data. Alternatively, they can obtain information from some TV telecasts on pollution status.

Wind speed (zero, low, medium or high) and wind direction are known to affect the dispersion of different pollutants. Liquid or solid precipitation, like rain or snow, is known to wash off pollutants from the air and also dilute their concentrations. Cloud colour, especially grey, brown-black, and orange clouds and the presence of smog and odour are strong indicators of air pollution. Hence, these factors should be considered while performing the experiments.

- The physical properties of air to be examined in this programme are: temperature, odour, and particulate matter.
- The chemical properties to be examined are: pH of precipitation, different air pollutants--carbon monoxide, sulphur dioxide and nitrogen dioxide.
- Vehicular pollution is also highlighted via activities, such as, vehicle density in a given area.
- The noise levels will also be monitored. Data will be collected preferably by using a noise meter.

Sampling details:

Choose a convenient site, preferably the same site for water bodies and soil analysis. The site should be a native, undisturbed open plot, with minimum structural obstacles and dumping. Air sampling can be done either by using a mobile high volume air sampling pump, or from the digital display board in the area, if available. Both these devises give information about the air quality of the *immediate* surrounding area only.

Guidelines for monitoring air quality:

1. Site selection: The big picture should be clear. In other words, participants of the study should know what they are looking for and why, i. e., whether one is studying the air (environment) quality of a road, node, sector or city. Accordingly, the sampling sites should be *representative* of the area and give a whole picture of the study area.
   The study is classified at different levels-scales--depending on the area of the site:
   - Micro -----a few metres to about 100 metres
   - Middle----100 mts to 500 mts
   - Neighbourhood---0.5 km to 4 kms
   - Urban---4-50 kms
   - Regional---The geography should be of homogenous nature
   - National/Global---Trans-boundary issues and global status.

   (Depending on the objective of the monitoring, one chooses the appropriate scale. For instance, if the objective of the study is to monitor the effect –source impact--of air pollutants on a population, then the appropriate site-scale could be: neighbourhood, urban, or even micro or middle levels measurements, according to convenience.)
2. Air monitoring devises are sensitive and site specific.
3. Continuous monitoring system: Electronic air monitoring indicators, which record the concentrations of major pollutants in the air on a continuous basis, are the best option.

4. Alternatively, approach an environmental consultancy company or monitor using a high volume air-sampling pump (details given later). Here the analysis of gaseous pollutants is based on absorption techniques.
5. Averaging period: Ideally, air monitoring and keeping its record should be done on a daily basis, at different times of the day (early morning, morning peak hour, mid afternoon, late evening and at late night), depending on the standards set (24 hrs standard. etc).
6. Monitoring the air quality with change of seasons is imperative. This is more so, before and after the monsoons, and in winters when dispersion is minimum.
7. Monitoring the air before, during and after certain festivals (like Diwali), and at different sites (traffic junctions, green parks, etc) could give interesting results for source identification.

Depending on the availability of the number of air sampling units, different strategies for air sampling is to be adopted. The points to keep in mind are:

- Wind data (location specific for previous years).
- The location and contours of the sites.
- If air monitoring is to be done at many different sites, then group them according to their location, wind direction and contours.

All samples for gaseous pollutants should be refrigerated and analysed within 48 hours.

STANDARDS:

Every country has its own set of standards or limiting concentrations for air and water pollutant. Any increase or rise of the pollutants above these limits is considered harmful to human health. These standards are based on the severity of the health effects (on humans, vegetation and other materials) caused by each of the pollutants.

The Ministry of Environment and Forests under the Environment Protection Act 1986 has formulated standards in India for different air (and water) pollutants. Standards have been set for vehicle emissions and day and night noise levels, too. (Standards are given separately under relevant heads in the worksheets.) The Central Pollution Control Board (CPCB), New Delhi, a statutory body constituted in 1974, is entrusted with the powers and functions to enforce the statutes (laws, etc) to control, prevent and decrease pollution in the country. This is carried out through the State Pollution Control Boards. In Maharashtra, the competent authority is Maharashtra Pollution Control Board (MPCB).

The standard values for different pollutants vary with the nature of sites, such as sensitive areas (national forests, hospitals zones and sensitive ecosystems), and industrial, residential and other areas, like commercial zones. The standards for different pollutants are checked at different durations depending on their dispersion rate, volatility and settling time.
The concentration of the chemical components in air is expressed in micrograms per cubic metre of air (μg\m^3).

Physical Properties: Activity 1

TEMPERATURE: Activity 1

The temperature of a place shows day/night and seasonal variations. It also differs with the altitude of the place. Temperature has influence on the precipitation and chemical cycles occurring in the atmosphere. Temperatures above 27ºC speeds up different chemical reactions in the atmosphere. Low temperatures, below 15ºC lead to condensation of fine particles.

A U-shaped maximum-minimum thermometer is used to measure the air temperature. On one side of the thermometer, the temperature increases as you read from the bottom to the top: this is the maximum side. On the other

side, the temperature decreases from the bottom to the top. The thermometer should be calibrated before taking the reading. Read the manual of instructions of the manufacturer and then set up the thermometer.

Materials required:

A maximum-minimum thermometer, pole or a wooden vertical post to nail/hold it. Avoid rooftops and concrete\paved surfaces as these can become hotter than a grassy surface and alter temperature readings.

Experimental procedure:

1. Mount the thermometer on a pole allowing air to circulate around it. It should be placed, in shade, 1.5 meters above the ground. The location should eliminate all vibrations.
2. Students should read the thermometer daily around 8.00 am, 12 noon, 4.00 pm and 8.00 pm, and note both the maximum and minimum temperatures. To avoid errors, do not touch or breathe hard near the thermometer bulb.
3. Students should read the thermometer with the eye and the top of the mercury column at the same level. Note the temperatures and report the average readings in Air Worksheet: Activity 1 (AWS: Activity 1).
4. Reset the thermometer by dragging the mercury column to the zero levels with a magnet and take the next set of readings.

ODOUR: Activity 1

This characteristic (along with certain visible characteristics like dark clouds, haziness or smog) is the first indicator of polluted air. Odour is defined as the sense of smell. Garbage dumps, sewage works, agricultural practices, exhaust from motor vehicles are some sources of odours. Industrial and food processing units, oil refining, paper and tanneries are other major odour producers.

Every chemical or pollutant has a distinct odour. For instance, the sulphide compounds in the air produce a distinct foul odour of rotten eggs. Foul smells may not cause direct damage, but may become a nuisance, causing discomfort, nausea, insomnia and headaches.

Experimental procedure:

This is a subjective experiment. The observer will sniff the air and note for specific smells. The smell may be defined as: odourless, foul, fishy, smell like rotten eggs, sweet, pungent, marshy or stale (Air worksheet: AWS: Activity 1).

To familiarize with the different smells, try out the following chemical reactions. Take care with strong acids (nitric and sulphuric acids) and the final product chlorine released in the second reaction.

$$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$$

(This produces reddish-brown fumes, with smell of NO_X.)

$$2NH_4Cl \xrightarrow{\Delta} 2NH_3 + Cl_2 + 2H$$

or

$$MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$$

(The release of chlorine gas produces a distinct odour.)

$$FeS + H_2SO_4 \longrightarrow FeSO_4 + H_2S$$

(This reaction gives a distinct odour of sulphide compounds.)

PARTICULATE MATTER: Activity 2, 3

The term “particulate matter” also termed as aerosols are small aggregates of solid and liquid particles in the air. These particles are composed of a carbonaceous fraction (sooty carbon), water-soluble inorganic fraction (ions of chloride, sulfate, nitrate and ammonium), and water insoluble inorganic fraction of elements and oxides. Their size approximately ranges from 0.0002μm to 500μm. They are generally categorized as Total Suspended

Particulate Matter (TSPM) and Respirable Suspended Particulate Matter (RSPM). The particulate size of less than or equal to (≤) 10 µm falls in the category of RSPM.

Depending on their size, different particles have varying settling velocities: for instance, smaller particles between 0.1-1µm settle easily in still air, while particles larger than 1µm have small but significant settling velocities. Aerosols of 20µm sizes have large settling velocities. The different classes of particulate matter are as follows:

Particulate matter	**Size (of diameter)**
Fine dust	less than 1µm
Coarse dust	above 100µm
Fumes	0.001 to 1.0µm
Mist	0.01 to 10.0µm
RSPM	≤ 10 µm
Fine (inhalation risks)	≤ 20 µm

Courtesy: Env. Biology, B. Mukherjee 1µm = 1 micron

Aerosols, such as mist and pollen dust, are produced naturally. Various human activities, such as industrial emissions, mining and quarrying, automobile exhaust and burning of fossil fuels also contribute to the aerosol load. Smoke consists of carbon or soot particles or tarry droplets. These are less than 0.1 µm in size and suspended in air. This smoke results from incomplete combustion of carbonaceous materials such as coal, oil and wood.

High concentration of aerosols in the air causes reduction of visibility with the sky appearing grey and hazy. The resultant haze, which is the most common indicator of particulate pollution, is due to the absorption and scattering of light by air particulates.

These aerosols have an adverse effect on health. They can easily enter and pass the filtering mechanism of the respiratory system and get deposited either in the trachea, walls of the air sacs, and the lung tissue. This results in

various respiratory disorders of upper, middle and lower lung infections. Variety of cardiac problems and even lung cancers are attributed to air pollutants. Recent research reveals that fumes and smoke from *chullahs* in homes, especially when wood is used as fuel, causes severe damage to the inmates. Women are the easy targets. This problem is multiplied in ill-ventilated homes.

Aerosols also have a killing effect on plants and other materials, like metals and buildings. Dust from cement kilns and other construction works including roads, combines with mist or rain and settles as a crust on the leaves of plants. Particles containing fluorides also cause damage to plants.

Materials required:

A vacuum pump of known flow rate, tubing, filter holder and glass fibre filter papers of appropriate size, or Whatman 1 or 41 papers.

Note: The collection efficiency will vary depending on the type of paper used. (This expt. does not use the high volume air sampler.) As the results of particulates are expressed as μg\m^3, the flow rate of the pump should be known. This information is available in the booklet of the manufacturer or displayed on the machine.

Experimental procedure:

Activity 2a:

1. Fix one end of the pipe to the pump and to the other end attach a filter holder with the fitted filter paper. Weigh the fresh filter paper before the experiment. (As Whatman paper made of cellulose acetate absorbs moisture, hence use a desiccator before and after weighing.)
2. Place the instrument in an open area in the site. Start the pump for a fixed time (two hours with regular breaks for the pump to cool).
3. Observe the deposition of particles on the filter. Weigh the filter and note (AWS: Activity 2).
4. The difference between the two weights gives a value of the amount of the particulates present in the sucked air.

5. Repeat the same process with other filters. The volume of the air sucked in a given time is fixed and mentioned on the pump.
6. For accurate results, contact the local municipality. Many municipalities give the particulate concentrations in terms of Total Suspended Particulate Matter (TSPM) and Respirable Suspended Particulate Matter (RSPM). Fill out the details in the data sheet (AWS: Activity 2a)

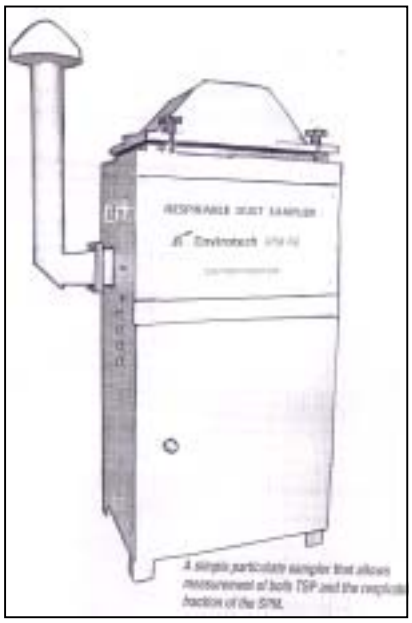
Activity 2b:

Repeat the above at different sites: residential, industrial, commercial, sensitive and traffic junctions. Try to perform this expt. at different times.

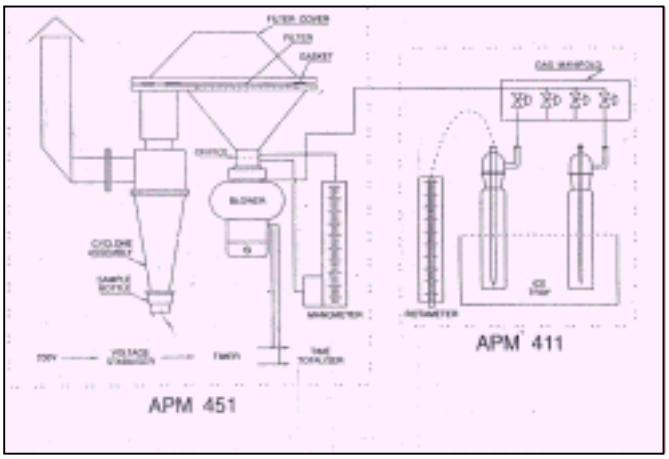
Activity 3:

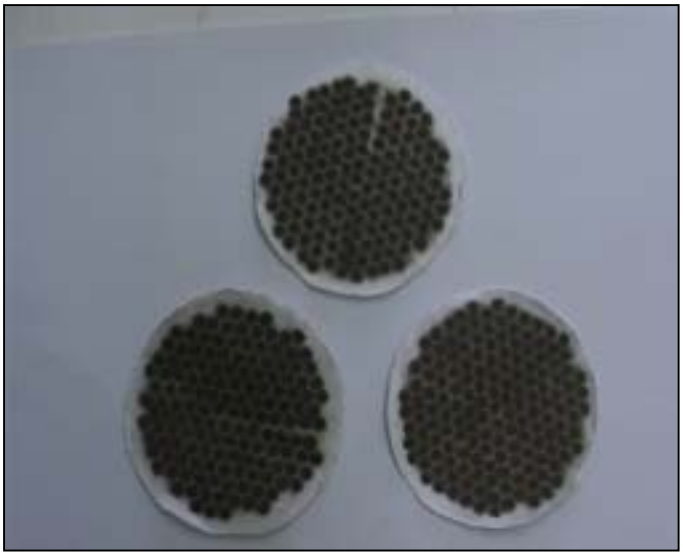
Depending on their sizes, particulate matter deposit in different sites in the respiratory tract. (Note that inhaled particles of about 20 μm deposit in the nose and upper air ways; 7 to 20 μm in bronchioles and still smaller aerosols are of about 0.5 to 7 μm.) This activity, assign the site of deposition for particulates of different sizes.

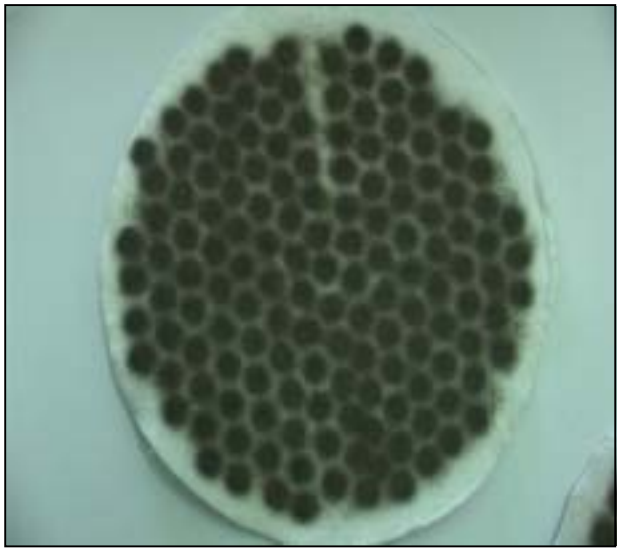
A high volume air sampler



Internal design of high volume air sampler







Courtesy: Environmental Assessment Division, BARC

Air particulate matter at Anushakti Nagar, Mumbai:

Wt. of particulate matter= 8.8 mg
Volume of air =144 m^3
TSPM concentration =200 $\mu g\ m^{-3}$

Details of Sample Collection

Sampling duration	= 24 hours
Flow rate of pump	= 100 litres / min
Total volume of air collected	= 144,000 litres = 144 m^3
Wt. of blank filter paper	= 0.5211 g
Wt of filter paper + sample (TPM)	= 0.5499 g
Wt. of TPM	= 0.0288 g
Concentration of TPM	= 0.0288 g/ 144 m^3 = 200 $\mu g\ m^{-3}$

Chemical Properties: Activity 4, 5

The common sources of air pollution in our country are: vehicular exhausts, industrial emissions and domestic combustion, such as burning of fuels, like kerosene and wood, and burning of garbage. These sources give out large amounts of chemical gases. Here a few chemical parameters of air will be studied. All the gaseous pollutants can be monitored from media, municipality-display boards or high volume air sampler (HVAS).

pH OF PRECIPITATION: Activity 4

Natural rain from the least polluted place on the earth is slightly acidic (pH between 5 and 6). This acidity is due to the presence of carbon dioxide in the air, which dissolves in the rainwater to form carbonic acid. Rainwater of greater acidity includes traces of strong acids, such as sulphuric acid and nitric acid. These strong acids have their origin in the gaseous sulphur oxides (SO_x) and nitrogen oxides (NO_x) present in the air.

The acid load in the atmosphere originates from fossil fuel combustion, contributed by industrialization and vehicular emissions. The resultant acid rain has a pH of 4.0-4.2 and is potentially damaging to the environment. It affects freshwater fishes, material surfaces and vegetation. The growth of vegetation is greatly affected leading to its reduced growth and inhibition of seed germination. Acid rains also cause a significant damage to material surfaces, especially metals due to its corrosive property.

Materials required:

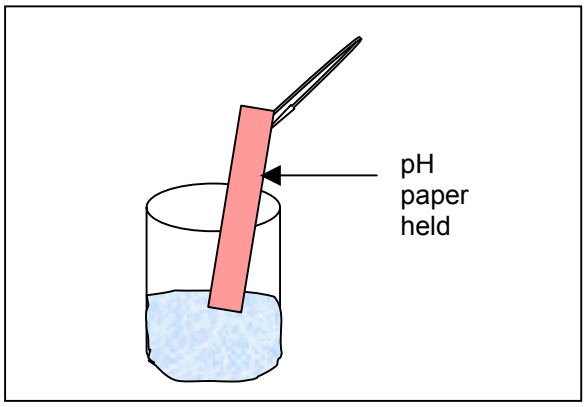
pH paper and a 100ml beaker/glass container.

Alternatively, one can use a pH meter too, if available. Before use, its calibration and being familiar with its principles and working is important.

Experimental procedure:

1. In a clean and dry beaker, collect the rainwater.
2. Use a forceps to hold the pH paper.
3. Dip a strip of pH paper into the rainwater.

4. Hold the pH paper in the water for 20 sec.
5. Make sure all sides of the pH paper are well immersed in water.
6. Remove the paper from the beaker and read the colour developed against the colour chart provided with the pH booklet.
7. Note down the corresponding value of the pH in the Air Worksheet (AWS-Activity 4).



CARBON MONOXIDE: Activity 5

Carbon monoxide (CO) is formed when carbonaceous fuel is burnt, under conditions of insufficient oxygen. The main contributors of CO are: automobile exhausts, petroleum refining operations, electric and blast furnaces, gas manufacturing plants and coalmines. The average rate of increase of CO is about 0.03 ppm\year (0.03 mg\l). The national ambient quality standard is 4 mg\m^3 and 10 mg\m^3 (1 hour) for residential and industrial areas, respectively. Above this concentration, CO acts as a pollutant.

High concentrations of carbon monoxide cause physiological and pathological changes in humans, ultimately leading to death. It binds 250 times more strongly than oxygen to hemoglobin in the blood. It inhibits many haeme – containing enzymes and interferes with oxygen transport by blood leading to physiological problems, brain damage and finally death.

As a pollutant, carbon monoxide does not have any damaging effects on material surfaces. At concentrations, below 100 ppm it does not show any drastic effect on the plant life. However, long exposures of even minute amounts of this gas leads to chronic injury of plants. Most instruments have a detection limit of 2 ppm (2 mg/l), making monitoring of low concentrations of CO difficult.

Experimental procedure:

Data for this gas should be collected from your local municipality, from public displayed air monitors or from TV channels. Alternatively, use a standard high volume air sampler pump. (Enter the result in Air worksheet (AWS: Activity 5).

Principle: This gas is analysed using the non-dispersive infrared absorption method. (The amount of CO in air is proportional to the distension of diaphragm, this distension being proportional to the intensity of radiation passing through the sample and reference cells.)

SULPHUR DIOXIDE: Activity 5

It is the most prevalent gaseous air pollutant in India. Burning of fossil fuels, such as coal and petroleum and domestic garbage are the major producers of this pollutant. Coal and petroleum contain varied amounts of sulphur compounds. Good quality coal, technically known as anthracite, is identified with less (less than 1%) sulphur. Bituminous coal, plenty in India, on the other hand, contains 4% of sulphur. Petroleum products contain 1 to 5% sulphur. Sulphur dioxide (SO_2) is also released during metallurgical processes. Clean fuel and efficient vehicular engines contribute a lot in reducing the SO_2 emissions. *The national standard for ambient concentration of SO_2 in the air is 80 µg/m^3 (0.028 ppm), averaged over 24 hours for residential areas.*

SO_X is also one of the contributory factors for poor visibility. Sulphur oxides ($SO_X \rightarrow SO_2$ and SO_3) are strong respiratory irritants. At 25-ppm concentration, the irritation is seen in the upper respiratory tract. SO_x–containing smoke

produced from bituminous coal, causes chronic and acute bronchitis, pleurisy and emphysema, common lung disorders. SO_x also cause eye irritation, tears and redness. In high concentrations, sulphur dioxide may also be fatal.

Experimental procedure:

Data to be entered as for other pollutants (AWS-Activity 5).

Principle: SO_2 present in the sample air is bubbled through a dilute aq. solution of Sodium tetra chloro mercurate, which quantitatively converts SO_2 to sodium dichloro sulfito mecurate. This reacts with p-rosaniline dye to form a red-violet coloured complex (p rosaniline methyl sulfonic acid). This is colorimetrically estimated at 560 nm.

OXIDES OF NITROGEN: Activity 5

The major sources of nitrogen oxides (NO_X) in the air are: fuel combustion as in different industries and vehicles and garbage burning. The quality of the engines in vehicles, such as spark ignition and compression ignition, also affect the emission amount \ quality of this gas.

The ambient air quality standard for nitrogen oxides is 80 µg\m^3 (0.028 ppm.) for 24 hours in residential areas. Above this concentration, the gas acts as a pollutant with serious effects, both on humans and on material surfaces.

Among the different nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO_2) are the main pollutants. At 0.25ppm, NO_2 absorbs visible light and causes reduced visibility. At these low concentrations, NO_2 causes acute eye irritation. At higher concentrations it leads to pulmonary fibrosis, with serious respiratory problems. NO reacts with moisture in the atmosphere to form nitric acid, causing corrosion of metal surfaces.

Experimental procedure:

Using a HVAS, air is collected in a solvent of NaOH solution. This is then analysed in the lab.

Principle: NO_2 in the sample is converted into a stable solution of $NaNO_2$. This is converted into an azo dye with sulphanilamide, which then couples with the reagent N (1-naphthyl) ethylenediamine dihydrochloride to form a colour complex. The latter is determined colorimetrically at 540 nm. (AWS-Activity 5).

LEAD: Activity 5

Lead occurs naturally in small quantities in the air, water and soil. It is a heavy metal, which can exist as an air pollutant in the form of vapours and as particles.

Often called as a 'silent killer and crippler of humans', automobile exhaust and lead-based paint are the most common sources of lead pollution in the air. This paint is dangerous when it is peeling, chipping, chalking or cracking. Improper renovation of homes with lead-based paint can generate lead dust in the air, and soil, and in and around homes. Industries, such as lead ore mining, lead ore milling, smelting, municipal solid waste incinerators, and lead-acid battery recycling facilities are other sources of lead in soil and air. Soil contaminated with lead is a potential source of lead exposure. As floor dust, it can become a source of lead contamination in the air. Other sources of air borne lead include, emissions from gasoline combustion (now eliminated by unleaded gasoline), smelters and battery manufacturers. In recent decades, the dominant source of lead exposure to humans is from emissions of motor vehicles operating on leaded petrol.

Humans can inhale lead particles or ingest lead via the consumed food and water. Although lead can enter the body in a number of ways, people living in urban areas are exposed to lead via inhaling airborne particles containing lead. Lead can be found in all tissues of the body and tends to accumulate in

the bones, where it is immobilized and hence stored. The liver and kidneys eliminate ingested lead slowly (over years) by excretion.

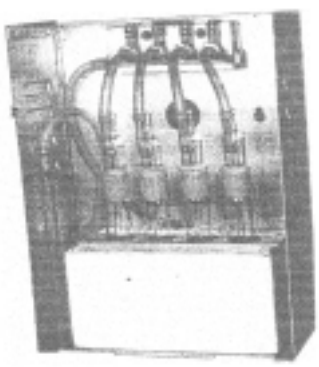
Lead affects practically all systems within the body, mainly the human central nervous system. Lower levels of lead can adversely affect the brain, central nervous system, blood cells, and kidneys. In young children, lead can cause learning difficulties. In adults, it leads to heart problems. At high exposures, lead can cause kidney disorders, anemia, convulsions, coma, and even death. The effects of lead exposure on fetuses and young children can be severe. They include delays in physical and mental development, lower IQ levels, shortened attention spans, and increased behavioral problems. Fetuses, infants, and children are more vulnerable to lead exposure than adults since lead is more easily absorbed into growing bodies, and the tissues of small children are more sensitive to the damaging effects of lead. Children may have higher exposures since they are more likely to get lead dust on their hands and then put their fingers or other lead contaminated objects into their mouths.

Symptoms of lead exposure have not been observed in blood lead concentrations below 0.2 µg/ml. *For the protection of human health, the national ambient air quality standards for airborne lead range from 0.5 to 1.5 µg/m^3 for sensitive, residential and industrial areas.*

Experimental procedure:

Using a HVAS, air is collected in a solvent of 1% HNO_3 or by filter paper. This is then analysed in the lab. (AWS-Activity 5).

The gaseous sampling attachment of the high volume air sampler:



AUTOMOBILE POLLUTION: Activity 6 to 9

In recent years, emissions from automobiles form one of the major components of air pollution in the country, especially in metropolitan cities. The main reason for this rise in air pollution is the increasing number of vehicles and the poor quality of fuel.

Exhaust of automobiles is highly complex, giving out a host of air pollutants. These include carbon monoxide, volatile oxides of carbon (VOC), particulates, nitrogen oxides (NO_X), unburnt hydrocarbons, sulphur dioxide, lead, and, of course, smoke. Smog formation primarily composed of ozone and particulate matter, is another outcome of traffic pollution. According to the World Health Organization, air pollution due to traffic threatens the health of billions of people in the country. The three main types of automobiles largely used in the country are:

- Passenger cars powered by four stroke engines
- Two wheelers powered by two /four stroke engines.
- Buses and trucks powered by four stroke diesel engines.

The vehicle exhaust depends on the fuel type and its contents. The amount and volume of pollutants emitted by a vehicle depends on a number of factors, including the engine type\design, the type of fuel, emission control device and the engine's mechanical operations, such as idle \accelerated engine and the road conditions.

The harmful effects of vehicular pollutants are many. To give one instance, the NO_x leading to the formation of ground level ozone, can aggravate breathing problems, including asthma and reduce lung functions. Exposure to carbon monoxide due to its competing nature with oxygen slows down reflexes with increasing drowsiness; ozone and particulates, even in very minute quantities, lead to lung malfunctioning, which shows up initially as breathing problems. In short, all the pollutants released in exhausts have synergistic and additive effects on human health, leading to early ageing of lungs in the long run.

Lead pollution in air, both due to vehicles and soldering industry in the country has attracted attention of many scientists, due to the detection of lead in the blood.

Experimental procedure:

A few survey-based exercises are designed to bring out the threat of vehicular air pollution in an area. This will be supported by the data of various pollutants like NO_x, particulate matter, and carbon monoxide collected from the nearest air monitoring station/pump, or municipality done on a regular basis and accordingly entered in the work sheet.

Activity 6:

1. The number of different types of vehicles at a particular site (residential area or a traffic junction), at specific times –for 1 hour at peak and non-peak times—has to be recorded. Repeat this exercise at the same time on three different days. Record the average number of vehicles in the air worksheet {AWS-Activity 6(i)}. Ideally, repeat this exercise at different times of the year/during different seasons.
2. Simultaneously, obtain and enter the pollution data {Activity 6(ii)} from the municipality for the above sites. Avail of the facility of the mobile air monitoring van from the municipality/HBCSE for this purpose. Remember to match the dates and time of the two.
3. Pollution data for the two sites—residential and traffic—{Activity 6(ii)} should be done with the same type of monitoring instrument.

Activity 7:

1. At a traffic junction, record the number of any one type of vehicle (e.g. cars) on an hourly basis, for any one day of the month (preferably on a working day).
2. Represent the vehicle numbers on a graph sheet. (The graph sheet consists of one cm squares, with each one cm. square further divided into 100 squares.) For every vehicle counted, darken (shade) one small square in one cm. square. For each hour (represented on X axis), use a different centimeter square.

3. Plot hours (at least 12 hours) on the x axis;
4. Simultaneously, monitor TPM, NO_x or CO levels for the same day and at corresponding time intervals.
5. Keep a separate record of the pollutants. Graphically represent different pollutants as different graphs.
6. Match/superimpose/layer the pollution data on the vehicle number data. Use colours to bring out different pollutants.
7. The y-axis could represent the pollutant concentrations.
8. This entire procedure should be repeated at least three times to get an understanding about air pollution and traffic.
9. Repeat the entire Activity in a residential area/ or near a green park.
10. Remember to use the same monitoring devise throughout the expt.

Activity 8:

This activity brings out the role of public transport in reducing air pollution.

1. For one week or one month, record the number of students coming to college/school in various vehicles: cars, school bus or BEST (public buses), 2-wheelers or by cycle. Also keep a record of those walking down to school / college.
2. Also, note the average number of students traveling per vehicle type.
3. A table of emission factor derived based on particle size analysis carried out by NEERI (National Environment Engineering Research Institute, Nagpur) is provided in the Worksheets (AWS: Activity 8).
4. If all the vehicle types are traveling at a fixed speed and cover a fix distance of 10 km from home to college, calculate the total PM 2.5 (particulate matter size less than 2.5μ) emitted per vehicle type.
5. Calculate the total emissions of PM 2.5μ for the recorded number of vehicles. Calculate the PM 2.5μ emission per one transported individual and enter the values in the Air Worksheet (AWS-Activity 8).

Activity 9:

1. In the next step, assume there is an increase in the number of vehicles in your area (at the approximate rate of about 2,000 cars per year).

2. Try to model this increase over a period of five years and the subsequent increase in the different types of air pollutants. Plot the standard for each pollutant also on these graphs.
3. Visualize a scenario for air pollution when more stringent air pollution norms are implemented in the country. This could include: advanced Euro norms for engine designs, or improving fuel quality by drastically reducing sulphur content, or using alternative fuels, such as CNG or with battery-powered vehicles.
4. Combined with several of the above steps, air pollution could be drastically reduced with strong administrative measures, including improved infrastructure and more disciplined traffic.

NOISE POLLUTION: Activity 10

Noise is any unwanted or unpleasant sounds around us. It is a reality of today's fast moving life. The increasing noise levels are mostly due to industrialization and ever increasing traffic.

Appliances used in homes, such as mixers, air coolers, water-pumps and loud music and in vehicles (locking, unlocking and reverse alarms) all add to the noise load. Use of loud speakers and loud musical instruments during different religious practices, festivals and marriages, also contribute to the decibel levels, both in rural and urban areas. In India, most of us are insensitive to noise pollution and disregard its existence.

Noise is recorded in decibel (db) units, which combines both sound pressure and intensity. The Central Pollution Control Board (CPCB) of India has laid down permissible sound levels for cities for four different zones, viz, industrial, commercial, residential and sensitive areas (extending about 100 m around educational institutes, courts and hospitals). Levels exceeding these constitute noise pollution. According to experts, the decibel levels of normal conversation ranges between 45-65 db, passenger cars and trucks generate decibel levels of 75 and 110 db respectively.

Noise pollution causes general degradation of environment and has an invisible but direct effect on our health. People exposed to high noise levels for prolonged periods suffer from a variety of ailments, ranging from deafness, to cardiac problems, high blood pressure to disturbances in sleep.

Activity 10 (I, ii, iii):

1. Obtain the decibel levels at different sites: sensitive areas, residential areas traffic junctions, commercial and industrial areas, from the local municipality. Alternatively, use a noise meter to measure the decibel levels in selected areas. Record the observations in Air Worksheet (AWS—Activity 10 (i)).

Activity 10 (ii)

1. To monitor the noise pollution caused by traffic, select an appropriate site so that the noise meter is exposed to the moving traffic.
2. Note the values in Air worksheet (AWS—Activity 10 (ii).

Activity 10 (iii):

1. In your municipal ward, or street, note down the number of marriage halls and religious places. Also fill in the their location details, number of surrounding trees (they act as sound absorbers), etc. in the worksheet.
2. Try to collect data about noise levels using the noise meter outside these places, especially during festivities. The measurement time should be at least 30 minutes.

Average permissible sound levels for Indian cities (prescribed by CPCB).

Areas	Day	Night
Sensitive	**50dB**	**40dB**
Residential	**50dB**	**45dB**
Commercial	**65dB**	**55dB**
Industrial	**75dB**	**65dB**

Air Worksheets

Name Of The Observer: **Date:**

College Name/Address:

General Observations Of The Site:

Site Name: **Location:**

Site description: Parks\gardens___, Open area___, Beach\ any water body___, Others_____

Type of vegetation: NIL___, Scanty___, Grassy___, Specify others___

Observation of the sky : Clear___, Cloudy___, Scattered clouds ___

If cloudy: Colour of the clouds: Grey___, Brown/black___, Orange___, Other___

Air movement: Windy___, Light winds___, Breezy___, No winds___

Wind direction: East\West\North\South___

Extent of visibility: Clear_____, Hazy___;

If hazy: Due to: Smog: ____, Mist: ____, Fog: ____ , Other____

Activity 1: Study Of Physical Properties Of Air

Day temperature:

Maximum: Result 1_____, Result 2: _____, Result 3: _____ ,

Average: _____^{o}C

Minimum : Result 1_____, Result 2: _____, Result 3: _____

Average: _____ ^{o}C

Smell (0dour): No smell ____, Smell _____

If smell is present, then : Pleasant___, Marshy___, Foul___, Fishy ___, Smell of rotten eggs___, Others: _____

Activity 2a: Total Particulate Matter (TPM)

Flow rate of the pump: _____litres\min; Time duration of pumping: ____

Total volume of air collected: _____m^3

Type of filter	Wt. of clean filter (gms) (X)	Wt. of filter+particulates gms (Y)	Wt. of the particulates (Y-X gms)	Amount/conc. of particulates in vol. of air collected (gms/m^3)
Whatman I				
Whatman A				
Glass fiber filter				

If electronic monitoring station is present in the area, record the concentration of particulates (TPM and RPM) below.

TPM: _____mg/m^3 ; RPM: _____mg/m^3

Actity 2b: Particulate Matter At Different Sites

Repeat the procedure of Activity 2a at different sites: commercial, residential, industrial, sensitive (hospitals) and traffic junctions. Note the weights of particulate matter calculated in the table below: If possible, repeat the expt. at different times of the day.

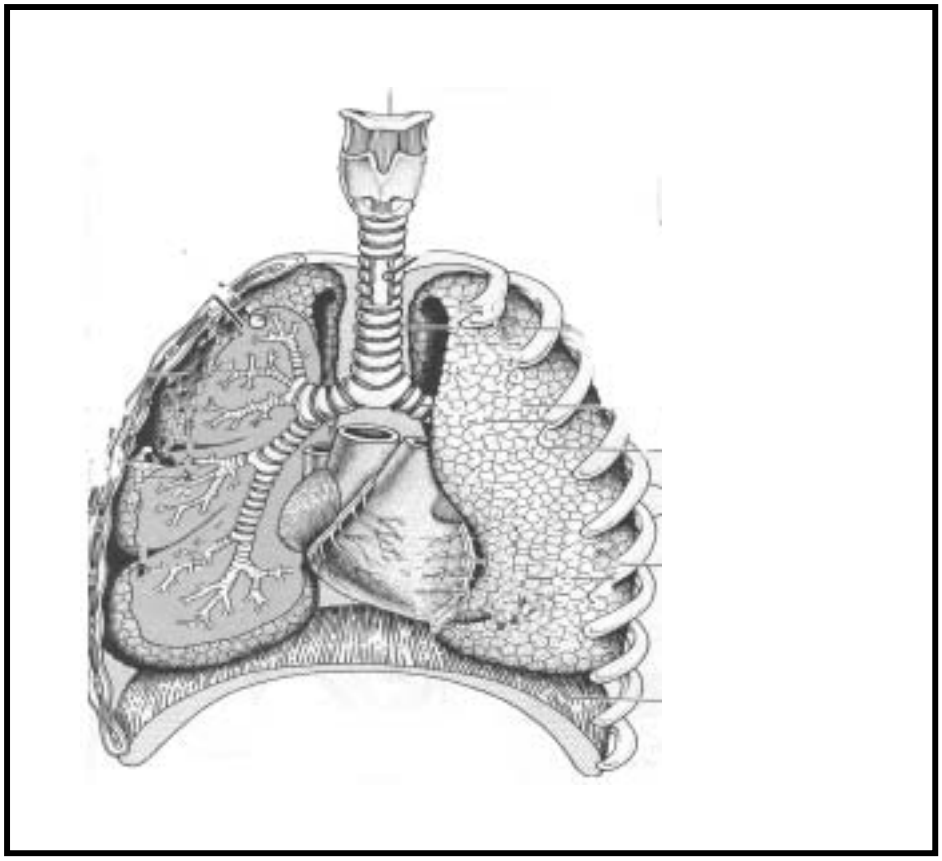
Type\Size of filter	Amount of particulate matter at different sites (gms/m^3)				
	Residential	Commercial	Industrial	Sensitive	Traffic junctions
Whatman1					
Whatman A					
Glass fiber filter					

Activity 3: Deposition Of Particulates In The Respiratory Tract

The site of deposition of particulate matter in the respiratory tract depends on their sizes: while the bigger particulates settle in the upper respiratory tract (nose and tracheal passages), the smaller ones settle in finer spaces of the bronchioles and in the alveoli of the lungs.

Given below are sizes of different particulates. Identify the appropriate deposition sites of these particulates in the different parts of the respiratory system (in the figure below).

Particulate matter	**Size (of diameter)**
Fine dust of *chullahs*	0.1µm
Pollens	120 µm
Dust	20 µm
Fumes-auto exhaust	0.01µm



Activity 4: pH Of Precipitation

Last recorded rainfall in: _____months/days/hour;

pH measured using _____

pH of precipitation: observer 1____; observer 2_____; observer 3_____

Average pH of precipitation:_____

Activity 5: Concentration Of Different Air Pollutants

Date:

Source of pollution data: Air monitoring station____, sampling pump_____,TV____ or press____

If the data refers to a specific site, then identify the site as: Industrial ___, Residential ____, Sensitive ___

Data for different pollutants

Pollutants	**Time weighted average**	**Concentration in air**
Carbon monoxide (CO)	**1hr** **8 hrs**	
Sulphur dioxide (SO_2)	**24 hrs**	
Nitrogen dioxides (NO_2)	**24 hrs**	
Total particulate matter (TPM> 10 µm)	**24 hrs**	
Respirable particulate matter (RPM<10 µm)	**24 hrs**	
Lead (Pb)	**24 hrs**	

Activity 6 (I): Automobile Pollution:

Average number of vehicles passing in a fixed time, say, in one hour.

Site / Location:_____

Date:_____**, Time:**_____

Type of vehicles	Residential area (R)		Traffic junction (T)	
	Nos. at (PT)	Nos. at (NPT)	Nos. at (PT)	Nos. at (NPT)
Cars				
Auto rickshaws				
Two wheelers				
Buses				
Trucks				

R: residential area; **T:** traffic junction; **PT:** Peak time; **NPT:** Non peak time

Activity 6 (Ii) Pollution Data For The Above Site

Date of obs.	Pollutant data obtained															
	CO				NO_x				SO_x				Particulate matter			
	R		T		R		T		R		T		R		T	
	PT	NPT	PT	NPT	PT	NPT	PT	NPT	PT	NPT	PT	NPT	PT	NPT	PT	NPT

Activity 7 : Match The Number Of Vehicles And Air Pollutants.

Make separate graphs for different pollutants.

Activity 8: Carbon Monoxide Emission Per Transported Individual For Different Vehicle-Types.

Emission factor derived on the basis of particle size analysis carried out by NEERI.

Type of vehicles	PM 2.5 emission (gm\km)
Cars	0.046
Taxis	0.046
LDDV*	0.840
HDDV**	2.180
3-wheelers	0.399
2-wheelers	0.0399

LDDV*-Low density diesel vehicle (diesel cars); HDDV**-high density diesel vehicles (buses and trucks)

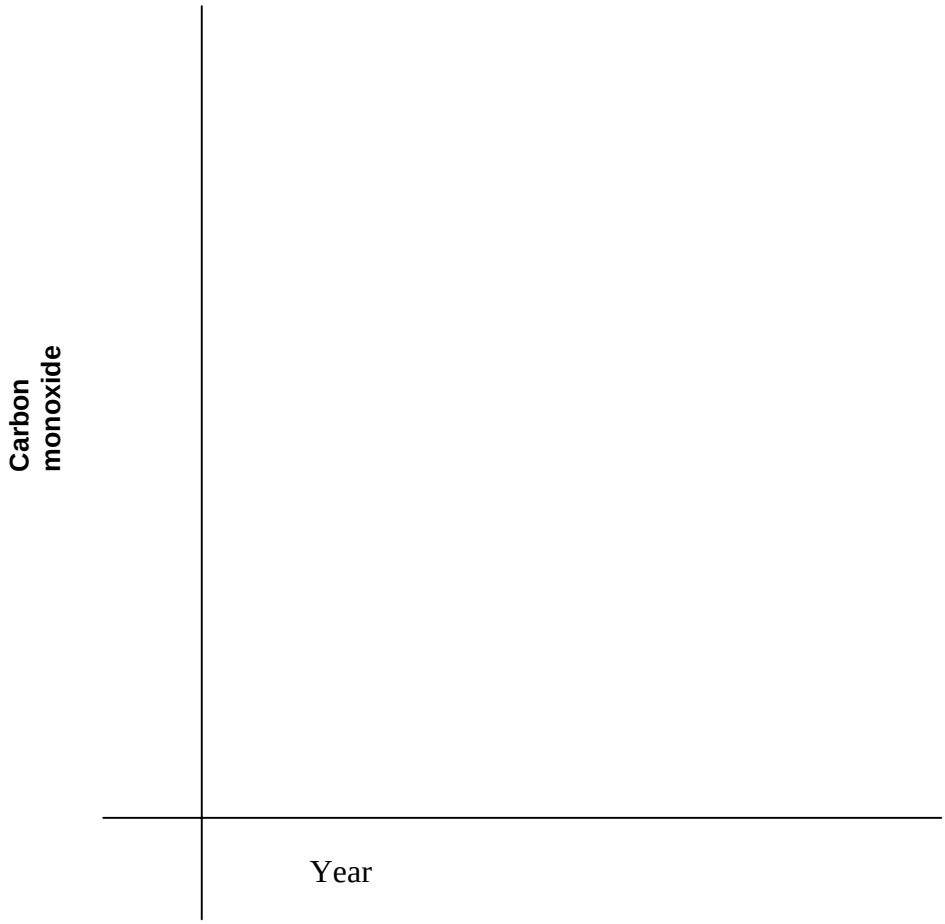
In this activity, (i) survey of different types of vehicles—petrol or diesel driven cars (LDDV), buses etc, used by students to come to college/school is to be noted. (ii) Note the average number of students /vehicle.
One has to assume here that ALL vehicles have traveled a fixed distance of 10 kms at a fixed speed.

Type of vehicle/ Nos.	No. of Vehicles (A)	Average number of students per car (B)	PM 2.5 * emission per vehicle type for 10 kms (gm/km) (C)*	Total PM 2.5 emission (gm\km) (CxA) (D)	PM 2.5 emission per transported individual (D/A)
Cars (petrol driven)					
Cars (diesel driven)					
School buses					
Two wheelers					
Auto rickshaws					
Cycle					

* NOTE: To get the correct value of C, calculate the emission for 10 kms.

Activity 9: Future Trends Of CO Emission

This is a hypothetical situation. Assume that in an area there are 20,000 cars and the existing CO levels are 11 mg\m^3. Plot trends of CO emission for the next five years, with a steady increase in car population at the rate of 2,000 cars\year. One assumes that there is no change in vehicle engine designs and fuel quality in this period. Also plot the standard value for CO.



One can model several situations for improving air quality by bringing out the impacts of fuel quality, change in engine designs (EURO II, III, IV) and better infrastructure.

Activity 10 (I): Noise Pollution

Decibel levels at different sites, obtained from a monitoring station and with a noise meter.

Area\site chosen	**Average decibel levels obtained from:**	
	Monitoring station	**Noise meter**
Residential		
Sensitive		
Commercial		
Traffic junction		

Activity 10 (Ii): Decibel Levels Recorded For Noise Pollution.

Name of the site.	**Decibels**	
	Max.	**Min.**

Activity 10 (lii): Decibel Levels Recorded At Different Points Of The Study Site.

Characterize area as: **R**: residential **S**: sensitive **C**: commercial **I**: industrial	**Name of site**	**Decibel levels at:**									
		Marriage halls		**Religious places**		**Parks**		**Schools**		**Hospitals**	
		Number +\ --	**Dcibel level at each hall**	**Number +\--**	**Dcibel level at each place**	**Number +\--**	**Dcibel level at each park**	**Number +\--**	**Dcibel level at each school**	**Number +\--**	**Dcibel level at each hospital**

National Ambient Air Quality Standards:

Pollutants	Time weighted average	Concentration in ambient air		
		Sensitive area	Industrial area	Residential area
Carbon monoxide	8 hrs	1.0mg\m^3	5.0mg\m^3	2. 0mg\m^3
	1 hr	2.0mg\m^3	10.0mg\m^3	4. 0mg\m^3
Oxides of nitrogen	Annual	15µg\m^3	80 µg/m^3	60 µg\m^3
	24 hours	30 µg\m^3	120 µg\m^3	80 µg\m^3
Sulphur dioxide	Annual	15 µg/m^3	80 µg/m^3	60 µg/m^3
	24 hours	30 µg/m^3	120 µg/m^3	80 µg/m^3
Respirable particulate matter(<10 um)	Annual	50 µg/m^3	120 µg/m^3	60 µg/m^3
	24 hours	70 µg/m^3	150 µg/m^3	100 µg/m^3
Suspended particulate matter	Annual	70 µg/m^3	360 µg/m^3	140 µg/m^3
	24 hours	100 µg/m^3	500 µg/m^3	200 µg/m^3
Lead	Annual	0.50 µg/m^3	1.0 µg/m^3	0.75 µg/m^3
	24 hours	0.75 µg/m^3	1.5 µg/m^3	1.0 µg/m^3

* Annual Arithmetic Mean of minimum 104 measurements in a year taken twice a week, 24-hourly, at uniform interval.

** 24-hourly/8-hourly values should be met 98% of the time in a year.

However, 2% of the time, it may exceed but not on two consecutive days.

Final Air Worksheet:

Note the average readings of the physical and chemical characteristics of air:

Date: Time: Location of site:

Characteristics of Air		**Observations**
Site identification: S - sensitive I - industrial R - residential		
pH of precipitation (rain/snow)		
Day temperature	Max.	
	Min.	
Odour **O** – odourless; **P** - pleasant **M** – mouldy; **Y**- fishy **F**- foul; **R**- rotten egg		
Total suspended particulate matter **TSPM** (µg\m^3) 24 hr		
Respirable suspended particulate matter **RSPM** (µg\m^3) (< 10 µm) 24 hr		
Sulphur dioxides 24 hr		
Oxides of nitrogen 24 hr		
Carbon monoxide (mg/m^3) 8 hr		
Lead ((µg\m^3)		

‘Water’ watch…

for good health

INTRODUCTION:

All aspects of water, its quality, quantity, its uses and sources, are at the center stage of discussions (academic, social and political) today in the country. On one hand, water quality is steadily deteriorating, and, on the other hand, there are increasing demands on this natural resource. Balanced development demands a scientific understanding of this valuable resource, as water quality and quantity has a direct impact on our health.

Water is an important and the most abundant resource in the biosphere. The water molecule is represented as H_2O, with an oxygen atom in the central position, bound by two hydrogen atoms.

The biological importance of water in supporting life is due to its unique physical and chemical properties. It is a universal solvent with high melting and boiling points, high heat capacity and maximum density as a liquid at 4^0 C, These properties are attributed to the structure of the water molecule. To give one instance, the last property allows organisms to live below the ice cover in denser and warmer waters.

The world’s water can be classified as fresh and saline water. It exists in three different states: liquid (salt and fresh), solid (fresh) and vapour (fresh). Fresh water constitutes only about 3% of the total water, and a large part of this is locked up as ice caps and glaciers. The remaining fresh water is found in rivers, streams, lakes and ponds and as sub-surface ground water aquifers. This freshwater balance is greatly dependent on the monsoon system in each region. The marine (salt) environment constitutes the large oceans and seas. The salt waters are equally important as they support an entire marine water ecosystem. Pollution of water sources/bodies could be hazardous for our very survival. This finite resource, which is so vital to all life on this earth, must be protected, conserved and treated with care.

WHAT IS WATER POLLUTION?

Rapid urbanization, industrialization and certain agricultural practices have led to pollution and deterioration of natural water bodies. These water bodies are constantly being abused by activities, such as, washing and domestic / industrial waste loads. Indiscriminate use of pesticides and fertilizers, combined with inadequate training of farmers and workers, has led to highly contaminated agricultural runoffs being released in water bodies. The highly toxic chemicals (malathoin, lindane, DDT and chlorphyrophos) used as pesticides in India, pollute our water bodies, or find their way in the ground water. Several of these chemicals, especially DDT, are banned in most of the countries in the world.

In urban areas, the situation is worsened often by the direct discharge into the natural water bodies of untreated or partially treated sewage and industrial wastes. Water pollution can also result from natural processes, such as, surface runoffs due to rains or presence of dead organic matter, but these are slow processes, giving enough time for the water body to rejuvenate.

Drinking water, which has been treated by municipalities, often is contaminated with sewage (and other waste) in transit from the storage reservoirs to residential units.

Some of the noticeable signs of water pollution are: dark, dirty colour of the water body, reduction in transparency, unpleasant smells, unchecked growth of weeds, decrease in the number of fish, oil and grease floating on the surface of the water body and bad taste of drinking water.

ANALYSIS OF WATER:

There are several physical, chemical and microbiological properties of water, which can be monitored to find out its overall quality. Among the many chemical properties are: pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), residual chlorine, alkalinity,

nitrates, nitrites, total Kjeldhal nitrogen (TKN), phosphate, sulphate, zinc, chromium, lead, copper, etc. For the initial phase of this program, a few chemical properties will be monitored.

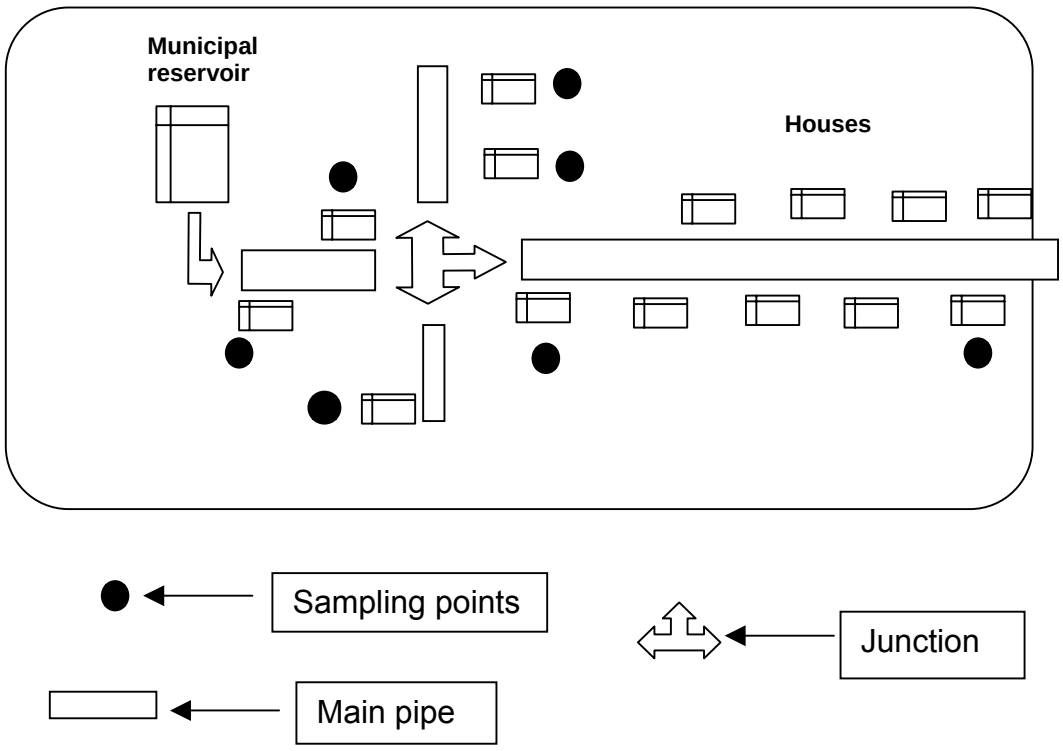
Before starting with water analysis, participants should be certain about the source of the water and the purpose for which the water is being used, and accordingly carry out the tests.

Physical properties examined are: smell (odour), colour, turbidity, temperature, suspended solids.
Chemical properties studied here are: pH, conductivity, alkalinity, dissolved oxygen (DO), biochemical oxygen demand, chemical oxygen demand, chlorides, fluorides, ammonia, phosphates and heavy metals like iron, copper and chromium.
Microbial parameter checked is: presence of the bacteria, *Escherichia coli (E.coli*—coliforms) and their numbers expressed as MPN (most probable number), will be checked in drinking water.

SAMPLING SITE DETAILS:

1. Site selection should be made with care, keeping in mind the purpose of the water body, i.e., the water is used for drinking, recreational use, or whether it is a dumpsite, like a *nullah*.
2. Any water source like rivers, streams and lakes is a good site for sampling. Beaches, ponds, or creeks and water tanks can be alternative sites for water sampling. Preferably, select a water source nearest to the school /college.
3. For monitoring drinking water, samples can be collected from taps, storage tanks (overhead and underground).
4. While collecting samples from the tank, consider the state of water level –nearly empty, half filled or full. The results will vary depending on these conditions.

5. Water sample should also be obtained directly during the supply hours. This would give a fair idea of the quality of municipal supply.
6. To verify the quality of municipal water supply, the water samples should be collected at different points as shown in the figure on the next page. As seen, one sample is collected from a point before the municipal pipe line bifurcates at the junction; two samples are collected after the bifurcation: one sample from the first point –house—near the junction and the next sample from the end of the pipe line, that is, near the last house in that line. This type of sampling confirms the exact point of contamination or seepage.



Tap water sampling from a municipal supply

7. The sample should be representative of the entire water body/source. The water samples for the entire analysis (to check all physical and chemical properties) should be collected from the same site under similar conditions.

8. Ideally, water samples should be collected and monitored two to three times every month. It is important that water is monitored during late summers, when the water levels dip in lakes and other reservoirs. Pathogens, such as protozoa, C*ryptosporidium parvum*, which settles in the sediments, and are resistant to chlorination, are then pumped into the water flow.

SAMPLING:

All sampling procedures should be performed under supervision. Care should be taken to avoid any accidents: never enter any water body without inquiring about its depth, currents and tides from a local person. Look out for informational signposts regarding the water body.

Materials required:

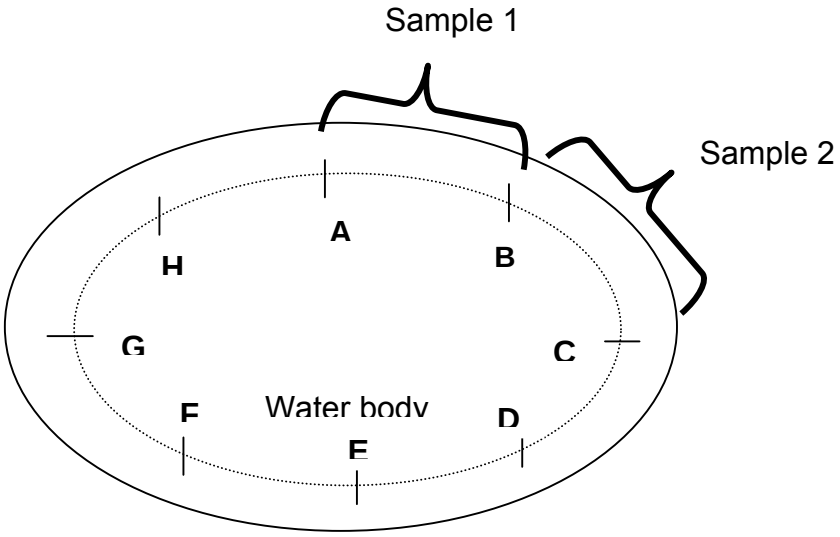
A small bucket with a strong rope and heavy stone attached to the handle, 500 ml polythene bottles with wide mouth, screw caps and sealing tape.

Experimental procedure:

1. If the sampling site is a well, holding on to a rope, lower the bucket into the water. To get the sample from a certain depth, use a bucket with an attached heavy stone.
2. Fill it partially with water. Pull out the bucket with water and thoroughly rinse the bucket. Discard this water.
3. Repeat the procedure and now use the water sample for analysis.
4. If the sampling site is an open water body like stream, lake, creek, or a sea, study its location and different points of entry and exit of water.
5. Ideally, surface water samples are collected by averaging grab sampling method:

    - All samples to be collected 300 cms (10 feet) away from the shoreline. Use a boat to collect all these samples.

- Starting from a point (A), collect ~50 ml water in a container. Repeat this at regular intervals, till a distance of about 5 m (pt. B) is reached. This will make one sample.
- From (B) continue sampling similarly for the next 5 m (pt. C). This will be the second sample.
- Repeat this procedure until you make a complete circle to come back to pt. A.
- If possible, try to obtain another sample from the center of the water body.



- Alternatively, with a boat, collect samples along the diameter so that opposite ends could be considered for sampling.

6. Depending on the accessibility of the water and to get the true picture of the quality of water of open water bodies, choose appropriate sampling points. For instance: (i) A point where there is an inlet of wastewater or other streams. (ii) A point from where water is pumped out. (iii) A sample collected from the center of the water body will give a fair idea of the level of pollution. (iv) A bottom water sample at a depth of about 5-10 mts will determine the extent of mixing and the presence of debris and other pollutants settling at the bottom.

7. Take a minimum of five samples from each water body, to represent the entire body.
8. First, rinse the bucket with water from the shore and then throw the bucket out as far as possible.
9. Take a sample from the top surface of water. Do not allow the bucket to fill up and sink. Avoid stirring the bottom sediment.
10. To obtain the sample, allow the bucket to fill to two-thirds or three-fourths levels. Then pull the bucket out of the water.
11. Avoid taking samples from shores where the water is stagnant.
12. Use a float with a rope, which could be a light object like an empty plastic bottle or a wooden block, to check the direction of the flow of water.
13. For drinking water, if the sampling point is a tap: Using a sterile container (use an autoclave or a pressure cooker), first rinse the bottle with tap water and then collect the water sample. (Check the earlier details on page 4.)

Bottling technique:

It is preferred to do all the water analysis, especially, the physical properties, at the site itself. Only certain experiments are performed in the laboratory. This requires that the sample be carefully bottled so that its original properties and chemistry are not altered.

1. Label a 500 ml polythene bottle giving the site and sampling details. Rinse the bottle and cap with the sample water.
2. Fill the bottle up to the top rim with sample water, so that when the cap is put on, no air is trapped inside. Seal the cap of the bottle with a sealing tape.
3. Store these samples in a refrigerator at about 4^0C until they can be tested.
4. Once the seal is broken, do the pH test first; then proceed with alkalinity and nitrites, followed by other tests.

5. Ideally, once the seal is broken, all the tests should be performed in a single laboratory session. Hence, prior planning is important.
6. The sampling for DO, BOD and COD requires a special bottle and technique, mentioned under the topic of DO.

Preservation of water samples:

The samples collected should be immediately checked for all parameters specially, pH, DO, BOD, COD, alkalinity and chlorides. If this is not possible, the samples must be preserved properly in order to avoid changes in their composition. The table below gives a list of preservation methods for different parameters.

Parameters to be analysed	**Preservation**	**Storage recommended**	**Maximum storage recommended**
pH	--	To analyse immediately within 4 hrs	--
Alkalinity	Refrigerate	24 hrs	14 days
BOD	Refrigerate	6 hrs	48 hrs
COD	Analyze as soon as possible or add concentrated H_2SO_4 till pH<2 and refrigerate	7days	28days
Chlorine	Analyze immediately	15min	15min
Fluoride	No preservation required	28days	28 days
Metals	Filter the sample and add conc. HNO_3 (~5 ml\l) till pH <2 and refrigerate.	7 days (Chromium to be analyzed within 24 hrs)	7 days (Chromium to be analyzed within 24 hrs)
Ammonia	Analyze as soon as possible, or add conc. H_2SO_4 (~0.8 ml\l) till pH<2 and refrigerate.	7 days	28 days
Phosphates	Add 40 mg\l of $HgCl_{2;}$ refrigerate.	1-2 days	7 days

Physical Properties: Activity 1

COLOUR: Activity 1

Clean water is colourless. However, natural water bodies often show colours due to the presence of dissolved or suspended solids and variety of water plants and organisms. Decaying organic matter, including weeds too, impart colour to water. Other sources that contribute dark undesirable colours are: effluents from industries, domestic sewage discharges and spillages from ships and boats, and other washing activities. Normally, the coastal areas are maximally affected, except the oil spills in mid-oceans.

Materials required:

Clean glass container, source of white light (if sunlight is not bright), a white cardboard or plain white sheet of paper for background.

Experimental procedure:

1. Transfer 50 ml of water sample in a clean and clear glass tube/container.
2. Observe the colour of the water by looking through (down) the tube, against a white background in bright\white light (sunlight preferred).
3. Compare the colour of the sample with clear distilled water under similar conditions.
4. Repeat with three different observers and note the observations with intensities of colours in the water worksheet (WWS: Activity 1).
5. At a later stage, measure the colour intensity quantitatively in colour units using potassium chloroplatinate and cobaltous chloride (Platinum-cobalt method) for accurate colour measurement.

ODOUR: Activity 1

Unpolluted clean water has no odour. However, water in natural bodies could acquire some odours ranging from mild to excessive. These odours could be due to certain treatment procedures such as chlorination, or due to natural

processes, like, decaying of vegetable matter (ammonia and hydrogen sulphide is given out with decaying vegetable matter). Human activities, such as sewage disposal or industrial discharges may also produce foul odours. Industrial effluents give out a variety of compounds like, halogens, sulphides, phosphates and volatile organic compounds, contributing to smells.

Materials required:

Two clean glass containers or test tubes.

Experimental procedure:

The experiment should be performed with a fresh sample, preferably at the site itself.

1. Take a clean glass container, and rinse it with the sample water.
2. Fill the container up to three-fourths volume with water sample and smell it.
3. Check for the following odours: sweetish, unpleasant or marshy, rotten eggs (sulphide), organic chemicals (volatile organic compounds), others (specify), no odour. Also, note the intensity of odours. Note down your observations in the water worksheet (WWS: Activity 1)**.** Repeat the procedure with three different students.

TEMPERATURE: Activity 1

Water temperature varies with climate, season and the time of the day. The temperature of a water body is normally lower than the surrounding air, unless thermal effluents are released in the water body. A gradual decrease in the temperature is observed with the increase in depth of the water body.

Temperature affects aquatic life and alters the physico-chemical processes occurring in water. For instance, high temperatures result in the decrease in concentration of dissolved oxygen. Water temperatures are altered both due to natural (direct sunlight) and human activities. Discharges of hot industrial effluents, from nuclear reactors and thermal power plants affects the water

temperatures. These processes can raise the temperatures considerably. Turbid waters absorb more sunlight hence record high temperatures.

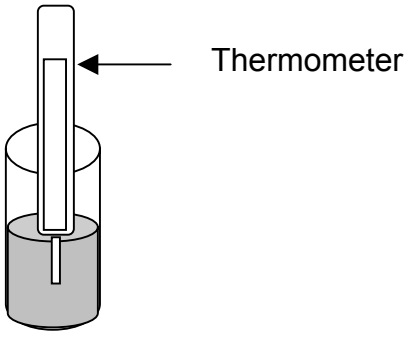
Materials required:

Clean glass container and alcohol thermometer.

Experimental procedure:

Temperature is measured with an alcohol thermometer, preferably at the site.

1. Hold the end of the thermometer (opposite to the bulb) and shake it to remove any trapped air. Note the temperature reading.
2. Immerse the thermometer into the water to a depth of about 12 cms, and hold it for 3-5 minutes. Take care not to drop the thermometer in the water (tie the thermometer to a strong string to avoid losing it).
3. Raise the thermometer and quickly note the reading. Remember to raise the thermometer (with the bulb within water) only as much is needed to read the temperature.
4. If temperature alters, lower the thermometer again in water, allow it to stabilize for one minute and then take the reading. Record the temperature along with date and time.
5. Repeat three to four times and note down the average reading in the worksheet (WWW: Activity 1).
6. Alternatively, take 100 ml of the sample in a 250 ml clean glass container. Place the thermometer upright and immerse the bulb in water, without touching the walls of the container.
7. Read the thermometer at the eye level and record the average reading after three repeats in the work sheet (WWS: Activity 1).



TRANSPARENCY: Activity 1

Clean water is relatively transparent and less turbid. Transparency or clarity is an expression of the optical property that allows light to scatter. It is also described in terms of turbidity, which is a result of the suspended solid matter present in water. These particles can be in the form of sand, clay, silt, organic matter and plankton.

Increased turbidity prevents light penetration, which, in turn, disturbs the natural ecology of the water body. Water bodies get turbid during monsoon due to increased surface runoffs, which carry the topsoil. Turbidity also increases the water temperature. Turbidity also changes with the land use pattern and by activities such as washing, dumping and wading of cattle.

Natural waters have a transparency ranging from one meter to a few meters. A value of less than one meter, can be expected in a water body with many weeds. A low value may also result due to the high concentration of suspended solids and pollution. Very clear lakes and streams without many weeds may record a transparency value of about 40 meters.

Materials required:

A clean glass container, test-tube, a wooden disc\cardboard disc to make a Secchi disc, brushes, black and white paint, hook screws, 6 mt. long rope, small piece (3-4”) metal pipe to act as a counterweight, meter stick, marker and glue.

Experimental procedure:

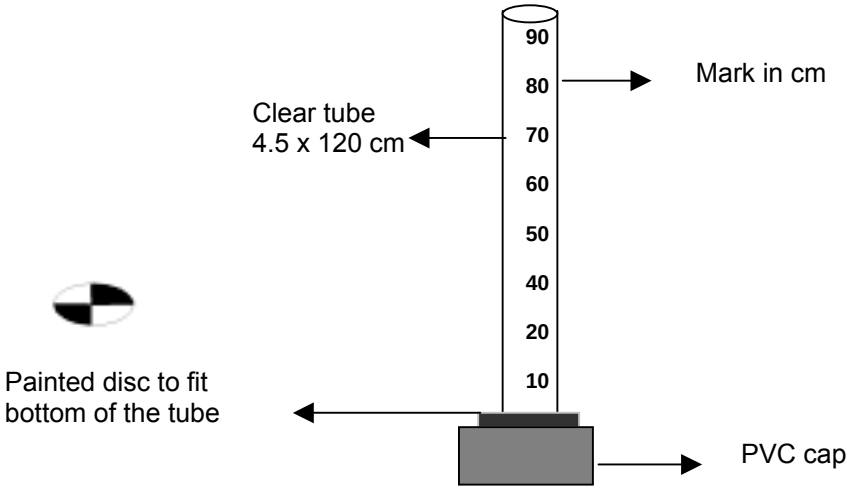
Transparency of water in natural waters as in rivers, lakes and creeks is measured using a Secchi disc:

1. Secchi disc is a slim wooden disc. Divide the area of the disk into four quadrants. Paint the two opposite quadrants in black and white.
2. Screw a hook screw on the top center and bottom center of the disk.
3. Tie a long rope, about five meters long, through the top hook screw.

4. Tie a short piece of rope on the bottom hook and string it through the pipe. Tie a large knot at the bottom of the pipe so that the pipe does not fall off when the disc is held in a vertical position.
5. Using a measuring tape or a meter stick, make markings (graduations) at every 10 cms with a dark colured marker on the rope starting from the point of attachment of the disc. Highlight every 50 cm with another colour marker and every meter (100 cms) with a red marker. Now the Secchi disc is ready for measurement.

Alternatively, the transparency protocol can be performed in the laboratory, too. For this, the tube turbidometer is used. To construct the tube turbidometer:

1. Take a clear glass tube, about 20-30 cms in length and a diameter of about 7 cms. Alternatively, use a 500 ml measuring cylinder.
2. Put a PVC cap on one end of the tube. The cap should firmly fit it.
3. Cut a disc of plastic or a cardboard, the same size as the tube diameter and prepare the disc with four quadrants, same as for Secchi disc method. Waterproof the disc by lamination or varnish.
4. Glue the disc to the PVC cap (or at the inner base of cylinder), with the painted side facing up. Use a marker and a meter stick to make a scale on the side of the tube.



Courtesy:GLOBE

Transparency measurement with the Secchi disc:

1. Lower the disc gradually into water until the disc **just** disappears.
2. Grab the rope at this point at the surface of water and mark this point as (B) with a marker.
3. Raise the disc until it reappears to view; grab the rope and mark that point as (A).
4. The rope will now have two points, which are a few cms apart.
5. Record both these depths and calculate the average depths (A+B/2).
6. Repeat the procedure three times and calculate the cumulative average.
7. Note this value as SDT (Secchi disc transparency) in the water worksheet (WWS: Activity 1).
8. Turbidity is usually measured in NTU (Nephelometric Turbidity Units). To convert the SDT value into NTU, multiply SDT with 1.5, which is a constant. (This constant –euphotic--will take care of the light factors involved while taking readings). This will give the SDT value.
9. To convert the SDT into NTU (turbidity), plot the SDT value obtained on the calibrated conversion graph provided {in Appendix (3)} and read the corresponding NTU units.

Tranparency measurement with the tube method:

This is a slight variation of the above method. Pour the water sample into the tube **until** the disc disappears. In other words, the center point of the disc should disappear, even though the black quadrants are visible. Look directly from the top of the water column.

Rotate the tube to confirm the view. Record this depth in the water work sheet (WWS: Activity 1).

Note: The Secchi disc method gives a rough estimation of transparency of water. For both the methods, light intensity and angular viewing will affect the readings. Hence, bright light of the sun should be behind the observer, i.e., observations should be made in a shadow, to avoid errors. If the shadow/shade is not present, use an umbrella.

For accurate measurements, a turbidimeter or nephelometer is used. This method is based on a comparison of intensity of light scattered by the water sample and a standard reference (solution of hydrazine sulphate and hexamethylene tetramine) under similar conditions.

CONDUCTIVITY:

This property is a measure of the ability of an aqueous solution to carry an electric current. It depends on the concentration and mobility of ions and temperature of the solution at the time of measurement. Solutions containing inorganic compounds show greater conductivity than solutions containing organic compounds. Hence, this property is an indirect method to measure the presence of salts of different ions. Greater the amount of ions (Ca^{+}, Mg^{+}, Cl^{-}, SO_4^{2-}, HCO_3, CO_3^{2-}) in water, higher is the conductivity.

Conductance (G) is defined as the reciprocal of resistance (R): {G= 1/R}.

Conductivity is measured with an instrument –conductometer--containing a conductivity cell, which could either be of platinum electrode type or non-platinum type. Conductance of a solution is measured using two chemically inert electrodes. These electrodes are fixed at two ends with the solution in between. The conductance of a solution is directly proportional to surface area of electrodes (A cm^2) and inversely proportional to the distance between two electrodes (L cms); k is the constant of proportionality.
Hence G ∞ k (A/L) µmho/cm, where k= 1/ohm-cm.
To convert in SI system, conductance is measured as: milli siemens per meter, ie, mS/m.
1 mS/m = 10 µmho/cm.

Note: All conductivity measurements should be carried out at 25^0 C.

Conductivity of distilled water produced in a laboratory is in the range of 0.5 to 3 µmho/cm, while that of potable water ranges between 50 to 1500 µmho/cm. According to the Central Pollution Control Board, the permissible limits of conductivity for fresh water are in the range of 50 to 500 µmho/cm; ground waters have more conductivity than surface water. Conductivity of polluted waters is high, e.g., industrial waste is 10,000 µmho/cm.

Materials required:

Distilled water, conductivity meter, thermometer, flask, beakers.

0.01 M anhydrous potassium chloride solution (appendix 1, preparation of solutions).

Experimental procedure:

1. Rinse the conductivity cell with 0.01M KCl three times. Dip the probe in a beaker containing standard solution of 0.01 M KCl. Adjust the reading of the instrument to 1412 µmho/cm at 25^0 C. The instrument is ready for use.
2. Thoroughly rinse the cell two to three times with the water sample.
3. Note the temp. of the water sample and read the conductivity.

Calculations:

$$\text{Conductivity µmho/cm} = \frac{k\ m}{1+ 0.019\ (t-25)}$$

Where km = measured conductivity at t^0 C

t = temp. of the water sample

SUSPENDED SOLIDS: Activity 2

Suspended solids are small and can easily be trapped on an ordinary filter paper. They are light and hence do not sediment down in a container. In water bodies, these solids are contributed by a variety of agriculture, municipal and

industrial activities. They make the water turbid and block the passage of light and thus they degrade the quality of water.

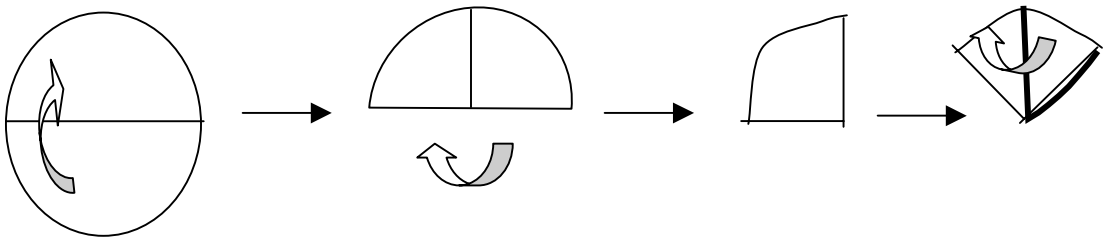
Materials required:

Two clean glass beakers (100 ml), a glass funnel, filter papers, oven and a weighing balance.

Procedure:

Thoroughly mix the water sample by stirring or shaking vigorously before proceeding with the experiment.

1. Filter 100 ml of sample water through a funnel layered with filter paper of known weight. Collect the filtrate in another clean container.



(Fold the filter paper into half; again fold into half; make a cone by pulling one layer on one side and three layers on the other side).

2. Stir the water sample and then pour through the filter-layered funnel, and slowly allow the water to filter. After all the water has filtered, allow the filter paper to dry at 105^0 C for about 30 mins. in an oven.
3. Weigh it with residue. The difference between the two weights represents the suspended matter present in the water sample.
4. Note both the weights and their difference in the water worksheet.
5. Repeat the procedure three times and report the average reading in the water work sheet (WWS: Activity 2).

Chemical Properties: Activity 3 to 14

pH: Activity 3

This is an indicator of acidity or alkalinity of water. Its value ranges from 0 to 14, with pH between 6 and 7 indicating a neutral state. Values above 7 indicate alkaline state and that below 7 indicates acidic condition. Natural water bodies are slightly alkaline in nature.

Different human activities such as mining, agriculture run offs and discharge of industrial and domestic effluents into water bodies can cause considerable pH fluctuation.

pH has a strong influence on the types of living organisms in a water body. Amphibians like frogs and salamanders are particularly sensitive to low pH. Acidic pH of water is corrosive in action for metal and concrete structures. Extreme pH on either side of the pH scale can lead to several skin and gastro-intestinal problems in humans.

Materials required:

A clean glass container, pH paper

Experimental procedure:

1. Rinse a 50 ml beaker at least twice with the sample water.
2. Fill the beaker about half way with the sample to be tested.
3. Hold the pH paper with a forceps and dip it into the sample for at least a minute.
4. Make sure that all the four sides of the paper are immersed in the water.
5. Remove the paper and compare the colour developed with the colour chart on the pH booklet.
6. Repeat the procedure three times and note the average pH in the water worksheet (WWS: Activity 3).

ALKALINITY: Activity 4

Alkalinity is the capacity of water to neutralize acids. It is mainly due to salts of strong bases and weak acids. In natural water bodies, alkalinity is due to salts of carbonates, bicarbonates, silicates and phosphates. High alkalinity due to Ca and Mg ions is considered unsuitable for irrigation. Although alkalinity has little or no effect on pubic health, high alkaline waters are unpalatable and are not used for domestic water supply. Water with low alkalinity (lower than 24 mg $CaCO_3$/liter) has low buffering capacity and is susceptible to change in pH.

For reasonably clean waters used for domestic purposes, alkalinity standards are 200 mg $CaCO_3$\litre.

Materials required:

Burettes, pipettes, conical flask, volumetric flasks (250ml and 1000ml), measuring cylinder, dropper, weighing balance.

0.02N concentrated sulfuric acid, 1N sodium carbonate, phenolphthalein, methyl orange, methyl alcohol, 0.02 N sodium hydroxide and distilled water (refer Appendix 1).

Experimental procedure

This test is done in two steps: (A) Phenolphthalein alkalinity defined as the amount of strong acid needed to lower the pH to 8.3, i.e., free alkalinity value. (B) Total alkalinity defined as the amount of acid required to further lower the pH to 4.5.

Part A: Phenolphthalein alkalinity:

Take 50ml water sample in a conical flask and add 3-4 drops of phenolphthalein indicator. If no pink colour is seen, phenolphthalein alkalinity is zero. If pink colour appears, titrate the sample against 0.02N H_2SO_4 till the solution becomes colourless. Note the readings and calculate the following:

$$\text{Phenolphthalein alkalinity} = \frac{\text{Volume of } H_2SO_4\text{(ml)} \times \text{normality of } H_2SO_4 \times 50 \times 1000}{\text{Volume of sample (ml)}}$$

Part (B): Total alkalinity

In the above same beaker, add 3-4 drops of methyl orange. Titrate the yellow solution against sulfuric acid till the colour changes from yellow to orange.

$$\text{Total alkalinity} = \frac{\text{Volume of } H_2SO_4 \text{ (ml) x normality of } H_2SO_4 \text{ x 50 x 1000}}{\text{Volume of sample (ml)}}$$

{In the above formula, 50 represents: 1ml of NaOH = 50 mg of $CaCO_3$, calculated from standardization procedure of H_2SO_4 (Appendix 1)}

Once we know the total alkalinity, determine if the alkalinity is due to hydroxide, carbonate or bicarbonate, from the table given below.

Values of P* and T*	Hydroxide alkalinity (as $CaCO_3$)	Carbonate alkalinity (as $CaCO_3$)	Bicarbonate alkalinity (as $CaCO_3$)
P =0	0	0	T
P <1/2 T	0	2P	T-2P
P =1/2 T	0	2P	0
P >1/2 T	2P-T	2 (T-P)	0
P = T	T	0	0

*P = Phenolphthalein alkalinity and T = Total alkalinity

Principle: Alkalinity of surface waters is due to presence of carbonates, bicarbonates and hydroxides. Alkalinity thus indicates the sum of concentration of all these ions. Borates, phosphates, silicates and other bases may also contribute to alkalinity values. Hydroxyl ions produced due to dissociation/hydrolysis of solutes react with acids (H_2SO_4, HCl); titrations to end point pH 8.3 (Phenolphthalein alkalinity) and then to pH 4.3 (total alkalinity) are done using indicators. These two alkalinities help to determine the specific ions that contribute to alkalinity in the water sample.

DISSOLVED OXYGEN: Activity 5

Dissolved oxygen (DO) is the amount of oxygen present in water. It is an important characteristic of any water body and is essential for maintaining its natural ecology. DO also reflects the physical, chemical and biological processes occurring in a water body, and is an indirect measure of photosynthetic activity in water eco-systems. Less oxygen means reduced number of life forms in the water body and is an indirect indicator of water pollution. DO is mostly contributed by atmosphere; algae and rooted plants also give out oxygen during photosynthesis. It is expressed as mg of oxygen in one litre (mg/l) of water. *The DO of unpolluted natural waters is usually in the range of 4 to 8 mg/l.*

Oxygen content of waters varies with salinity, turbulence, photosynthetic activity and temperature. Since it is a poorly soluble gas, its solubility directly varies with atmospheric pressure at any given temperature. The range of solubility of atmospheric oxygen, in fresh waters is, 14.6 mg\l at 0^0 C to about 7.0 mg\l at 35^0 C under one atmospheric pressure. Warm water holds less oxygen as compared to cold water. Therefore, water fauna and flora experience stress during the hot summer months. Build up of organic wastes of dead plants and animals, discharges of domestic waste and industrial effluents containing oxidizing chemicals are the major factors that cause depletion of DO in a water body. Eutrophication (increase in algae numbers) also causes DO depletion.

Materials required:

250 ml DO bottle (any glass bottle with a air-tight stopper), 2 nos. of 2 ml syringes (glass or plastic), 1 no. of 10 ml. syringe, conical flasks, an ink dropper. Manganese sulphate ($Mn(II)SO_4$) solution , alkaline potassium iodide (KI) solution, sulphamic acid (NH_2SO_3H), 1% starch solution and 0.025 N sodium thiosulphate ($Na_2 S_2O_3$) (refer Appendix—Preparation of solutions 1).

Experimental procedure:

DO is measured by Winkler test. Before proceeding with the expt, the water sample has to be fixed (removal of oxidizing chemicals by chelation) for DO immediately at the site itself.

DO fixing:

1. The 250 ml DO bottle is filled completely with water sample.
2. The bottle is immediately corked up to ensure that no air bubble is trapped. To the sample water, add 2ml of $MnSO_4$ solution with a pipette or a syringe. The solution should be added well below the surface of the water. Mix the contents by inverting the bottle 3-4 times.
3. Next, add the same amount of alkaline potassium iodide (KOH\KI) solution to the sample water. Mix well until a brown precipitate forms.
4. A brown precipitate is formed and will soon settle down. Place the stopper tightly and shake the bottle vigorously.
5. Allow the sample to stand for at least 20 minutes.

Measurement of DO

1. To the above fixed water sample, add 2 gms of sulphamic acid.
2. Replace the stopper and mix the solution to dissolve the precipitate.
3. Pour out 50 ml of this sample into the conical flask.
4. Holding the conical flask in one hand, gently add thiosulphate solution drop by drop, with simultaneous mixing of the contents. Care must be taken not to spill the contents of the flask.
5. When the colour of the contents in the flask changes to pale yellow, stop adding thiosulphate. Note the volume of thiosulphate added.
6. Drop wise add the indicator (1 % starch solution, about 15-20 drops) with a dropper to the conical flask.
7. Shake the flask and observe the colour change to blue.
8. Now again add the thiosulphate solution drop wise until the blue color disappears. This is the endpoint of the titration. Note the volume of thiosulphate added.
9. Note the total volume of thiosulphate added (A ml). This will be the sum of the amount of thiosulphate added before and after adding starch.

10. Volumes of sodium thiosulphate consumed, say 'A' ml, is equivalent to the milligram concentration of DO in 50 ml. solution. Hence, '2A' of sodium thiosulphate is equivalent to DO in mg/l.
11. Record both readings in the water worksheet (WWS: Activity 4).

$Mn^{2+} + ½\ O_2 + 2\ OH^- \rightarrow MnO_2 + H_2O$

$MnO_2 + 2I^- + 4H^+ \rightarrow Mn^{2+} + I_2 + 2H_2O$

$I_2 + 2\ S_2O_3^{2} \rightarrow 2I^- + S_4O_2^{2-}$

5 ml of 0.025 M of $Na_2S_2O_3$ is equivalent to 1 mg\l of DO

Principle: DO is estimated using the Winkler or iodometric method. Manganese reacts with alkali (during fixation) to form a white ppt. of $Mn(OH)_2$, which gets oxidized to brown ppt. {of $MnO(OH)_2$}. In acidic medium, Mn ions are reduced by I^- (iodide) ions to form I^2 (iodine). The amount of I^2 liberated is equivalent to the amount of oxygen in the sample. This I^2 is titrated with standard $Na_2S_2O_3$ solution. Fast quantification is ensured by addition of Mn (II) salts in strongly alkaline medium. Interference due to oxidizing agents such as NO_2^- and SO_3^{2-} present in wastewater is eliminated by addition of sodium azide (NaN_3) to alkaline I^- solution. On acidification, NO_2 is decomposed.

BIOCHEMICAL OXYGEN DEMAND (BOD): Activity 6

Among the various tests carried out for analysis of open water body, BOD test is one of the most important tests reflecting water quality. BOD refers to the amount of dissolved oxygen required by microorganisms (decomposers) for decomposition of three types of materials: organic matter (carbonaceous), in-organic like sulphides and ferrous ions and reduced forms of nitrogenous matter present in water. In other words, BOD indicates how much waste could be accommodated in a water body without its further deterioration. The test is widely used to measure the wastes that could be loaded to sewage treatment plants and in finding out the BOD-removal efficiency of such plants.

A large amount of organic matter in water leads to increased growth of decomposers. These demand a high amount of oxygen for their respiration. If the growth of the decomposers is unchecked, the oxygen demand by them leads to deficiency of dissolved oxygen in water creating anaerobic conditions. Such anaerobic conditions deprive water plants, animals and microorganism (aerobic) of enough oxygen for respiration, leading to their death. This causes eutrophication of water body, where it is completely covered with a layer of algae and other water plants. However, dissolved oxygen is always found in the upper layers of waters being in direct contact with air. Thus, all forms of life, especially water plants, crowd on the surface, further reducing entry of sunlight into the water body.

BOD measurements give variable results depending on the water body. For standardization, BOD is taken at different times of incubation of microbes and hence there is 5-Day BOD test (5-d BOD, BOD_5), 60-90 incubation test called as ultimate BOD or (UBOD) and continuous oxygen uptake by Respirometric method. Here the 5-d BOD method is used. To mimic the original water body quality in the water sample collected, seeding and dilution of the water sample is carried out. These also maintain the pH at 6.5 to 7.5 for BOD estimation.

According to the standards laid out by the CPCB, BOD limits for: (i) drinking water (DW) without conventional treatment but after disinfection, (ii) DW after conventional treatment and disinfection, (iii) organized outdoor bathing source and (iv) industrial effluents discharged in inland surface waters should not exceed 2, 3, 3, and 30 mg/l resp. (5-d at 20^0 C). (See BOD under liquid waste for further details.)

.

Materials required:

Reagent bottles of 250-300 ml, volumetric flasks, beakers, pipettes, burette, measuring cylinder, weighing balance, incubator and aerator (for vigorous shaking).

Double distilled water (BOD free), ammonium chloride (NH_4Cl), disodium phosphate hydrogen heptahydrate (Na_2HPO_4 .$7H_2O$), dipotassium hydrogen phosphate (K_2HPO_4), potassium dihydrogen phosphate (KH_2PO_4),

magnesium sulfate heptahydrate ($MgSO_4 .7H_2O$), calcium chloride ($CaCl_2$), ferric chloride hexahydrate ($Fe\ Cl_3 .6H_2O$), concentrated sulfuric acid and distilled water, dilution water and seeding mixture (See Appendix 1).

Experimental procedure:

Conventionally, a 5-d BOD test is done wherein the amounts of oxygen required for biochemical degradation of organic matter in five days is measured. This requires that samples be incubated at 20^0 C for five days. Then DO is measured initially (Day 1) and after incubation (Day 5); the BOD is calculated as the difference between the two DOs (D1-D2).

The amount of BOD in wastewaters often exceeds the concentration of DO. Therefore, it is necessary to dilute the sample (with dilution water) for estimation of the BOD. This dilution water contains all the nutrients and appropriate pH suitable for bacterial growth. It could be distilled, tap or any stream water free of biodegradable organics and other bio-inhibitory substances, such as chlorine and heavy metals. If the sample is highly polluted (such as, industrial effluents, high temperature and extreme pH wastes) and if it does not support any microbial growth, then these samples are seeded with a microbial population obtained from supernatant of domestic wastewater.

1. Collect the water samples and fix the sample as mentioned for DO. Next, dilute these samples with dilution water (see appendix 1). The dilution ratio for various water samples is given below. Dilution is not necessary for unpolluted/potable water.

Sample	Percentage dilution	Dilution mixture (sample + water)		Total volume
Polluted water		Sample	Water	1000 ml
	50 %	500ml	500ml	1000 ml
	25 %	250ml	750ml	1000 ml
	20 %	200ml	800ml	1000 ml
	10 %	100ml	900ml	1000 ml

If the waters are polluted/dirty, use 25% and 50% dilutions for analysis. If water is from industrial effluents/excessively treated not allowing any microbes to survive, then seed the dilution water with a culture/domestic waste. Adjust the pH of the sample to7.0 using an acid or a base.

2. Fill the BOD bottles with the sample and immediately estimate DO.
3. Make two sets of bottles for each dilution. Immediately estimate the DO of one sample of each dilution. Label these as D1. Keep the other set for incubation at 20-25^{0}C for five days. The airtight bottles are incubated in dark to prevent photosynthesis.
4. Determine the DO of incubated samples after 5 days (D2).
5. Carry out blank readings for the above two sets before and after incubation (B1 and B2). The blank does not contain the sample water (only contains dilution water).

Calculation: (i) (If sample is not seeded)

$$\text{BOD (mg/l)} = \frac{D1-D2}{P}$$

Where: D1 and D2 are the DO content of the samples on days 1 and 5
P is the volume of sample used for titration

(ii) (If sample is seeded)

$$\text{BOD (mg/l)} = \frac{(D1-D2)-(B1-B2) \times F}{P}$$

Where: D1 and D2 are the DO content of samples on days 1 and 5
B1 and B2 are the DO content of samples on days 1 and 5
F is the total volume of solution in the DO bottle
P is the volume of the sample used for titration.

The quality of water in terms of BOD values can be interpreted as :

BOD (mg\l)	0-1	2	3	5	>10
Water quality	Very clean	Clean	Fairly clean	Doubtful	Bad

CHEMICAL OXYGEN DEMAND (COD): Activity 7

COD reflects the degree of organic and inorganic pollution in a water body. It is a good measure of pollutants in waste and natural waters. It is defined as the amount of oxygen required for complete oxidation of all substances present in the water. The COD values are always higher than BOD values because all pollutants are not mineralized in the biochemical processes. COD is a preferred to BOD in determining the quality of industrial effluents containing non-biodegradable organic pollutants. Such effluents record very low values of BOD. Besides, determination of COD is faster as it does not require any incubation period.

According to Central Pollution Control Board, COD standards for clean water bodies lie between 4-10 mg/l. Standards for discharge of effluents in different waters is: 250 mg/l. These waters include: inland surface water, land for irrigation and marine coastal areas.

Materials required:

Conical flask, burette, pipette, bunsen burner, tripod stand, wire gauze, beaker, measuring cylinder and weighing balance.

0.25N Potassium dichromate, 0.25 N ferrous ammonium sulfate (FAS solution), concentrated sulfuric acid, 1,10 phenanthroline monohydrate, ferrous sulfate ($FeSO_4$. $7H_2O$), mercuric sulfate and distilled water (see appendix 1).

Experimental procedure:

1) Take 20 ml of water sample in a conical flask and add 0.1 gm (pinch) of mercuric sulfate
2) Slowly add 5ml of concentrated sulfuric acid (an ice bath must be used to avoid spurting) and add 10ml of 0.25 N potassium dichromate solution. Cool the flask and again add 30 ml of sulphuric acid, taking the above-mentioned precautions. Add few porcelain pieces to prevent jumping during boiling (reflux) in the next stage.
3) Cover the flask with a watch glass/small petri plate and allow it to stand in boiling water bath for 30 mins. If the colour of the solution changes to green (indicating high COD), dilute the sample water appropriately with distilled water and repeat steps 1 to 3. If the colour after boiling remains orange, proceed with step 4.
4) After boiling (solution colour is orange), double the volume of the sample with distilled water.
5) Add 5 drops of ferroin indicator (see appendix 1) and titrate against 0.25N FAS solution. The end point of the titration is reddish brown colour.
6) Similarly, carry out the titration for distilled water blank.

Calculation:

$$\text{COD (mg/l)} = \frac{(Y-X) \times (N) \times 8 \times 1000}{\text{Volume of water sample taken for digestion}} \times \text{dilution factor}$$

(if sample is diluted)

Where:

Y is the volume of ferrous ammonium sulfate (FAS) for the blank

X is the volume of FAS used in titration for the sample

N is the normality of FAS

8 is the equivalent wt of oxygen

1000, to determine COD value in 1 liter of water sample.

Dilution factor (DF): is 1, if 20 ml sample is diluted with 20 ml of DW. Or, DF= 2, if 20 ml sample is diluted with 40 ml DW.

Principle: Boiling a mixture of chromic and sulphuric acids oxidizes most types of organic matter. Potassium dichromate in the presence of sulphuric acid is the commonly used oxidizing agent. The sample is refluxed with the acidic oxidant in the presence of mercuric sulphate to neutralize the effect of chlorides and catalyst (silver sulphate). The excess of potassium dichromate is titrated against ferrous ammonium sulphate with ferroin as an indicator. The amount of chromate used is proportional to the oxidizable organic matter present in the sample.

CHLORIDES: Activity 8

Chlorides are one of the major constituents of water and wastewater. The presence of chlorides in drinking water in concentrations below 250 mg\l causes no harm to the human body. At concentrations greater than 250 mg\l chlorides impart a salty taste to water. The degree of salty taste depends on the cation associated with the chloride and on the concentration of the salt in water. Chloride salts of sodium produce more saltiness than those of magnesium and calcium. The concentration of chlorides is higher in wastewater (domestic sewage) than in fresh natural waters. As sodium chloride is an important constituent of human diet, it passes unchanged through the digestive system and expelled out of the human system.

The natural sources of chlorides in open water bodies are contributed by washing of mineral rocks containing salts of potassium, magnesium, etc. Excessive amounts of chloride suggest water contamination due to seepage of sea water into surface and ground water, human faecal contamination (as sewage contains high amount of salt content), and industrial discharge of effluents.

Chlorides are essential for plants and animals and are stored as sodium chloride in their body. Chlorides are not considered to be harmful to human health. However, high concentrations are harmful to plants and damage may

occur at 70-250 mg\l. *Drinking water standard for chloride lies between 200-250 mg\l.*

Materials required:

Volumetric flasks, conical flask, measuring cylinder, burettes, pipettes, weighing balance, potassium chromate (K_2CrO_4), silver nitrate ($AgNO_3$), NaCl and aluminum hydroxide suspension (see Appendix 1).

Experimental procedure:

1. If the sample is highly coloured, add 3 ml of the aluminum hydroxide suspension; mix and allow it to settle and then filter.
2. Take 1ml of the water sample and adjust the pH between 7.0-8.0 (use either NaOH or conc. H_2SO_4).
3. To this sample and add 1ml of potassium chromate.
4. Titrate against standard silver nitrate solution until a brick red precipitate is formed. The first drop of $AgNO_3$ that turns the precipitate to brick red in colour shows the endpoint.
5. Note the colour of the precipitate and not the solution to get the accurate endpoint. Repeat the procedure with blank containing distilled water. This method is termed as Argentometric titration.

Calculation:

$$\text{Chloride (mg/l)} = \frac{(X-Y) \times \text{Normality of } AgNO_3 \times 35.45 \times 1000}{\text{Volume of sample (ml)}}$$

Where:

X is the volume of $AgNO_3$ required for sample;

Y is the volume of $AgNO_3$ required for blank.

35.45 is equivalent weight of chlorine; 1000 is factor for conversion to liter.

Principle: Chloride is determined by Argentometric titration in which potassium chromate acts as an indicator in alkaline conditions. On titrating with $AgNO_3$ solution using K_2CrO_4 as a self-indicator, silver nitrate is precipitated as silver

chloride and further converted to silver chromate (brick red ppt) thereby indicating the end point.

FLUORIDES: Activity 9

The natural source of fluorides in water is the weathered material from rocks. The concentration of fluorides in ground waters is higher than in surface waters. Effluent from fertilizer, glass and chemical manufacturing industries are major anthropogenic sources of fluorides in water.

Detection of fluorides in drinking water is important as high concentration of fluoride consumption causes discolouration of teeth and abnormalities in skeletal system called *fluorosis,* the incidence of which is high when fluoride levels are greater than 1.5 mg/l in drinking water. At concentrations of 1 mg/l in drinking water, fluorides prevent dental caries, with no harmful effects on overall health. *The acceptable limit for fluorides in drinking water is 1.5 mg/l.*

Materials required:

Colorimeter/spectrophotometer, test tubes, pipettes, 1000 ml volumetric flasks, measuring cylinder and a weighing balance.
3-alizarin sulfuric sodium salt, zirconyl chloride octahydrate, concentrated sulfuric acid, sodium fluoride and distilled water (see Appendix 1).

Experimental procedure:

1. Take 10 ml of the sample in a clean 50 ml flask.
2. Add 1.0 ml of acid zirconium-alizarin solution (mixed reagent) to the sample. Make the volume to 50 ml.
3. Mix well immediately and allow it to stand for 20 minutes at room temperature.
4. Repeat the procedure with reagent blank
5. Read the colour developed at 540 nm and determine the concentration of fluoride in sample using the standard graph. Alternatively**,** compare the colour developed against the colour grid provided and note the

observation as low (L), permissible (P), high (H) or critical (C) in the water work sheet (WWS: Activity 9). Note: Higher fluoride conc. gives yellow colour. (The intensity of this yellow colour decreases with increase in fluoride conc.) Lower concentrations of fluoride give a reddish brown colour (the intensity of this red colour increases with decrease in the fluoride concentration).

Preparation of standard graph:

Stock sodium fluoride (NaF) solution: Prepare a stock solution of 100-ppm NaF. From this, prepare a working stock solution of 10 ppm. Use this working stock to prepare a range of standards of 1-5 ppm Measure the colour obtained at 690nm. Plot a graph of absorbance vs. concentration.

Principle: Fluoride reacts with the zirconyl alizarin reagent to form colourless $Zr\ F_6^{2-}$ and the dye. The colour of the dye lightens with the increase in amount of fluoride.

AMMONIA: Activity 10

Ammonia is a natural component in surface water, ground water and domestic sewage. It is produced largely due to deamination (removal of amino groups) of organic nitrogen-containing compounds and hydrolysis of urea. In water bodies, ammonia is some times produced by the reduction of nitrates under anaerobic conditions. *The maximum permissible limit for ammonia is 0.5 mg/litre.* Concentrations of ammonia higher than this value indicate pollution, and it becomes harmful for humans, fish and other water life forms.

Materials required:

100 ml beakers or test tubes, ink dropper, 5ml and 1ml syringes or pipettes, Nessler's reagent (*Nessler's reagent is poisonous and utmost care has to be practiced while handling it), 6N sodium hydroxide (NaOH) solution, 10 % zinc sulphate ($ZnSO_4$) solution, standard ammonia solution (100 ppm), EDTA solution (refer Appendix—Preparation of solutions (1)).

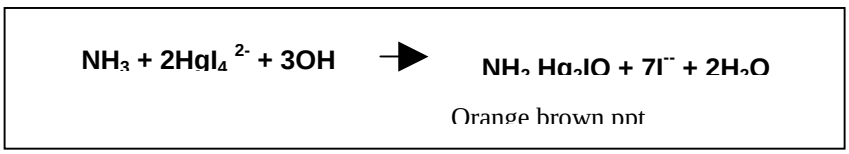
Experimental procedure:

1. Take 10 ml of the sample in a clean beaker. Add 10 drops of NaOH with a pipette or ink dropper (to neutralize the acid used for storage).
2. To the above mixture, add 0.1ml 10% $ZnSO_4$.7H2O followed by 0.1ml 6N NaOH.
3. Stir and filter the mixture. This process will remove all interfering ions of Ca, Fe, Mg, S^{2+} precipitate.
4. Slowly tilt the beaker and collect the colorless fraction in a fresh beaker. Add 1 drop of 50% EDTA. Mix the contents well.
5. Add 0.6 ml Nessler"s reagent. Shake well to mix the contents.
6. Compare the colour developed against the colour grid provided and note the observation as low (**L**), high (**H**), critical (**C**) or permissible (**P**) in the water work sheet (WWS: Activity 10).
7. If a colorimeter is available, measuring the resulting yellow color at 420 nm gives quantitative estimation of ammonia content in the sample. Plot this value against a standard graph.

Preparation of standard graph:

Stock ammonium chloride solution: Prepare a 100-ppm (refer Appendix (1) solution of ammonium chloride (NH_4Cl). From this solution, prepare a working stock of 10 ppm. Prepare a range of concentrations from the working stock (0.1 to 5 ppm). With these solutions (10 ml), proceed as for the sample solution. Measure the colour obtained at 420 nm. Plot these values against the concentrations to obtain a standard graph.

Principle: The presence of ammonia in higher concentrations (above 5 ppm) is indicated as a brown precipitate with Nessler's reagent, where the actual amount is calculated by reading on a spectrophotometer or colorimeter.



PHOSPHATES: Activity 11

Natural waters contain phosphates either in the organic or inorganically bound form. Run-offs from agricultural fields, detergent industries, biological sludge from sugar and canning industries and domestic sewage add phosphates into the water body. *In natural waters, phosphate concentrations range from 0.005 to 0.020 mg\l. According to US Public Health Department, the maximum permissible concentration of phosphates in drinking water is 0.1 mg\l.*

Higher concentration of phosphates is a clear indicator of pollution. Phosphates in water bodies indicate high levels of nutrients, which lead to undesirable growth of algae and other water flora (eutrophication), decreasing the DO content of the water body. Besides giving a distinct odour to the water body, high levels of phosphates lead to skin and eye allergies and colouration of teeth.

Materials required:

Conical flasks, beakers, test tubes, 10 ml and 1 ml syringes or pipettes, colorimeter, concentrated sulphuric acid (H_2SO_4), conc. nitric acid (HNO_3), 10% ammonium molybdate, stannous chloride solution, standard phosphate solution (100 ppm) {refer Appendix (1): Preparation of solutions}.

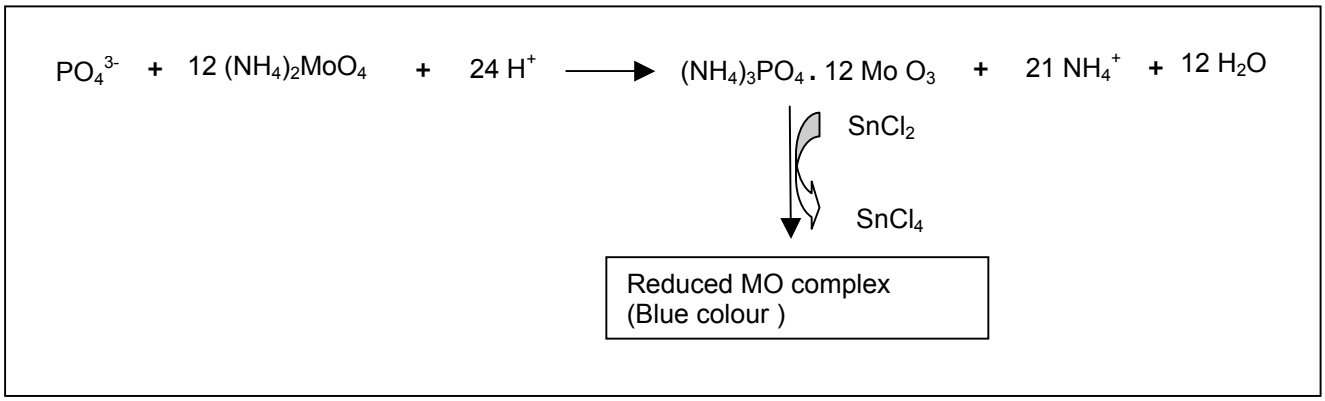
Experimental procedure

1. Take 10 ml of the sample in a clean test tube.
2. Add 0.4 ml of ammonium molybdate solution in the test tube.
3. Add 1 drop of stannous chloride solution with an ink dropper.
4. Read the colour developed against the colour grid and report the observation as **C, H, P** or **L** in the water work sheet (WWS: Activity 11).
5. To quantify the amount of phosphates present in the sample, measure the absorbance of the colour developed at 690 nm between 10 – 12 minutes after the development of colour.
6. Plot the absorbance value of the unknown sample against the standard graph to estimate the concentration of phosphate in the sample.

Preparation of standard graph:

Stock anhydrous potassium dihydrogen phosphate (KH_2PO_4) solution: Prepare a 100-ppm (Refer Appendix (1)) solution of anhydrous potassium dihydrogen phosphate (KH_2PO_4). From this prepare a working stock of 10 ppm. From this working stock, prepare a range (0.1 to 5 ppm). With these solutions (10 ml), proceed as for the sample solution. Measure the colour obtained at 690nm. Plot the values against the concentrations to obtain a standard graph.

Principle: The phosphate in the water reacts with ammonium molybdate solution in acidic medium to form molybdo-phosphoric acid. The later reacts with stannous chloride solution and is reduced to form a blue colored complex. This blue colour is measured at 690 nm to calculate the concentration of phosphates.



HEAVY METAL POLLUTION: Activity 12 to 14

Metals with high specific weight (specific weight greater than 5.0 g cm^{-3}) are termed as heavy metals. The list includes metals like mercury, cadmium, lead, iron, copper and zinc. All heavy metals in nature are of natural (geogenic) origins. They are widely used in industrial processes as reactants or catalysts.

Heavy metals are often discharged into water bodies from spills, industrial discharges, agricultural run-offs, leaking chemical tanks and landfills. Though

found in low concentrations in natural waters, they tend to concentrate in certain components, such as, clay sediments and in living organisms, such as mollusks, mussels and shellfish. Since these metals are non-degradable, they persist in the environment and cause long-term pollution.

Heavy metals in water can cause several skin and gastro-intestinal problems. Long-term exposure may affect many enzymatic activities and disturb the development of an organism, including humans.

IRON: Activity 12

Iron may either be in the Fe^{2+} or Fe^{3+} state, dissolved or suspended in water. Surface water contains less than 1 ppm of Fe. Some ground waters and acid surface drainage may contain higher levels. Waters containing more than 2ppm iron cause staining of clothes and gives a bitter astringent taste. *The maximum permissible limit by USPHS for filterable Fe in drinking water is 0.3 mg/l (ppm).*

Materials required:

5 and 10 ml syringes/pipettes, 50/100ml conical flasks, colorimeter, water bath; conc. hydrochloric acid (HCl), 1ml of 10 % hydroxyl amine hydrochloride ($NH_2OH.HCl$), 10 ml ammonium acetate buffer, 2ml phenanthroline, standard iron stock solution {refer Appendix (1)}.

Experimental procedure:

Iron in the sample is detected by the Phenanthroline method: Total dissolved Fe(II) conc. between 0.01 and 5ppm can be determined by this method. Detection limit is 50 µg of Fe. in solution.

1. Take 10 ml sample in a clean and clear container.
2. Add 0.5ml conc. HCl and 0.2ml $NH_2OH.HCl$ (10%).
3. Boil the mixture in a water bath for 15 minutes.
4. Cool the solution to room temperature and then transfer it to 50/100ml conical flask.

5. Add 2 ml ammonium acetate buffer.
6. Then add 0.4 ml phenanthroline.
7. Shake well.
8. Wait for 10- 15 min for maximum colour development.
9. Compare the colour developed against the colour grid provided and note the observations as **L, P, H or C.** Note your observation in the water work sheet (WWS: Activity 12).
10. Alternatively, measure absorbance at 510 nm against reagent blank. Plot the absorbance value of the unknown sample against the standard graph to estimate the concentration of iron in the sample.

Preparation of standard graph:

Stock ferrous ammonium sulphate [$(NH_4)_2$ Fe $(SO_4)_2$. $6H_2O$] solution: Prepare a 50-ppm solution of ferrous ammonium sulphate [$(NH_4)_2$ Fe $(SO_4)_2$. $6H_2O$] {refer Appendix (1)}. From this, prepare a range (0.1 to 5 ppm). With these solutions (10 ml), proceed as for the sample solution. Measure the colour obtained at 510nm. Plot these values against the concentrations to obtain a standard graph.

Principle: Fe (III) is reduced to Fe(II) by NH_2OH adjusted to pH 3.2/3.3. Next, it is treated with 1,10 phenanthroline. Resulting orange red solution is measured at 510 nm.

COPPER: Activity 13

Copper is one of the essential elements required in human diet, the adult daily requirement being about 2.0 mg of copper. Copper salts are used in municipal water supply systems for controlling biological growth in reservoirs and in distribution pipes and as catalyzers in various chemical reactions. Copper in combination with sulphate is also used as a pesticide. High concentration of copper in natural waters is due to pollution from agricultural run offs or corrosion of copper– containing alloys in pipes and fittings. Presence of

copper causes undesirable flavouring of drinking water. *The permissible levels of copper in drinking water are in the range of 0.05-1.5 mg\ml.*

Materials required:

100 ml beakers, test tubes, pipettes, water bath and a colorimeter.
Liquid ammonia (NH_3), 15% citric acid, 1% sodium diethyl dithio carbamate, 1% iso-amyl acetate, distilled water and standard copper solution (10 µg \ml), {refer Appendix (1)}.

Experimental procedure:

Take 5ml of sample in a clean beaker. Add 5ml of citric acid and with a dropper add 4 drops of liquid ammonia.

1. Add 1 ml of carbamate solution + 39 ml of distilled water + 10 ml of iso amyl acetate.
2. Shake the beaker vigorously for 15 min and allow it to stand until the two layers are clearly demarcated.
3. Slowly decant\pipette the upper organic layer and compare the colour developed with the colour grid provided and note your observations as L, P, H or C in water work sheet (WWS: Activity 13).
4. Alternatively, collect the upper organic phase carefully in a test tube. Measure the absorbance of the organic layer at 440 nm against reagent blank. Plot the absorbance value of the unknown sample against the standard graph to estimate the concentration of copper in the sample.
5. Note the value in the work sheet. Plot a standard graph with concentration on the X axis and absorbance on the Y-axis.

Preparation of standard graph:

Stock copper (Cu) solution: Prepare a 200-ppm {refer appendix (1)} solution of copper. From this prepare a working stock of 10 ppm. With this working stock prepare a range (0.1 to 5 ppm). With these solutions (5 ml), proceed as for the sample solution. Measure the colour obtained at 440 nm. Plot these values against the concentrations to obtain a standard graph.

Principle: Copper present in the water sample interacts with sodium diethyl dithio carbamate in an alkaline medium to form the copper salt of carbamate. This complex is golden yellow in colour. Adding a few drops of liquor ammonia creates alkaline conditions. The golden yellow colour is extracted in the organic phase of iso-amyl acetate and is then estimated colorimetrically. Citric acid is added to prevent precipitation of other metal ions due to change in pH. It also acts as a chelating agent.

CHROMIUM: Activity14

In natural waters chromium exists as trivalent (Cr^{3+}, $Cr(OH)^{2+}$ and $Cr(OH)_4^-$) or in the hexavalent form ($Cr O_4^{2-}$ and as $Cr_2O_7^{2-}$. Cr^{3+}). However, in potable waters hexavelent chromium alone is prevalent. The hexavalent chromium forms strong complexes with amines and are adsorbed by clay particles. The amount of chromium ions in the water is dependent on the hardness and alkalinity of the water. The main contributors of chromium pollution are washes from chrome iron ore; chromium is also released in the discharges of alloy, electroplating and pigment industry.

Chromium is non-essential for plants, but is an essential trace element for animals. High loads of hexavalent chromium are known to have carcinogenic effects and are harmful to tissues of humans. *The permissible level for chromium (VI) in drinking water is 0.05mg/l.*

Materials required:

Test-tubes, pipettes, conical flask, beakers, flask, measuring cylinder, watch glass, rubber bulb, weighing balance, hot-plate, colorimeter.

Potassium dichromate, concentrated nitric acid, concentrated sulfuric acid, concentrated ammonium hydroxide, potassium permanganate, sodium azide, concentrated phosphoric acid and diphenylcarbazide.

Experimental procedure:

To determine the concentration of total chromium in the sample, it is first necessary to treat the sample by acid digestion to concentrate the chromium present in the sample. For total chromium estimation, convert all the chromium into the hexavalent state. This is done by oxidation with potassium permanganate.

Treatment of sample (acid digestion):

To determine the total chromium content in the sample, digest the sample as follows:

1. Transfer 50 ml of well-mixed sample in a beaker or flask. Add 5ml conc nitric acid and cover with a watch glass. Slowly boil and evaporate the solution till only half of the initial amount remains (this takes about 3 to 4 hours). Cool the flask.
2. Again add 5ml conc nitric acid and 10 ml of conc sulfuric acid and observe for brown fumes. Next, evaporate by boiling until brown fumes disappear and the solution becomes clear. Some white fumes of SO_3 also might appear. (This takes about 90 mins.)
3. If the solution does not become clear, repeat step no. 2 (add 5 ml conc HNO_3 and 10 ml H_2SO_4 and boil until white fumes appear.)
4. Cool and dilute to 50 ml with distilled water and boil for 5 minutes to dissolve any salts.

Oxidation of trivalent chromium:

1. Carefully with a rubber bulb, pipette out the treated sample in a conical flask and add 10 drops of methyl orange.
2. Add concentrated ammonium hydroxide until the solution begins to turn yellow.
3. Check the pH of the solution. Add sulphuric acid drop wise (~20 drops) until the solution is acidic. Add excess of 1ml of sulphuric acid drop wise.
4. Adjust the volume to about 40 ml with DW and add a few glass beads. Heat to boiling. Add few drops of potassium permanganate solution till persistent red colour appears.

5. Continue to boil for 2 mins (the solution may become turbid). Add 1ml sodium azide and boil gently, till the red colour fades. In turbid solution, a ppt. may be formed.
6. If red colour does not fade after boiling for few minutes, then add another 1 ml of sodium azide.
7. Boil till red colour has faded completely and then cool the solution. If ppt is formed, filter the solution and proceed for colour development.

Colour development and measurement:

1. Add 2 ml. of phosphoric acid to the above sample and check the pH. Adjust the pH to 1.0.
2. Take 10 ml of this sample in a clean flask.
3. Add 0.5 ml of diphenylcarbazide solution, mix and let it stand for 5-10 mins. A violet colour is formed if chromium is present.
4. Determine the OD at 540 nm using reagent water as reference (diphenylcarbazide + distilled water to make the volume 100 ml). Alternatively, compare the colour developed against the colour grid provided and note the observations as L, P, H or C. Note your observation in the water work sheet (WWS: Activity 14).
5. Correct the absorbance of sample by subtracting the OD of blank from sample reading. Calculate the concentration of chromium using the standard graph (calibration curve).

Preparation of calibration curve

Prepare a stock solution of 100 ppm followed by a working stock solution of 10ppm. Using this working stock, prepare a range of 0.1-5ppm. Add 2ml phosphoric acid and 0.5 ml diphenyl carbazide. A dark violet colour is formed. Determine the OD at 540nm. Determine the concentration of sample using this standard curve.

Principle: The total chromium is converted to hexavalent chromium before colour development. The hexavalent chromium present in the sample reacts with diphenylcarbazide in acid condition to form a red-violet

coloured complex of unknown composition. The intensity of colour developed is directly proportional to the concentration of chromium and is detected colorimetrically at 540nm.

Calculation:

$$\text{Concentration in mg/litre} = \frac{\text{Concentration obtained from graph}}{\text{A x B}} \text{ x } 100$$

A = amount of raw sample used for digestion

B = amount of digested sample used for analysis from a volume of 100 ml.

Microbial Properties: Activity 15

Natural waters contain a variety of microbes, such as, fungi, protozoa, algae, bacteria and viruses. Majority of these microorganisms play a useful role in self-purification of the water body. This purification is a result of organic biodegradation by microorganisms. However, some of the microorganisms produce toxins and cause diseases. These are the pathogenic microbes. Microbial contamination of water is caused due to the release of domestic sewage contents into the water bodies or by unhygienic practices. This results in the release of a large number of pathogenic bacteria into the water.

It is difficult and laborious to check for all microorganisms in water. Hence, a few indicator organisms are often checked to assess the bacteriological quality of water. The most commonly used indicators are the total bacterial count and the count of a bacterium called, *Escherichia coli (E.coli*) count.

BACTERIOLOGICAL QUALITY OF WATER:

This is an important parameter of water quality from the public health point of view. *E.coli* is the normal microbial flora of the human intestines. They are frequently released in the human faeces. The presence of *E.coli* in water is a clear indicator of faecal contamination and, therefore, the water is not fit for drinking.

The presence and numbers of *E.coli* is estimated by the presumptive coliform test and is expressed as Most Probable Number (MPN) of *E.coli* in water. This number is derived based on certain probability functions. The number indicates the approximate mean density of coliforms in the sample.

For the presumptive coliform test, a known volume of the sample water is added to tubes containing culture media (i.e., fermentation tubes). The tubes are then incubated for a fixed time, and later checked for the production of acid and gas. The presence of both the gas and acid production is a positive indicator for coliform bacteria.

The number of tubes showing positive is recorded and matched with the MPN table provided {Appendix (4): MPN chart}, and the corresponding number is reported as the MPN for the water sample. The result is expressed as the most probable number (MPN)/100 ml of organisms present. The MPN for the quality of water is interpreted as follows:

MPN result	**Water quality**
<1	Excellent
1-2	Satisfactory
3-10	Suspected
>10	Not suitable for drinking

Materials required:

Normal microbiological materials: sterile cotton, test tubes or culture tubes, conical flasks pressure cooker, incubator or hot case, pipettes, newspaper, measuring cylinders, physical balance, cooking stove, Bunsen burners or spirit lamps and Durham tubes (small tubes of about 2.5 cm long with one end closed and the other end open. The gas produced accumulates in this tube.)

Culture medium:

A culture medium provides the necessary nutrients for growing microorganisms. The MacConkey broth is the most commonly used medium

for the isolation of coliforms. The coliforms present in the water sample ferment the lactose in the culture media leading to the production of acid and gas. A pH indicator is also added to this medium for the detection of acid.

Readymade double strength (ds) MacConkeys broth nutrient medium is available in the market. If not available, the media can be prepared as follows:

Ingredients required: 40 gm peptone, 20 gm lactose, 10 gm bile salt (sodium thaurocholate), 10 gm sodium chloride, 0.15 gm neutral red and 1000ml distilled water.

1. Dissolve all ingredients except the neutral red dye in 800 ml of distilled water in a conical flask. Some of the nutrients may not dissolve easily. In such case, the mixture is heated slightly to dissolve all nutrients and allowed to cool.
2. Adjust the pH of the solution to 7.4 by adding acid or base accordingly. Add the neutral red dye after adjusting the pH. Finally, make up the volume to 1000 ml. The culture broth is ready now.
3. Prepare single strength broth by dissolving half the amounts of the ingredients used in the double strength in 1000 ml distilled water. Adjust the pH of the broth to 7.4 similarly as for (ds) broth.

Experimental procedure:

This is a technical microbiological experiment and requires skill and practice of handling culture media and maintaining sterile conditions. It is necessary to perform the experiment under proper supervision. Collect the water samples for MPN test in sterile bottles.

1. Take 9 test tubes; add 10 ml of single strength (ss) MacConkey broth to 6 test tubes and 10 ml of double strength broth to 3 tubes.
2. Place a Durham tube in each test tube in an inverted position using forceps. Plug each test tube with cotton plugs. These are the fermentation tubes.

3. Wrap the tubes containing the medium separately in newspapers. Keep the tubes in a container on a stand inside the pressure cooker. Add sufficient water to fill a quarter of the tub.
4. Heat the pressure cooker. Place the weight on the cooker just after the steam starts escaping the nozzle. Continue heating for 20 minutes. Put off the flame. Allow the pressure to come down.
5. Open the lid and remove the tubes. Allow the tubes to cool.
6. Place two lit bunsen burners or spirit lamps about 15-20 cms apart or at a workable distance. This provides a sterile working platform.
7. Pipette out 1 ml of the broth carefully in the center of the two burners to avoid contamination. Replace the cotton plugs immediately.
8. Add 10 ml of water sample to each of the three double strength tubes using a sterile 10 ml pipette and label as 10 ml.
9. Similarly, add 1 ml of the water sample to each of the three single strength tubes using a sterile 1 ml pipette and label the tube as 1 ml.
10. Add 0.1 ml of the water sample in the remaining 3 single strength tubes using a fresh sterile 1 ml pipette and label the tube as 0.1ml.
11. Incubate all the tubes in a incubator at 37 ^{0}C for 24 to 48 hours. If an incubator is not available, a hot case used in the kitchen can be used. This can keep the warmth up to 6 hours after which the temperature in the hot case drops to the ambient temperature.
    - During summers, place the tubes in a small beaker in the hot case. Close the lid tightly. Remove the lid every 6 hours and observe.
    - In order to maintain the temperatures during winter and rainy seasons place a 50 ml beaker with boiling water in the hot case. Close the lid tightly and incubate. Replace the hot water every 6 hours and at this point check for any changes in the tube.
12. After the incubation, observe all the test tubes.
13. Examine all the tubes for the production of acid as indicated by the change of the broth colour from orange to yellow. Also, check for the production of gas, indicated by bubbles in the Durham tube.
14. Count the number of tubes showing positive results. Also, note the volume of the water sample.

15. If the tubes do not show a positive result at the end of 24 hours, they should again be incubated until 48 hours and examined similarly.
16. The absence of gas and acid production is recorded as a negative result.
17. If the presumptive test is positive, determine the MPN of coliforms present in 100 ml of the water sample using the MPN table.

    (For example, if gas appears in all three tubes labeled 10 ml and two tubes labeled 1 ml the MPN table indicates that there are approximately 93 coli forms in 100 ml of the water sample).
18. Absence of gas and acid production constitutes a negative presumptive test indicating that the water sample is devoid of any coliforms.
19. Since the presumptive test is sometimes positive for non-coliforms, a confirmatory test has to be performed to confirm the presence of coliforms.

Confirmatory test: Streak a loop full of the culture from a positive test tube onto a deferential\selective media like Eosin methylene blue agar plate and incubate the plate up side down for 24-48 hours in a incubator and check for the growth of colonies. The eosin methylene blue in the medium allows selective growth of gram-negative bacteria.

The presence of *E.coli* in the sample is indicated by a pink-red colony with a shiny surface. Count the number of *E.coli* colonies and express it as colony counts per 100 ml. Note this number in water work sheet (WWS Activity 15).

A few points to think about:

- Check the microbial, plant and animal population in the water body.
- Check the presence or absence of mosquito larvae in the water body.
- Compare the quality of water (physical, chemical and biological parameters) in stretches where mangroves are present and absent.

Water Worksheets

Name Of The Investigator: **Date:**

College Name/Address:

Site Name: **Location:**

General Observations Of The Site:

Monitoring of: Drinking water source_____, Open water body___

If monitoring drinking water: Source of drinking water: Wells____, Bore wells____,
Municipal supply____, Other____
Position of storage tank: Underground___, Overhead____
Type of storage tank: Plastic___, Metal___, Concrete____, Other____
Sampling point: Tap____; Other____
Sampling point for overhead tank: At inlet of water supply____
When: Full tank____, Tank half empty____, Tank nearly empty_____
Sampling point for underground tank: At inlet of water supply____
When: Full tank____, Tank half empty____, Tank nearly empty____

If monitoring open water body: Water type: Salt____, Fresh ____,
Moving water: River____, Stream ____, Creek___, Other ____
Standing water: Pond ___, Lake ____, Reservoir____, Well_____ , Other____
Sample collection point for moving and standing water: Shoreline ____,
Bridge_____, Boat____, Other____
Clarity of water body: Clear ____, Turbid ____

Activity1: Study Of Physical Properties Of The Water Sample

Serial no.	Colour		Smell/Odour		Temperature °C	Turbidity		
	Type C-colourless B-blue G-green R-red B-brown Others (specify)	Intensity D-dark L-light	Type O-Odourless F-fishy S-sweetish E-faecal U-unpleasant Others (specify)	Intensity St-strong F-faint M-moderate		Depth of sechi disc when: (cms)*		
						Visible (A)	Invisible (B)	Difference (B-A)
Average								

Report the transparency as NTU by referring to the graph in the appendix (3) – SDT-NTU conversion chart. (Note: Greater the NTU->-> smaller the transparency)

(R*eport the average readings/observations in final water data sheet*)

*** Tube method observations:**

Pour sample water till the disc pattern disappears. Black quadrants will be somewhat visible, but mark that depth at which the center point of the disc blurs or disappears. Often, for potable water, the pattern is visible even after filling of the entire tube; enter the length of the tube in cms.

Observations:

____ cms: (depth at which the center point of the disc gets invisible/blurred)

OR

____ cms: if pattern/center point is visible with the entire tube full of water.

(*Repeat three times and report the average readings in final water data sheet.)*

Activity 2: Suspended Solids:

Date of sampling: Date of performing the experiment:

Drying temperature:

Observations for the wet weight-dry weight experiment

Sr.no	Weight of clean filter paper in gms (A)	Weight of paper + residue in gms (B)	Weight of residue in gms (B-A)
Average			

Average weight of the residue: _____

(***Report average reading of residue weight in the final water data sheet.***)

Chemical Properties

Activity 3: pH

Date of sampling: Date of performing expt:

pH measured with: _____

pH value of distilled water: _____

pH value of sample water: _____

Observer 1: ___, Observer 2: ____, Observer 3: ____,

Average pH: _____

(Report average reading in the final water data sheet)

Activity 4: Alkalinity Of Water

Alkalinity is expressed in terms of mg of $CaCO_3$

Solution in the pipette: _____ Solution in the flask: _____

Indicator used: _____End point: _____

Titration readings for alkalinity:

For phenolphthalein:

Serial No.	Vol. of HCl in ml			Constant reading (S)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

For methyl orange:

Serial No.	Vol. of HCl in ml			Constant reading (B)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

$$\text{mg/l of } CaCO_3 = \frac{\text{constant reading(ml)} \times \text{Normality of acid} \times 50 \times 1000}{\text{Volume of sample}} = \text{mg/l}$$

(Report the average value in the final water data sheet)

Calculations:

2 mole of NaOH ≡ 2 moles HCl ≡ 1 mole $CaCO_3$;
(1 mole NaOH ≡ ½ mole $CaCO_3$)-)

1000ml of 1N NaOH ≡ 50 gm of $CaCO_3$-: 1ml of 1N NaOH ≡ 0.05 g of $CaCO_3$ = 50 mg of $CaCO_3$

If NaOH is N normal then the equation is = 50 x ml of acid used for neutralization x N

If V is the volume of water sample taken then equation is = 50 x ml of acid used for neutralization x N

V (ml of water sample used)

In order to determine for 1 liter of water sample = 50 x ml of acid used for neutralization x1000

V (ml of water sample used)

NOTE: Determine both phenolphthalein and methyl orange alkalinity for each sample. Use the reference table given in the protocol sheet in order to determine the relation between the two types of alkalinity and report accordingly.

Activity 5: Dissolved Oxygen

Date of sampling: Date of performing the experiment:

Solution in burette/syringe: Solution in flask\beaker:

Indicator: End-point colour:

Observations of titration

Sr.no.	Reading for sodium thiosulphate			Constant burette reading "A"
	Initial	Final	Difference	
1				A ml = _____
2				
3				

Calculation:

$2Na_2S_2O_3 = I_2 = (O)$

i.e., 2 moles of $Na_2S_2O_3$ = 1 mole of nascent oxygen

1000ml of 1N $Na_2S_2O_3$ = 8gm of oxygen

1ml of 1N $Na_2S_2O_3$ = 8mg of oxygen (equivalent wt. of oxygen)

1 ml of 0.025 N $Na_2S_2O_3$ = 8 X 0.025 mg of oxygen

A ml of 0.025N $Na_2S_2O_3$ = 8 X 0.025 X **'A'** mg of oxygen

This is for 50 ml sample

For 1000 ml of sample **=** $\frac{8\times0.025\times \mathbf{A} \times1000}{50}$ **=** $\frac{0.2\times\mathbf{A}\times1000}{50}$ mg oxygen \L

Average Dissolved Oxygen: _____ mg\l

(Report average reading of DO in the final water data sheet)

Activity 6: Biochemical Oxygen Demand (BOD)

Date of sampling: Date of performing the experiment:

Solution in burette/syringe: Solution in flask\beaker:

Indicator: End-point colour:

Observations of titration

For sample (similarly for blank):

On Day 1

Serial No.	Vol. of $Na_2S_2O_3$ (ml)			Constant reading (X)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

On Day 5

Serial No.	Vol. of $Na_2S_2O_3$ (ml)			Constant reading (Y)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

BOD of water sample in mg/l (not seeded) = $\frac{D1 - D2}{P}$

BOD of water sample in mg/l (seeded) = $\frac{(D1- D2) - (B1 - B2) \times f}{P}$

D1, D2 are dissolved oxygen values of water sample on day one and day five.

B1, B2 are dissolved oxygen values of blank on day one and day five.

P is volume of sample used for titration; **f** is volume of mixture in DO bottle.

(Report average reading of BOD in the final water data sheet)

Calculation:

$2Na_2S_2O_3 = I_2 = (O)$

i.e. 2 moles of $Na_2S_2O_3$ = 1 mole of nascent oxygen (O) ; 1000ml of 1N $Na_2S_2O_3$ = 8gm (O)

1ml of 1N $Na_2S_2O_3$ = 8mg of oxygen (equivalent wt. of oxygen)

1 ml of 0.025 N $Na_2S_2O_3$ = 8 ×0.025 mg of oxygen

X/Y ml of 0.025N $Na_2S_2O_3$ = 8 × 0.025 × 'X'/'Y' mg of oxygen

This is for 50 ml sample:

For 1000 ml of sample = $\frac{8\times0.025\times X/Y \times1000}{50}$ = $\frac{0.2\times X/Y\times1000 \text{ mg oxygen/l}}{50}$

DO on day 1 = D1 = ____mg\l; DO on -day 5 = D2 =____ mg/l

Activity 7: Chemical Oxygen Demand (COD)

Date of sampling: Date of performing the experiment:

Solution in burette/syringe: Solution in flask\beaker:

Indicator: End-point colour:

Observations of titration:

For sample

Serial No.	Vol. of ferrous ammonium sulphate (FAS) (ml) (burette reading)			Constant reading (X)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

For blank

Serial No.	Vol. of FAS (ml) (burette reading)			Constant reading (Y)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

$$\text{COD of sample in mg/l} = \frac{(Y-X) \times N \times 8 \times 1000}{\text{Volume of sample}}$$

Where:

Y= burette reading for blank; X= burette reading for sample

N = normality of FAS

8 = gm equivalent of nascent oxygen

1000 = factor for liter conversion

(Report average reading of COD in the final water data sheet)

Calculation:

$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3(O)$

$14\,H^+ + Cr_2O_7^{-2} + 6e^- + 6\,Fe^{+2} \rightarrow 2Cr^{+3} + 7H_2O + 6Fe^{+3} + 6e^-$

1 mole of $K_2Cr_2O_7$= 3(O)

i.e., 1 moles of $K_2Cr_2O_7$ = 3 mole of nascent oxygen

$1/6K_2Cr_2O_7 \rightarrow$ **$1/6\,Cr_2O_7^- \rightarrow 2/6\,Cr_2^{+3} = 6/6\,Fe^{+2}$**

1000ml of 1N $K_2Cr_2O_7$ = 8gm of oxygen

1 Fe = 8 g (O)
1000 ml of 1N Fe = 8g (O); therefore 1 ml of *n* N Fe = 8mg x *n*

Volume (Y-X) of *n* N Fe = (Y-X) x *n* x 8 mg
If volume of samp mg / V

$$\text{For 1000 ml} = \frac{(Y-X) \times N \times 8 \times 1000}{\text{Volume of sample}}$$

Activity 8:Chlorides

Date of sampling: Date of performing the experiment:

Solution in burette: Solution in flask\beaker:

Indicator: End-point colour:

Observation of titration

For sample:

Serial No.	Vol. of $AgNO_3$ in ml			Constant reading (X)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

For blank:

Serial No.	Vol. of $AgNO_3$ in ml			Constant reading (Y)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

$$\text{mg/l of chloride} = \frac{(X-Y) \times \text{Normality of } AgNO_3 \times 35.45 \times 1000}{\text{Volume of sample}} = \quad \text{mg/l}$$

Where,

X = ml of $AgNO_3$ required by water sample
Y = ml of $AgNO_3$ required by blank
35.45 is equivalent weight of chlorine
1000 is liter conversion factor

(Report the average value in the final soil data sheet)

Normality of $AgNO_3$ = Normality of NaCl x Volume of NaCl

Volume of $AgNO_3$

Use this normality for the main formula in order to determine chloride content in mg/liter

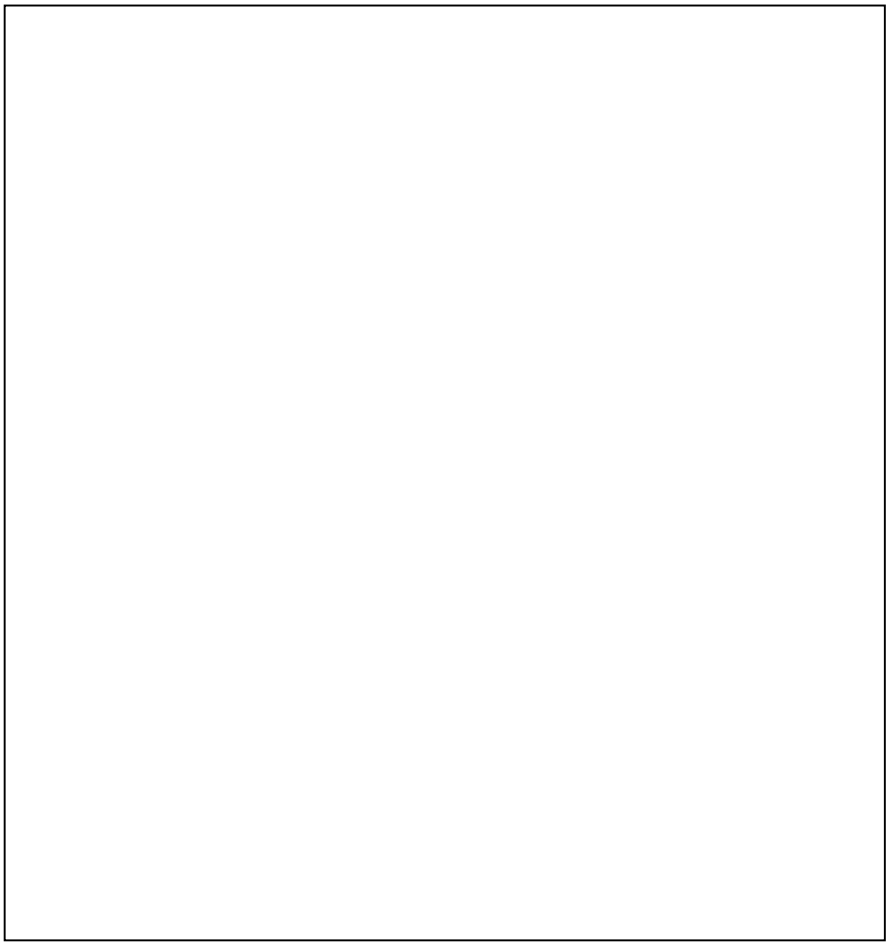
Activity 9: Fluorides

Date and time of sampling: Date of performing the experiment:

Observations:

Concentration of fluoride in the sample observed by comparing the colour developed against the colour grid, as L, P, H, C: _____

Plot and read the concentration of the sample from the standard graph.



Readings: Observer 1=_____ Observer2 =_____ Observer 3 =_____

Average value of fluoride in the sample =_____ppm

(Report average readings of fluorides in the final water data sheet)

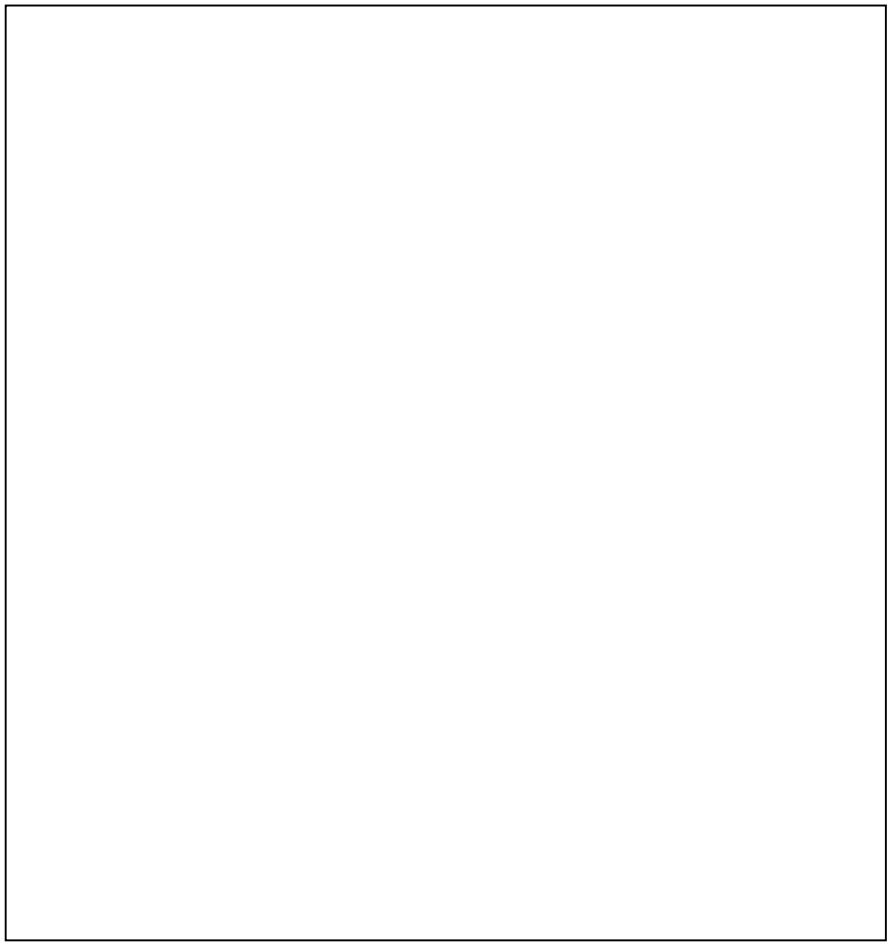
Activity 10: Ammonia

Date and time of sampling: Date of performing the experiment:

Observations:

Concentration of ammonia in the sample observed by comparing the colour developed against the colour grid, as L, P, H, C: _____

Plot and read the concentration of the sample from the standard graph.



Readings: Observer 1=_____ Observer2 =_____ Observer 3 =_____

Average value of ammonia in the sample =_____ppm

(Report average readings of ammonia in the final water data sheet)

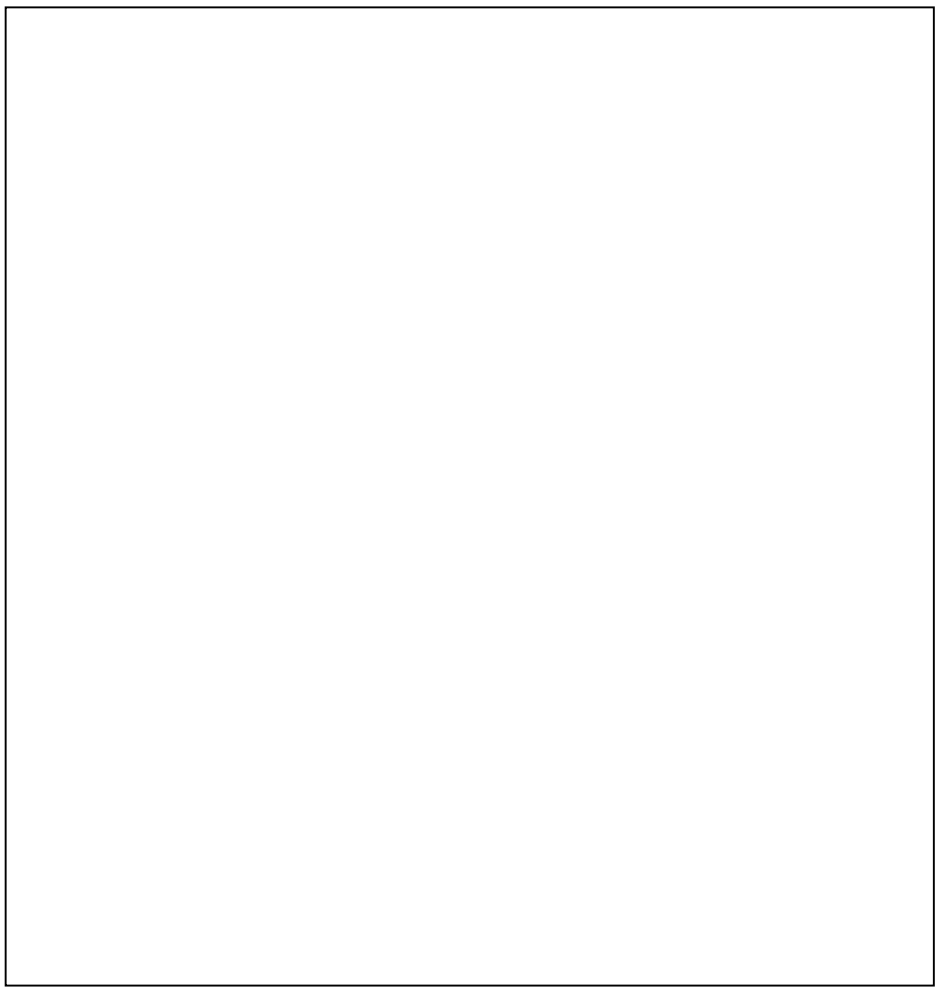
Activity 11: Phosphates

Date of sampling: Date of performing the experiment:

Observations

Concentration of phosphates in the sample observed by comparing the colour developed against the colour grid as L, P, H, C: _____

Plot and read the concentration of the sample from the standard graph.



Observer 1=_____ mg\l; Observer 2 =_____ mg\l; Observer 3 =_____ mg\l

Average phosphate concentration in the sample = _____ mg\l

(Report average readings of phosphates in the final water data sheet.)

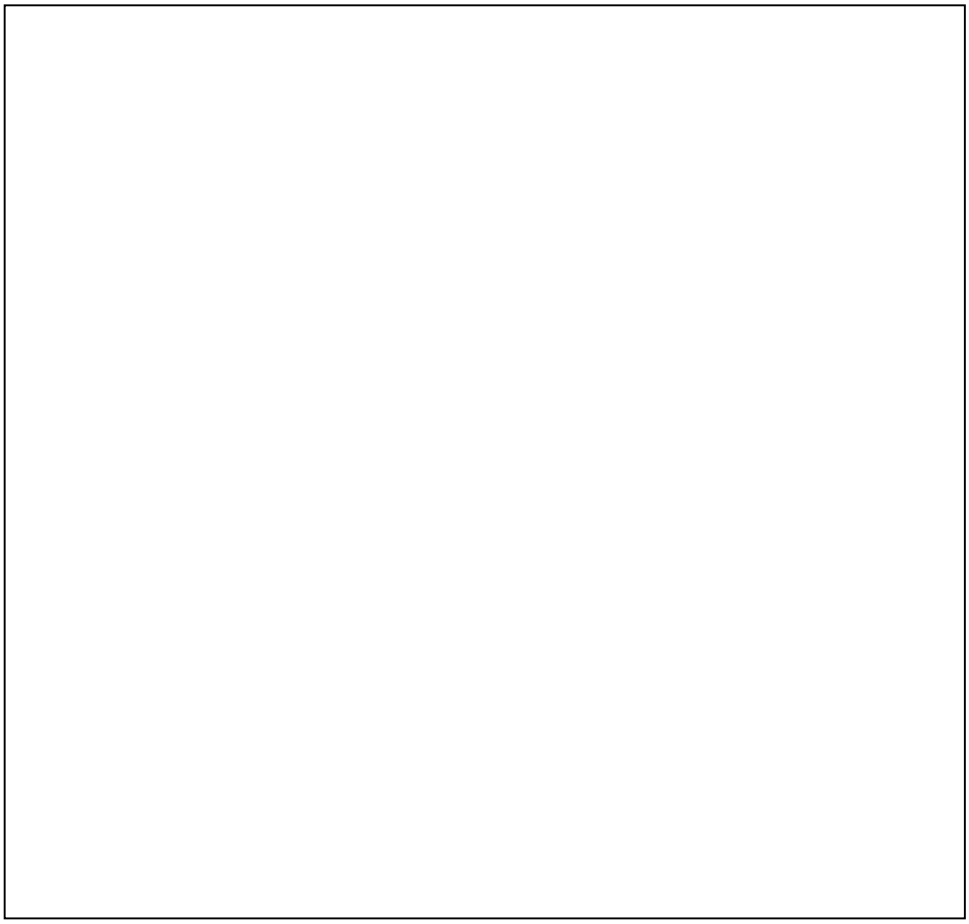
Activity 12: Iron

Date of sampling: Date of performing the experiment:

Observations:

Concentration of iron in the sample observed by comparing the colour developed against the colour grid as L, P, H, C: _____

Plot and read the concentration of the sample from the standard graph.



Observer 1=_____; Observer2 =_____; Observer 3 =_____

Average value of iron in the sample =_____ppm

(Report average readings of iron in the final water data sheet.)

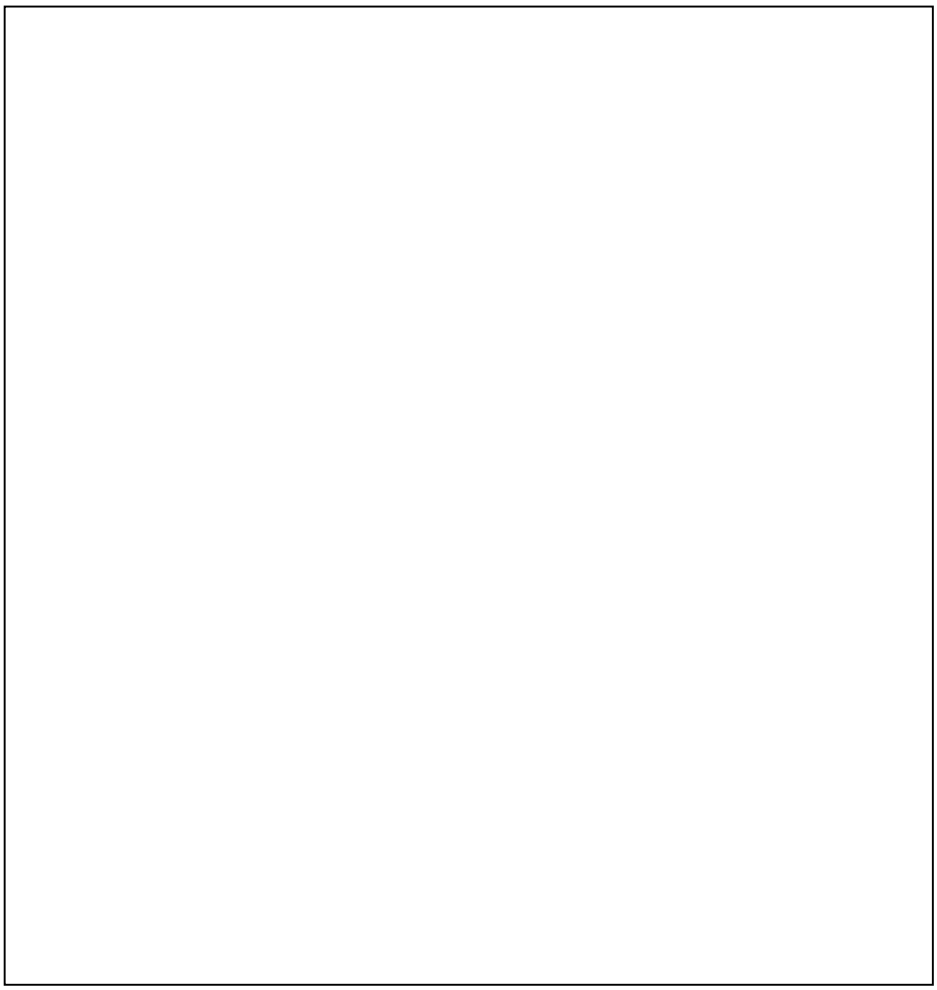
Activity 13: Copper

Date of sampling: Date of performing the experiment:

Observations:

Concentration of copper in the sample observed by comparing the colour developed against the colour grid as L, P, H, C: _____

Plot and read the concentration of the sample from the standard graph.



Observer 1=_____Observer2 =_____ Observer 3 =_____

Average value of copper in the sample =_____mg\l of copper

(Report average readings of copper in the final water data sheet.)

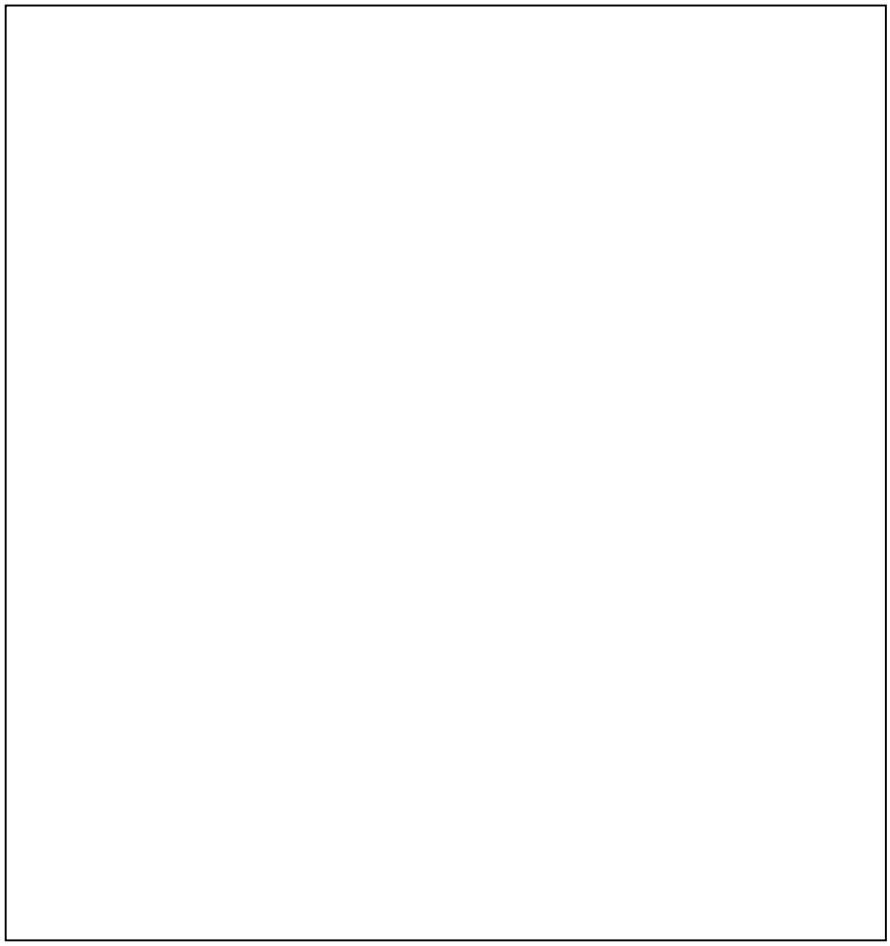
Activity 14: Chromium

Date and time of sampling: Date of performing the experiment:

Observations:

Concentration of ammonia in the sample observed by comparing the colour developed against the colour grid, as L, P, H, C: _____

Plot and read the concentration of the sample from the standard graph.



Readings: Observer 1=_____ Observer2 =_____ Observer 3 =_____

Average value of chromium in the sample =_____ppm

(Report average readings of chromium in the final water data sheet)

Activity 15: MPN count of water sample:

Date of sampling: Date of performing the experiment:

Observations

Site name	**Sample source**	**MPN count**				**Confirmatory test**	
		No. of positive tubes of:				No. of colonies observed after:	
		10 ml	1 ml	0.1 ml	MPN	24 hrs	48 hrs

Most probable number *of E.coli* in the water sample is: ____

Confirmatory test:

24-hour colony count: _____

48-hour colony count: _____

(Report average MPN of the sample in the final water data sheet.)

Final data sheet:

Note the average values of your observations to give a comprehensive view of the water quality

Site details: identify the site as: residential ___, industrial___, commercial____

Water Characteristics		Observations	
		Average readings	Grid reading
			L, P, H, C
Sample source: **G: ground water** **S: surface water**			
Identify source as: **W: wells** **H: hand pumps** **B: bore wells** **L: lakes** **T: tanks (E: elevated\ U: underground)** **O: other**			
Colour:	**D: Dark** **L: light**		
	NC: colourless B: blue **G: green** **R: red** **Others specify**		
Odour:	**St: Strong** **Ft: Faint** **M: Moderate**		
	O-Odourless **F-fishy** **S-sweetish** **U-unpleasant** **Others (specify)**		
Temperature $^{\circ}$C			
Turbidity: **By seechi disc** **By tube method**			
Non- filterable solids			
pH			
Alkalinity			
Dissolved oxygen (DO)			
Biochemical oxygen demand (BOD)			
Chemical oxygen demand (COD)			
Chlorides			
Fluorides			
Ammonia			
Phosphates			
Iron			
Copper			
Chromium			
***E.coli* MPN**			

Standards for quality of drinking water (including all fresh water bodies) according to IS-10500-1991

Standards for physical properties of drinking water

Physical property	**Standards**
Colour	Colourless
Odour	Odourless
Temperature	Varies with air temp.
Transparency	No turbidity
Non filterable solids (suspended matter)	1000 mg/litre

Standards for chemical properties of drinking water

Chemical property	**Standard values**
pH	**6.5-8.5**
Alkalinity	**200 mg $CaCO_3$\l**
DO	**4-6 mg\ l**
BOD	**3 mg\l (with treatment)**
COD	**4-10 mg\l (for clean water bodies)**
Chlorides	**200-250 mg\l**
Fluorides	**1.5 mg\l**
Ammonia	**0.5 mg \l**
Nitrites	**50 mg\ l**
Phosphates	**0.1 mg\ l**
Iron	**0.3 mg\l**
Copper	**0.05-1.5 mg \ l**
Chromium	**0.05 mg\l**

‘Soil’ watch…

for good health

INTRODUCTION:

Soil, or the shallow upper layers of the earth, is an important natural resource. Highly abused in recent decades, it is often used as a dumping ground for both, wastewater and domestic/urban solids waste. Several air pollutants, especially heavy metals, also settle in soil to find their way into the food chain. Few realize that the health of soil is intricately related to human health.

Soil has a strong influence on the entire ecosystem. Hence it is often called the ‘great integrator’.

Soil allows water, energy and heat to flow through it. It helps in percolation of water into confined and unconfined groundwater aquifers. It holds nutrients and water, and functions as a filter that cleans the water as it flows through it. The soil cover is essential for the production of food crops and forests. It has an intimate association with plants, animals and microorganisms. Soil moisture and temperature has a great influence on the climate of the place.

Soil is a decomposition product formed by weathering of a parent rock. It has two main components, namely the mineral inorganic matter derived from the weathering of a rock, and an organic component provided by colonization of plants and animals in the soil. The close integration of these two components characterizes the mature soil. Soil is dynamic—it keeps on changing with time, especially soil moisture and temperature. However, the mineral composition changes slowly, over a period of hundreds of years.

SOIL PROFILE:

A soil profile represents the way the soil looks if one cuts a longitudinal section of it out of the ground. Soil profile is made up of layers called horizons. These horizons could be as thin as a few millimeters or thicker than a meter.

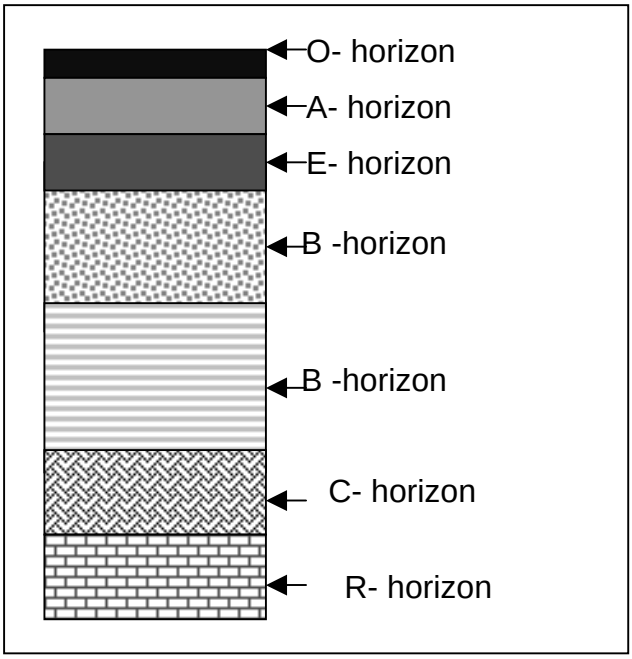
Clear well-demarcated horizons are often found in undisturbed areas. In city areas, the horizons may not be that distinct. Not all soils have the same horizons. The type and number of horizons in a profile often depend on how the soil is formed.

Different horizons are identified based on slight differences in their colours, sizes of particles and distinct textures of soil particles. Conventionally, the different horizons are labeled as O, A, B, C, D, E and R.

Details of the various horizons in a soil profile (Courtesy: GLOBE)

Horizon	Location	Composition	Found in:
O	Soil surface	Rich in organic materials (vegetation, remains of dead animals and insects)	Forested areas
A	First mineral layer/top soil	Rich in mineral matter; may include completely decomposed organic matter and hence dark in colour; can show two textures: granular and platy.	Agricultural areas/tilled layer
B	Second layer or sub-soil	Reflects the weathered parent material; also called the accumulation horizon due to accumulation of leached out materials from A and E; rich in iron, aluminum, clay and organic matter. Also saturated with water and hence shows red, yellow and brown colours.	Found in all soil profiles
C	Third major layer	The composition (colour and structure) is similar to the parent material.	-do-
E	Optional, between A and B	Mainly composed of the alluvial material, i.e., clay, iron, aluminum and organic matter, which have been leached from it; the horizon appears white or light in colour; it shows two textures: platy or single grained.	Found in wet conditions, as in forests, with dominance of coniferous trees
R	Lowest of the soil profile	Reflects the bedrock on which the soil is formed indicating the parent material of the soil, such as glacial, alluvial or volcanic material.	In all soil profiles

The horizons ‘O’ and ‘E’ are found only in forested areas. Agricultural, dessert or grassy areas show a profile starting with ‘A’ horizon and do not have the ‘E’ horizon. An eroded area will show a profile that may start with ‘B’ horizon. Shallow soils or soils that are not extensively weathered may go from ‘A’ to ‘C’ with no ‘B’ horizon.



A typical soil profile (Courtesy:GLOBE)

WHAT IS SOIL POLLUTION?

Soil pollution is defined as the presence of one or more contaminants in quantities and for durations, which are injurious to animals, plants and for human health. It is caused due to various human (anthropogenic) activities.

The rapid growth of industries and agricultural units, along with urbanization has resulted in the production of large amounts of wastes, from sources such as, municipalities, agriculture, industry and commercial establishments. The improper disposal of these wastes in degraded landfill areas and the un-regulated use of pesticides and chemicals in agriculture, industry and households add a heavy dose of contaminants into the soil. The load of these

contaminants cannot be absorbed by the normal soil nutrient cycle. These pollutants then contribute directly or indirectly to soil pollution.

These pollutants have the potential to disturb the entire ecological balance in nature. They can disturb the normal metabolic and physiological cycles of different life forms living in the soil, and tend to collect in large amounts in plants and animals (bioaccumulation and biomagnification—gradual increase in pollutant concentration from the primary producer to the final consumer). Over a period, these pollutants concentrate in the tissues of plants and animals and get into the human food chain. This leads to harmful effects and a variety of diseases in the humans.

Pollutants are also easily trapped in the air spaces between soil particles. The capacity of soil to exchange cations and anions also decides how best a retainer of pollutant the soil is. Subsequently, the water table and aquifers, which are known to carry pure, clean water for generations, are also polluted.

ANALYSIS OF SOIL

Useful information about the suitability of the soil for different purposes--agriculture, industrialization and urbanization--is obtained by analysing the soil. Monitoring the different parameters of soil gives an idea about the extent of soil pollution and hence the health of soil. This then helps to develop new regulatory norms for a clean environment.

Here a few physical and chemical properties that give indications about the quality or the health of the soil will be analysed. Study of land (green) cover will also be carried out.

The soil samples will be analyzed for the following physical properties: Soil profile, structure and consistence, colour, texture, temperature, moisture, infiltration capacity and presence of wastes like plastics, paper, glass, metal.

The following chemical properties will be checked up: Soil pH, conductivity, calcium carbonates and heavy metal pollutants like iron and copper.

Soil will also be monitored for the following biological indicators: Land (green) cover study which involves calculation of percentages of canopy and grass cover and identification of dominant and co-dominant species and common plants.

SAMPLING:

Sampling site could be local open fields, school play grounds (not manured gardens) or beaches. Ideally, the site area should be natural (not paved), flat, open with natural vegetation, away from any buildings. The number of sampling points chosen should represent the entire area under survey.

A detailed sampling procedure is given below with dimensions. However, depending on the size of the site area, one could reduce the corresponding dimensions.

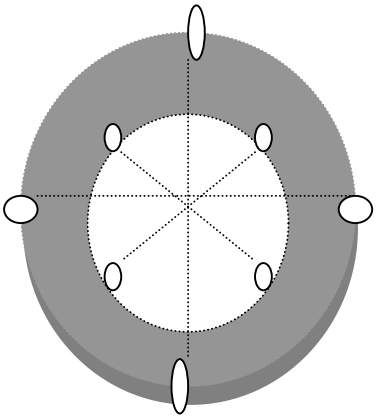
Soil sampling procedure:

Ideally, the sampling is done in a star pattern, where the samples are collected each time from a different location on the star along a single transect. Alternatively, sampling can be done in a circle or a quadrangle, with samples collected along the diameter or diagonals.

Before starting, take an overview of the sampling site, its total area and sampling points. These points should be representative of the entire sampling site.

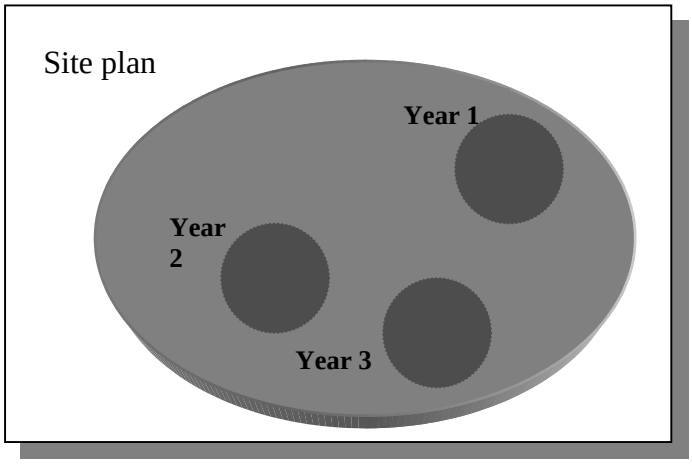
1. Choose any reference—centre--point in the site. From this reference point, locate four points approximately one meter north, south, east and west with a compass.

2. Layout a circle of about two meters diameter. (Alternatively, lay out a quadrangle by marking three points one meter away from the reference point: in the east, west and south or accordingly.)
3. Locate another set of four points halfway between the earlier points along the circle/square connecting these points. This gives us eight points on the circumference.
4. Four more points should be marked 25 cm away from central reference mark along the north, south, east and west transects. These could be the first sampling points.



Circle pattern of 2mt diameter for soil sampling

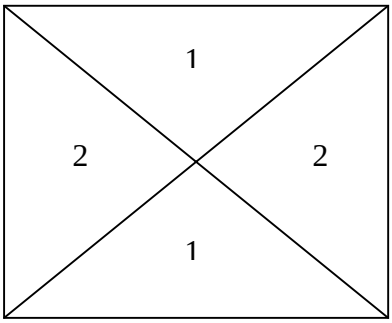
5. Each time the sampling should be made from a different pit along a single transect at a distance of 25 cms from the previous sampling pit.
6. Every year, select a new reference mark about 25 metres away from the previous circle/quadrangle for sampling.



Site plan showing different circular sampling points for different years

Alternatively,

7. To collect soil samples, in the chosen site, make square grids of about 5 x 5 meters at various reference points. Divide the square into four quadrants. From each quarter, scoop out some topsoil at about 5 to 10 cms depth with a non-metallic shovel, collecting the soil as cone in the centre. Mix the soil from four quadrants and this will be the sample used for analysis. This method is known as 'Quartering and Coning',



1 + 1 = 1a

2 + 2 = 2a

1a + 2a = soil sample

8. Pass the soil through a sieve (25 mesh) to separate stones and other debris. The soil sample should then be placed either in airtight containers or in zip plastic bags. These samples can then be analyzed in the laboratory.

SOIL PROFILE: Activity 1 and 2

Soil profile indicates many things: its geological and archaeological history and the climate changes experienced over years. It can also give an indication of about some physical and chemical soil properties and hence can predict the best uses of the land.

Materials required:

Garden tools like shovels and small spades, water bottle with squirt top (as in plastic sauce bottles), plastic sheet or sheets of news paper on which you can lay out the soil layers, meter stick or measuring tape, 20 nails or coloured board pins to mark the horizons, plastic bags or sealable containers of one liter size to carry the soil sample, water proof markers and buckets for removing soil.

Experimental procedure:

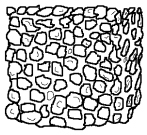
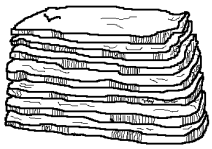
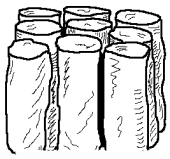
1. Select a relatively flat, undisturbed and safe site with natural vegetation to dig for studying the soil profile. Alternatively, an already dug pit (road construction site, etc) close to your sampling site will also do for analysis of the soil profile.
2. Check with the local authorities so that different utility cables, water or sewer pipelines are left undisturbed.
3. With a spade, dig a pit one meter deep and as round as is necessary to easily observe all horizons of the soil. This may require a person to get into the pit.
4. At this stage, think of 'soil as a great integrator' and represent the idea as a concept map (SWS: Activity 1).
5. Spread a plastic or newspaper sheet and lay the soil from each layer as a separate pile. Use a shovel or a big garden spoon, if necessary, to dig out some soil from the layers. A bucket can be used to carry the soil to the plastic sheet.
6. Transfer a small portion of the soil samples dug out from each horizon in separate plastic containers or plastic bags, and label them appropriately.
7. Use these samples for further characterization and analysis to be performed in the classroom.
8. Look at the side of the soil pit where the sun shines directly so that the soil profile and its properties are clearly visible.
9. Starting from the top of the profile and moving down to the bottom, observe the soil profile closely for changes in soil colour and structure. If the soil is dry, spray a little water to help in distinguishing the colours of the various zones.
10. Mark the locations of each of these changes or boundaries by fixing a nail or board pins.
11. It is sometimes difficult to demarcate and identify the various horizons clearly. Often, there may be only a few very thick horizons present. Do your best to record exactly what you observe in the field.
12. Measure the width of each horizon to the nearest cm. and record the observation in the soil worksheets [SWS: Activity 2 (i)].

13. If the horizons are very thin (less than 3 cm), do not report them as a separate layer. Combine the thin horizon with the one above or below and record.
14. If possible, using the profile characteristic data provided in the introduction, try to draw a schematic representation of the soil profile with appropriate names for the various horizons observed [SWS: Activity 2 (ii)]. Consider the profile from all sides of the pit.
15. Once the protocol is completed, students should remember to refill the pit with the original soil.

SOIL STRUCTURE AND CONSISTENCE: Activity 2

Soil structure refers to the arrangement of soil particles in natural aggregates. These aggregates are called as peds. The different types of soil structures are: granular, rocky, massive, platy, columnar and prismatic or even structureless. The soil structure has an influence on its properties, like infiltration rate and moisture holding capacity. These soil structures/peds breakup in varied ways. This breakup determines the soil consistence.

Various soil structures

 Granular	 Columnar	 Prismatic
 Platy	 Blocky	 Massive
Mixed structure	 Single grains	**No well-defined structure**

(Courtesy: LOBE)

Materials required:

Same as materials used for soil profile experiments.

Experimental procedure:

1. Take a sample of the soil from the pit; alternatively observe for the soil structure in the pit itself, using a lighted torch (battery operated).
2. Observe the various patterns of soil structure and fill out the soil worksheet [SWS: Activity 2 (i)].
3. To study the soil consistence: Take a moist ped of soil.
4. Spray (put) water and mix the soil well, if it is dry.
5. With a bit of pressure with your fingers, try to crumble the ped. It will crumble differently depending on the soil type. Hence, they are classified as:
    - Loose ---if there is trouble picking out a single ped and the structure falls apart before handling it;
    - Friable—the ped breaks with small amount of pressure;
    - Firm---the ped breaks with a good amount of pressure leaving an impression on the fingers before breakage;
    - Extremely firm—the ped cannot be broken with the fingers. A hammer may be needed.

Note your observations in the soil worksheets [SWS: Activity 2 (i)].

SOIL COLOUR: Activity 2

Different soils show a variety of colours. It could be red, brown, black, yellow and occasionally white. Soil colour is determined by the percentage composition of silicon, iron and humus. Red colour indicates the presence of oxidized iron in the soil, while yellow colour indicates the presence of hydrated forms of ions.

Usually, the upper layers of the soil appear darker due to the presence of organic matter. At lower depths, it becomes pale to yellow indicating high

moisture content. Black soils develop in waterlogged and anaerobic conditions.

Materials required:

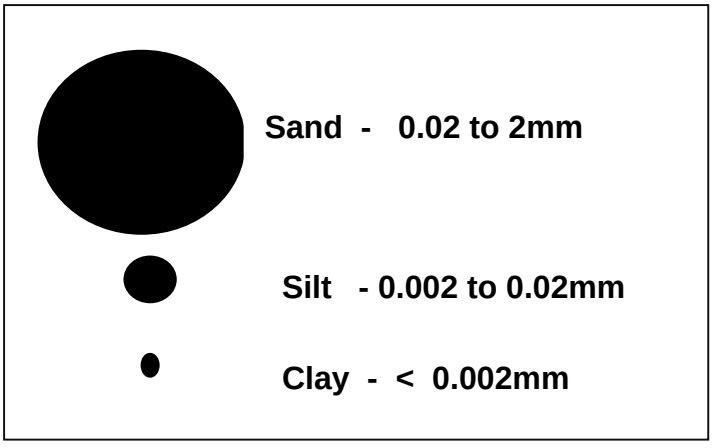
Materials are same as mentioned in the soil profile experiment.

Experimental procedure:

1. Dig out a portion of the topsoil. Clear the soil of all debris like roots and wastes (such as plastics and paper).
2. Alternatively, take the soil sample earlier collected in soil profile experiment for this observation.
3. Check if the soil is wet or dry. If the soil is dry, moisten it by squirting some water and then observe for its colour.
4. Note down the observations in the soil worksheets [SWS: Activity 2(i)]
5. Observe for any variations in colour of the different soil horizons.

SOIL TEXTURE: Activity 2

Soil is a mixture of particles of various sizes. Based on their sizes, the particles are graded as: sand, silt and clay



Gradation of different soil particles according to size
(Courtesy:GLOBE)

Soil texture is defined as the proportion of sand, silt and clay in the soil. Hence, the different types of soils are sandy, clayey, silty and loamy. Loamy soils have equal proportions of clay and sand particles.

Texture influences many soil properties, such as, its moisture, mineral storage, its water retention capacity and root penetration. The smaller the size of the soil particle, the greater is its surface area in relation to its volume. Sandy soil allows easy water percolation and has very low metal ion and water retention capacity. Clayey soils, on the other hand, exhibit high water retention capacity, and are poorly aerated with low water infiltration capacity. Clay particles have large surface area and the surface molecules tend to have negative charges. These negative charges give the clay their cation exchange properties, which make it a good concentrator of all heavy metals in cationic state.

Materials required:

Materials are same as mentioned in the soil profile experiment.

Experimental procedure:

The soil sample is collected as stated earlier.

1. Take a small amount of soil sample and add enough water to moisten it (the way in which we make our *atta* for *chappatis*).
2. Work on this mixture with your forefinger and thumb to form ribbons. If the soil feels hard and sticky, and you are unable to form a ribbon, it is clayey in nature.
3. If it feels less hard and sticky, and is soft and relatively easy to squeeze, then it is clay-loam.
4. If the soil is soft, smooth and easy to squeeze and is only slightly sticky, it is classified as loam.
5. If the soil feels very smooth, with no sandy grittiness/coarse, then it is silt. One can also get silty clay or silty loam.
6. If the soil feels very gritty, then it is sandy. There could be combinations of sandy clay, sandy loam or sandy clay-loam.

7. If the soil feels neither very gritty nor very smooth, it has same amounts of silt and sand particles, it is sandy-silty in nature; clay particles may be absent or in small amounts.
8. Note the observations in the soil worksheets [SWS:Activity 2 (i)]

One can also represent the soil profile as a pyramid or triangle of proportions of different soil textures. This pyramid is obtained if each horizon in a profile is classified based on the soil texture. One can come across combination of textures in a horizon, too. Note your observations in the soil work sheet [SWS: Activity 2 (iii)].

PRESENCE OF ROOTS, ROCKS AND ANTHROPOGENIC MATERIALS: Activity 2

Presence or absence of roots, rocks and materials generated by human activity (anthropogenic) give hints about the origins and the overall health of the soil. Presence of roots often in the upper two horizons indicate the type of vegetation growing in a certain area. In contrast, absence or fewer roots could be due to either no vegetation at the chosen site, or give indications that the site is a *disturbed* area and it does not reflect the original situation. Soils with good root presence indicate fertility of the soil. Rocks, often found in deeper horizons, indicate the origin of soils and its parent material. Man-made materials, especially waste materials, like plastic, glass, metals and polythene bags are often found buried in the soil. Long-term deposition of these wastes degrades the soil by release of harmful chemicals.

Materials required:

Materials are same as mentioned in the soil profile experiment.

Experimental procedure:

1. Visually inspect the soil profile and check for roots, rocks and other materials in different horizons.
2. Ideally, collect soil samples from each horizon in a container.

3. Soil will have to be sifted through a mesh. Alternatively, feel the soil with your fingers. Any stony or a hard rocky fragment of 2 mm and more in size is categorized as rock.
4. Record your observations in soil worksheet as present (+) or absent (-), along with their proportions as few, or many [SWS: Activity 2 (i)].

SOIL TEMPERATURE: Activity 3

Soil temperature has important influence on the climate of a place. Over a long period, soil temperature influences the water cycle (i.e., the overall precipitation in a place and cloud formation) and has an important role in land and sea breeze formation.

The temperature of the soil is dependent on a variety of factors like the moisture content of the soil and surface vegetation. The moisture content of the soil is closely related to its heat absorbing capacity. One calorie of heat energy is needed to raise the temperature of one gram of water through one degree Celsius, while, only 0.2 calories is sufficient to raise the temperature of one gram of soil to the same level. The thermal conductivity of the wet soil is higher than that of dry soil. The heat propagated to the lower layers is greatly dampened due to poor conductivity of the soil. As the daytime temperature varies, one can observe variations in the soil temperatures too at different depths (though there might not be much variation in the wet garden soil). In the morning hours, the deeper layers of the soil are cooler and temperatures of the upper exposed layer are high. The reverse is seen in the evening, when surface heat has been conducted to the deeper layers.

Surface vegetation also has a considerable effect on lowering soil temperature due to moisture trapping by roots. Hence it is important to take soil temperature at at least two hours interval and at different times of the day and at different depths.

Materials required:

Garden shovels or other digging tools, digital probe thermometer or any thermometer, 12 cm long nail, long rod (about 20 cm), hammer, and a wooden block with 6 mm diameter hole drilled through it.

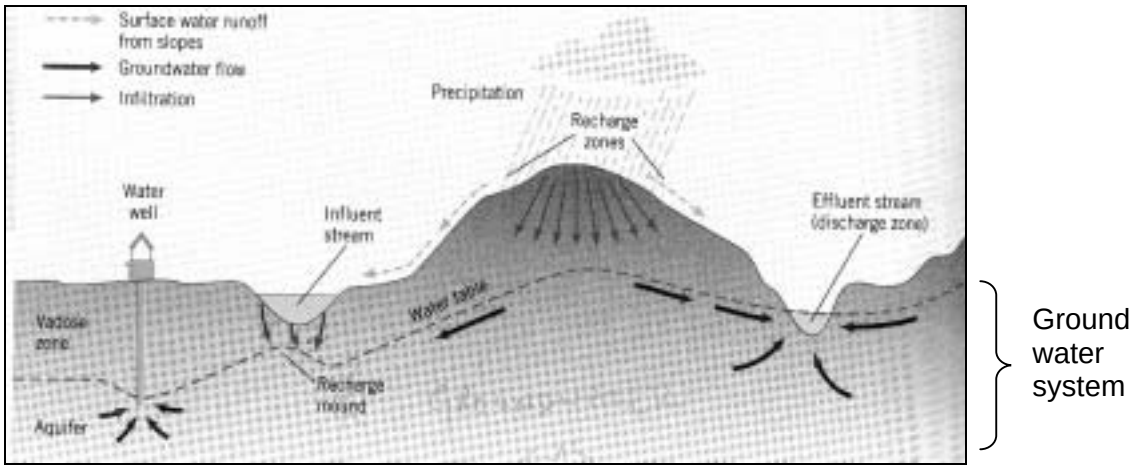
Experimental procedure:

1. Select a relatively flat sunny area; the ground should not be compacted but can be covered with light vegetation.
2. Make a hole in the soil of about 5 cm. deep, insert the nail through a wooden block and push it so that only two cm of the nail is above the top of the block. If the ground is hard, use a hammer.
3. Remove the nail with a twisting motion. If the ground cracks or bulges up as you remove the nail, repeat the process again at a distance of 25 cm.
4. Carefully insert the thermometer through the block. Gently push the thermometer so that the bulb is at the depth of 5 cm in the ground.
5. Wait for two minutes; read the thermometer. Wait for another minute and reread the thermometer. Remove the thermometer and the block without disturbing the soil.
6. Repeat the steps two to five without the wooden block, but use depths of 12 and 20 cms. Keep a temperature record and represent the observations as a graph [SWS: Activity 3 (i, ii)].
7. Ideally, the temperatures should be monitored at an interval of two hours, at different times of the day. However, you can monitor at two hours intervals in the early morning, in the afternoon and in the late evening on two consecutive days.

Activity 3 (iii) in the soil worksheet will further bring out the temperature variability under different situations.

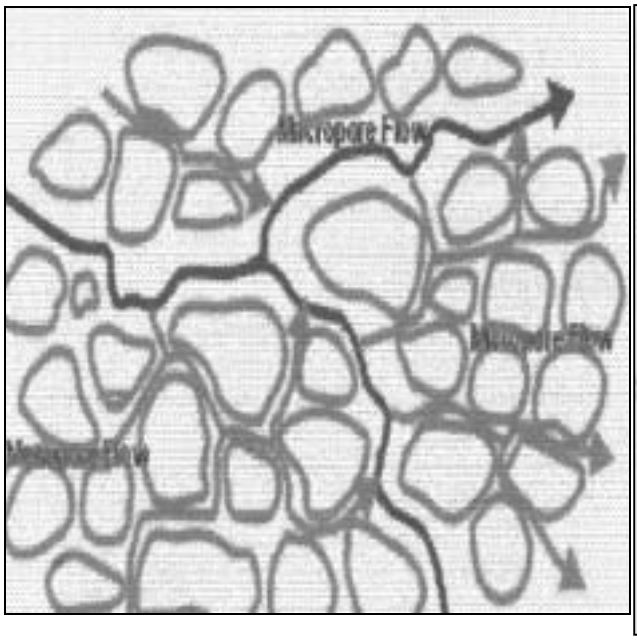
SOIL MOISTURE: Activity 4

Soil receives its water supply mainly from precipitation in the form of rain and snow. Some of this precipitation (rain water) runs off the surface of the soil into the seas, *nullahs*, and other water bodies, while some water percolates and infiltrates into the soil. The percolated water is partially used by plants and part of it is lost from the soil due to evaporation. The remainder of the percolated water fills and moves through the soil pore spaces and finally finds its way towards the water table and ground water. The points where the surface water percolates into the ground water system are called the recharge zones. Places where the ground water seeps out are called as discharge zones (e.g. springs). These studies are important when one considers the movement of ground water in sanitary landfills or burial grounds.

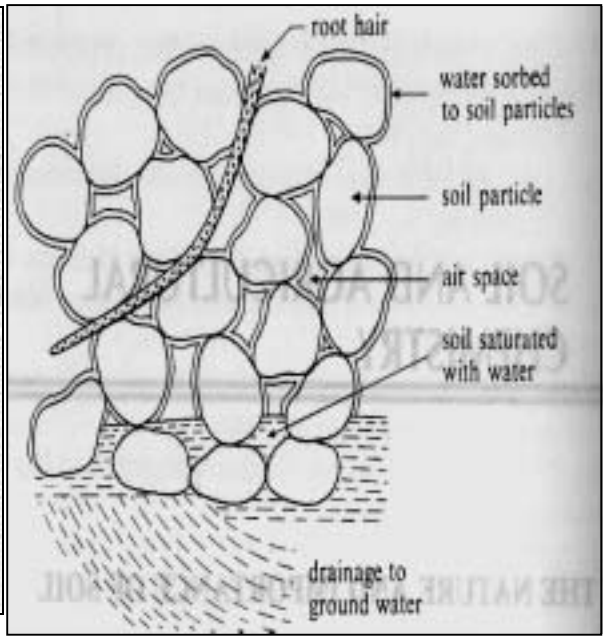


Diagrammatic representation of the surface water flow systems
(Courtesy: Env. science—Earth as a living planet)

Water that moves into the ground water first seeps through the soil. This layer of earth is called as vadose zone, which is unsaturated. Then the water enters the ground water system. The upper surface of this is called the water table.



Microscopic view of soil particles showing the flow of water into the soil through the air spaces.



Microscopic view of the soil

Courtesy: Environmental Biology

There are points in the ground water zone from which adequate quantities of water can be obtained. These points are called aquifers. Certain soil types or earth materials, such as loose gravel and sand particles with air spaces, or rocks with open fractures, make ideal aquifers.

Water in the soil flows through the pores or spaces found around the soil particles. This movement of water is not straight and smooth, but is jerky, as the water molecules have to move around the soil particles. This jerky movement is termed as mechanical mixing. This mechanical mixing allows dissolution of the pollutants trapped in the soil particles to finally reach the water table. This should alert us to the easy movement of pollutants from one area of the soil to the ground water at a far away distance. Molecular and turbulent dispersions are important parameters for water transport to ground water.

Materials required:

Tools to dig and remove soil samples, oven for drying the samples, weighing balance and clean, dry, heat resistant containers.

Experimental procedure:

The dry and wet weight technique is used here.

Dig out soil samples from different depths, i.e., 0-5 cm, 10, 30, 60, 90 cm. The samples collected from the different horizons are transferred to clean, dry containers of known weight.

1. Weigh the soil samples along with the containers. This is the wet weight of the sample soils. Record the value as (A gms).
2. Dry the samples in an oven at 95° C for 10 hours/overnight.
3. Remove the containers from the oven and allow them to cool. Weigh the dried soil samples and record the value as (B gms).
4. Record the drying time and the dry weight to the nearest 0.1gm in the soil work sheet (SWS: Activity 4).
5. Calculate the water weight (C) by calculating A-B.
6. Empty the soil samples from the containers and clean them.
7. Weigh and record the weights of empty containers (D gms).
8. Calculate the weight of dry soils by subtracting the container weight from the dry weight (B-D). Calculate the soil water content by dividing the water weight by the dry soil weight [SWS:Activity 4 (i)].
9. Represent the values as a graph [SWS: Activity 4 (ii)].

SOIL INFILTRATION CAPACITY: Activity 5

Another important property of soil is its infiltration capacity, which is defined as the flow rate of water through the soil into the ground. The infiltration rate depends on several structural properties of the soil, such as, its texture and structure, bulk-density, water content and organic matter present in it. The infiltration rates vary widely, ranging from 20 mm/hr for clay and compacted soils (with low as 0.1 to 0.01 cm/day), to 60 mm/min for loose dry sand.

Infiltration capacity of different soils will be studied here. In turn, this could reflect how different pollutants in the soil also can infiltrate, often finding their way into the ground water or aquifers. (Think: how do pesticides find their way into the food chain?) To confirm this point, chemical analysis of soil should bring out the absence or presence of different pollutants.
Further, one could plan a series of advanced activities and study water infiltration with respect to different soil characteristics, such as shape, size and compaction of soil. What do you think would happen in case of a heavy downpour on a large compacted surface area versus in a natural open field?

In simulated laboratory set ups, one could also add different types of chemicals {soda bicarb —highly alkaline, sodium bicarbonate (Na_2HCO_3), or vinegar (acetic acid), or citric acid crystals} to the water sample. Check for the changes in pH, if any, in the infiltrated water. Repeat this experiment for different types of soils, or with the entire soil profile.

Materials required:
Two metal cans (10-20 cm diameter and 5-10 cms diameter), buckets, ruler, waterproof marker and stopwatch or a watch with a second hand, hammer, a block of wood, funnel.

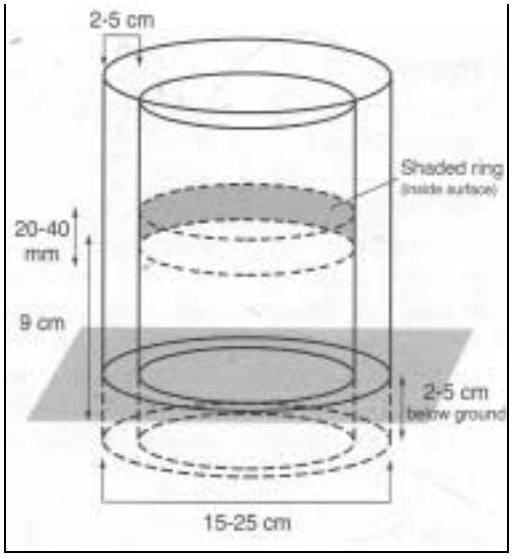
Experimental procedure:
First, make the two - canned infiltrometer. Cut the bottom of the cans.

1. Using a marker, shade a ring on the inside of the smaller can, at a distance of about 9 cms from the bottom of the can. The width of this ring should be 20 to 40 mm. Use this ring as your reference mark (R).
2. Insert the smaller can into the bigger one. Measure the distance between the two rims of the cans at their open mouth regions.

Procedure for measuring the infiltration rate:

1. Cut the vegetation, if any, to the ground surface.
2. Twist the cans into the soil and fix them at 2- 5 cms deep into the soil.
3. Measure the heights of the lower and upper edges of the reference band (R) from the ground level.

4. Pour water into both the cans so that the water level is slightly above the inner reference mark. Match this level in the outer can too.
5. Start your watch as the water level reaches the upper reference mark.
6. This is the start time (A). Observe how the water level slowly/rapidly falls down—in other words, water is infiltrating into the soil.
7. Keep a check of the water level in the outer can: it should be maintained at the same level as in the inner can. You may have to pour water with a funnel in the outer can. Avoid spilling into the inner can.
8. As the water level reaches the lower edge of the reference band (R), note this time as your end time (B).
9. Calculate the time interval (C) {which is B-A} and note it.
10. Repeat the above steps at least nine times or for 45 minutes, till you get two consecutive constant readings. Note in [SWS: Activity 5 (i)].
11. Calculate the time interval for each reading (C).
12. Note the water level change, which is the same as the width of the reference band (R).
13. Calculate the mid point of the time interval, i.e., A+C\2
14. The flow rate is calculated as R\C in mm\min.
15. Plot a graph with the C values on the X-axis and the flow rate values on the Y- axis [SWS: Activity 5 (i)].



Typical infiltrometer (Courtesy: GLOBE)

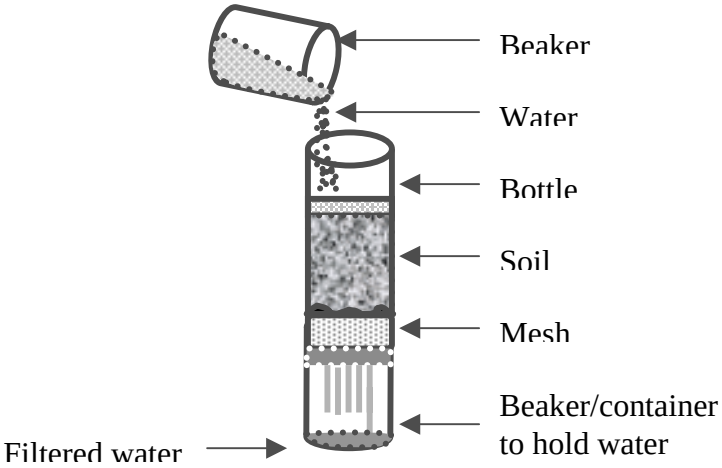
(ii) This activity is to demonstrate the relationship between water infiltration and different types of soils and bring out the role of soil characteristics (particle size distribution) on infiltration rate and water holding capacity.

Materials required:

5 nos. clear 2-liter bottles, a stopwatch, 6 nos. 500ml beakers, soil samples, mesh/nylon cloth, tape, 5-liter water, pH paper and scissors.

Experimental procedure:

1. Collect at least five different types of soil samples.
2. Note the soil characteristics such as, soil types, structure, consistencies, and colour.
3. Take five nos. of 1.5 to 2 liter plastic bottles and cut the bottom and top ends of the bottle.
4. Fix a nylon net/ mesh piece at the mouth end of the bottle with a string/ tape.
5. Place the bottle with the mesh side down, over a catchments beaker. Fill each bottle with a different soil sample.
6. Collect 5 liters of water, check its pH and clarity, and note it.
7. Start the stopwatch and using a clean beaker pour approximately 300 ml of water into the first soil filled bottle.
8. Observe the water flow through the soil and collect in the catchments beaker.
9. Stop the watch when the water stops dripping into the beaker. Record the time duration for the water flow.
10. Check the pH and clarity of the collected water and observe for any changes.
11. Repeat the same procedure for the remaining soil samples.
12. Record the different time durations for each type of soil, and changes in pH and water clarity, if any.
13. Record the observations in soil worksheet [SWS: Activity 5 (ii)].



(iii) Perform the wet /dry weight protocol for the above soil samples after the experiment. This test will tell about the water holding capacity of the soil [SWS: Activity 5 (iii)].

Materials required:

A clean and dry container of known weight, oven for drying and a weighing balance.

Experimental procedure:

1. After the infiltration experiment, transfer some soil into a dry container of known weight. Note the weight of the soil and container.
2. Subtract the weight of empty container from this to get the weight of wet soil.
3. Dry the soil in an oven at 95˚C, and at hourly intervals, regularly weigh the soil. Avoid spilling.
4. Stop the drying when a same value for two consecutive readings is obtained. Note this weight. Subtract the weight of empty container from this to get the weight of dry soil.
5. Difference between the dry and wet weights gives the water content of the soil
6. Record this in the soil work sheet [SWS: Activity 5 (iii)].
7. Repeat this protocol for all the soil types used in the activity described earlier.

Chemical Parameters: Activity 6 to 9

SOIL pH: Activity 6

The measure of the hydrogen ion concentration of soil gives its pH. This depends largely on relative amounts of the adsorbed hydrogen and metallic ions. Hence pH is a good measure of the acidity and alkalinity of the soil. *Normally, the pH values of the soil lie in the range of 4.5 and 8.5.* Soil is often considered as an amphoteric buffer showing the properties of both acids and bases. A well-buffered soil is less subjected to climatic and environmental fluctuations. pH is also a strong indicator of soil fertility.

Several factors determine soil pH including the concentrations of different salts and carbon dioxide, the exchangeable cations, the parent material, land management practices and the activities of organisms living in the soil.

The chemical composition of rain and all other waters entering into the soil also has a strong influence on the soil pH. In the wet tropics, soils are slightly acidic due to constant leaching of the salts (replacement of calcium, magnesium, potassium and sodium ions by hydrogen ions) from the soil. In contrast, soil from dry areas is frequently alkaline. Places rich in calcium as in limestone areas are distinctly alkaline. In the soil profile, the upper layers with humus are generally acidic, while the deeper ones are alkaline. Solubility of different ions in the soil is highly dependent on the soil pH. Certain ions/substances are more soluble in acidic soil and may easily leach out causing nutrient deficiencies. The pH of the soil also influences the activities and relative abundance of the different groups of soil organisms. Acidic soils have few species of soil organisms and favor development of fungi; basaltic (intermediate pH) have a richer fauna and lime stone (alkaline) soils have the greatest number of soil organisms. Knowledge of the pH of the soil helps farmers to take decisions for improving soil fertility. Soil pH may also affect the pH of the ground water or near by surface water, like streams or even lakes.

Materials required:

pH meter or pH paper, distilled water, spoon, conical flask.

Experimental procedure:

1. Use the soil sample collected in the profile experiment for this purpose.
2. In a clean container, mix sun-dried, sieved soil with distilled water in the ratio of 1:1 (100 gms/100ml). Handle the soil with a spoon/spatula to avoid soil contamination with oils and other materials on your hand. Mix enough soil and water so that the pH reading can be made in the supernatant.
3. Stir the soil-water mixture every 3-minutes for 15 minutes. After 15 minutes, allow the mixture to settle until a supernatant forms.
4. Measure the pH of the supernatant formed by dipping the pH paper held with a forceps into the clear supernatant.
5. Hold the pH paper in the supernatant for a minute until the colour of the pH paper changes on both the sides. Remove the paper from the container, read the colour developed against the colour chart on the pH paper booklet and note the pH in the soil work sheet (SWS: Activity 6).

pH-dependent soil characteristics

pH dependent soil types	Characteristics
Acidic soils	• **Found in humid regions with high rainfall.** • **Formed due to continued leaching of salts.** • **Lime application neutralizes the acidity.** • **Crops like millets and peas tolerate acidic soils.** • **Trees, such as, tamarind, *Gliricidia* and *Deris indica* can grow here.**
Saline soils or white alkali soils	• **Found in regions where: water logging and water table are high as in several regions of the Punjab.** • **Formation of surface white encrustations, due to excess soluble salts like: chlorine, sulphate and sodium.** • **Ridge-trench, sub-surface and furrow irrigation planting reduces toxicity of soil.** • **Trees like *Azadiracta indica* (neem), *Prosopis* sps., *Albizia* sps. can grow here.**
Alkaline or sodic soils	• **Found in places rich in limestone.** • **The soil appears black due to presence of sodium carbonate.** • **It has low infiltration rate.** • **Treatment: Addition of gypsum (hydrous calcium sulphate), silt and rice husk improves texture.** • **Trees: neem, *Alibizia* sps. *Derris* sps. and Subabul grow here.**

CALCIUM CARBONATES : Activity 7

The presence of calcium carbonates in the soil leads to alkaline conditions of the soil. Hence, alkalinity is an indirect indicator of this salt. *In fact, high pH exceeding pH 9 is a good indicator of calcium carbonates in the soil.* The main sources of calcium carbonates are limestone and degraded organic matter, like bones. High alkalinity reduces crop yield and affects flora and fauna. High concentrations of calcium carbonates may lead to hardness of water.

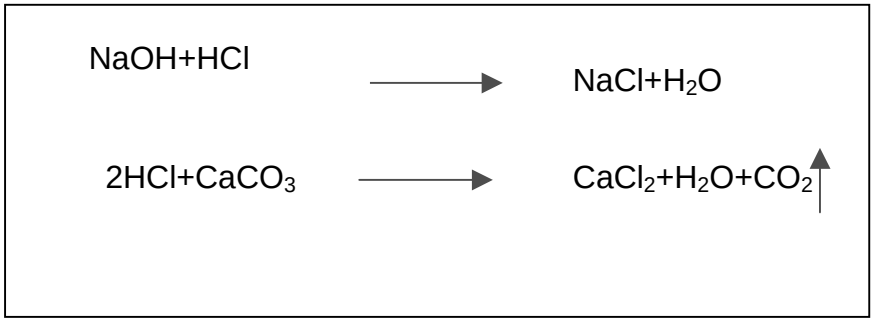
Materials required:

Conical flask, pipettes, aluminum foil and filter paper, 1N hydrochloric acid (HCL), 1N sodium hydroxide (NaOH), indicator--bromothymol blue.

Experimental procedure:

1. Transfer 5 g of soil sample to a dry conical flask. Add 100 ml of 1N HCL. Cover the flask and allow the mixture to stand for 1 hr with regular mixing at every 15 mins.
2. Decant the supernatant through a filter paper. Take 5 ml filterate, add 0.4 ml of bromothymol blue and titrate it against 1 N NaOH till the colour changes from yellow to orange. Note the pipette reading as '**S' (sample).**
3. Repeat the procedure for a blank using 5 ml 1N HCl; note the reading as '**B**' **(blank)**. Using the formula in the soil work sheet calculate the % of calcium carbonate [SWS: Activity 7].

Calcium carbonate in the sample neutralizes HCl. The excess of HCl is titrated against NaOH using bromothymol blue, which changes colour from yellow to orange at a pH of 3.7.



HEAVY METAL POLLUTION: Activity 8 and 9

Certain concentrations of heavy metals are present in the soils as natural mineral constituents. But often soils can collect large quantities of heavy metals and other waste products from various activities. These metals are introduced into the soil from spills, industrial discharges, agricultural practices, leaking tanks and landfills. In other words, unscientific management of all wastes, both liquid and solids, contribute largely to pollution or degradation of soil. Dumps of junk automobiles, electronic appliances and containers also add to this problem.

Vehicular emissions and fuel combustion result in heavy loads of metal residues in the soil. Among these, mercury, cadmium, lead, iron and zinc are the frequent contaminants. They tend to concentrate in certain components of the soil, such as, clay sediments and in organisms, such as mollusks, mussels and shellfish. Since metals are non-degradable, they persist in the environment and cause long-term pollution. Heavy metals can cause several problems to humans, including skin and gastro-intestinal problems. Long-term exposure may affect many enzymatic activities and disturb the development of an organism, including humans.

For detection of heavy metals, the clear supernatant of the soil mixture will be used. The **protocol (A)** of this step is as follows:

1. In a clean, dry beaker, mix the sample with DW in a 1: 2 ratio.
2. Stir the mixture well by shaking the flask every 3 minutes for 15 minutes. Heat the mixture till the volume of water reduces to half.
3. Allow the mixture to stand for 20 minutes or so, till the soil sediments and a clear liquid appears on the top. Use this supernatant liquid for the analysis of heavy metals as instructed.

Effects of heavy metals on human health

Heavy metal	Source	Effects due to bio-accumulation
Arsenic	Occurs naturally	Chronic poisoning, loss of weight, diarrhoea alternating with constipation, conjunctivitis and sometimes skin cancer**.**
Cadmium	Mining, chemical and metallurgy industry.	Chronic poisoning, kidney malfunctions and formation of kidney stones.
Lead	Lead smelters, storage batteries	Mental retardation and death.
Mercury	Industrial wastes	Neurological problems, renal damage
Cyanides	Waste from metal treatment with heat, electroplating.	Rapid death due to inhibition of cellular respiration

Note : Since the standards for heavy metals in soils were not available, use the colour grid provided for water for determining the heavy metal levels present in the soil. But, remember that these levels are not the cut off limits for these pollutants. Also, the colour of the soil may add to the colour developed.

IRON (Fe): Activity 8

Iron may be present in the soil in dissolved or suspended state. It may be in the Fe^{2+}, Fe^{3+} or $Fe(OH)_3$ state, suspended or filterable. When the ground water is acidic, iron is present as Fe^{3}; when the ground water is alkaline or neutral, iron is present as $Fe(OH)_3$. It gets easily transferred to the ground waters. Some ground waters naturally contain high levels of iron. Though Fe is an essential element of our diet, its accumulation in humans causes a variety of problems, including those of liver, kidneys and muscles.

Materials required:

Conc. HCl, 1ml hydroxyl amine hydrochloride ($NH_2OH.HCl$ (10%), 50/100ml volumetric flask, 10 ml ammonium acetate buffer, 2 ml phenanthroline (refer appendix 1), 5 and 10 ml syringes.

Experimental procedure:

1. Take 10 ml sample supernatant (protocol A) in a clean and clear container.

2. Add 0.5ml conc. HCl and 0.2ml $NH_2OH.HCl$ (10%).
3. Boil the mixture in a water bath for 15 minutes.
4. Cool the solution to room temp. and transfer it to 100ml flask.
5. Add 2 ml ammonium acetate buffer, followed by addition of 0.4 ml phenanthroline.
6. Shake well. Wait for 10- 15 min for colour development (colour is stable for 30 minutes).
7. Compare the colour developed against the grid provided. Note the observations as **L, P, H or C** {SWS: Activity 8}.
8. Alternatively, measure absorbance at 510 nm against reagent blank. Plot the absorbance value of the unknown sample against the standard graph to estimate the concentration of iron in the sample.

Preparation of standard graph:

Stock ferrous ammonium sulphate $[(NH_4)_2Fe(SO_4)_2.6H_2O]$ solution: Prepare a 50-ppm (Refer appendix 1) solution of ferrous ammonium sulphate $[(NH_4)_2 Fe(SO_4)_2 . 6H_2O]$.

From this prepare a range of concentrations including 0.01, 0.1, 0.3, 1 and 5 ppm. Using 10 ml of each of these solutions, proceed as for the sample solution. Measure the colour obtained at 510 nm. Plot these values against the concentrations to obtain a standard graph.

Total dissolved Fe(II) conc. between 0.01 and 5 ppm can be detected by this method. Detection limit is 50 µg of Fe. in solution. Fe^{+3} is reduced to Fe^{+2} by NH_2OH adjusted to pH 3.2-3.3. It is then treated with 1,10 phenanthroline. Resulting orange red solution is measured at 510 nm.

COPPER (Cu): Activity 9

High concentration of copper in the soil is due to pollution from agricultural run offs or corrosion of copper–containing alloys in pipe-fittings and industrial effluents. Salts of copper are often used in water reservoirs and in distribution pipes as it prevents growth of weeds. It binds strongly with the organic components of the soil and is found as metalo-organic complexes. It exhibits

very slow mobility. The concentration of copper in the soil determines its uptake rate in the plants: concentrations less than 100 ppm show low uptake and at higher levels there is a significant increase in the uptake.
The normal background concentration of copper in the soil is 1-20 ppm. Increasing concentrations and values exceeding the threshold limit of 100 ppm is an indicator of serious pollution.

Copper is easily accumulated in plants and at concentrations of 20 ppm it is toxic to the plant. It is an essential micronutrient in the human diet, the recommended daily allowance (RDA) being 2.0 mg. It plays a significant role in enzyme catalysis and the electron transport processes. Copper gets accumulated in the blood, bones and muscles.

Materials required:
Separating funnel, test tubes, pipettes, standard copper solution (10 µg \ml), liquid NH_3, 15% citric acid, 1% sodium diethyl dithio carbamate, 1% iso amyl acetate (refer Appendix 1), distilled water.

Experimental procedure:

1. Take 5 ml of sample supernatant (protocol A) in a clean beaker.
2. To the above add 5ml of citric acid and with a dropper add 4 drops of liquid ammonia.
3. Add 1 ml of carbamate solution + 39 ml of distilled water + 10 ml of iso amyl acetate.
4. Shake the beaker vigorously for 15 min and allow it to stand till the two layers are clearly demarcated.
5. Compare the colour developed with the colour grid provided and note your observations as L, P, H or C.
6. Alternatively, drain off the lower aqueous layer and collect the upper organic phase carefully in a test tube. Measure the absorbance of the organic layer at 440 nm. against reagent blank. Plot the absorbance value of the unknown sample against the standard graph to estimate the concentration of copper in the sample.

7. Note the value in the soil work sheet [SW: Activity 9]. Plot a standard graph with concentration on the X axis and absorbance on the Y-axis.

Preparation of standard graph:

Stock copper (Cu) solution: Prepare a 200-ppm (Refer appendix 1) solution of copper solution.

From this prepare a range of concentrations including 0.01, 0.05, 0.1, 1, 10, 20 and 100 ppm. Using 10 ml of these solutions, proceed as for the sample solution. Measure the colour obtained at 440 nm. Plot these values against the concentrations to obtain a standard graph.

Copper present in the sample reacts with sodium-diethyl-dithio -carbamate in an alkaline medium to form the Cu salt of the carbamate. This complex is golden yellow in colour. A few drops of liquid ammonia generate the alkalinity. The golden yellow colour is extracted into the organic phase of iso -amyl acetate and is then estimated colorimetrically. Citric acid is added to prevent the precipitation of any metal ions due to change in pH. Citrate also acts as a chelating agent.

Note: One can carry out soil analysis for other chemical constituents as in water.

Soil Worksheets

Name Of The Investigator: **Date:**

College Name/ Address:

Site name: **Location:**

General observation of the site:

Vegetation: Present_____, Absent_____

If present, then type of vegetation: Natural ___, Cultivated____, Garden ____, Others_____

Type of surface cover: Short grass (<10 cm) ____, Long grass (>10 cm) ____, Shrubs_____, Herbs____, Others_____

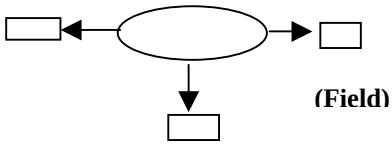
Type of canopy cover: Umbrella (overarching) canopy ____, Conical vertical canopy _____, Other_____

If vegetation is absent, then describe the site in brief: _____

Rain within last 24 hours: Yes___, No____; Last rain: _____

Activity 1: Soil Concept Map

Draw a concept map/flow chart with minimum 20 fields or concepts to justify the statement: 'Soil is a great integrator'.



Activity 2: Soil Profile

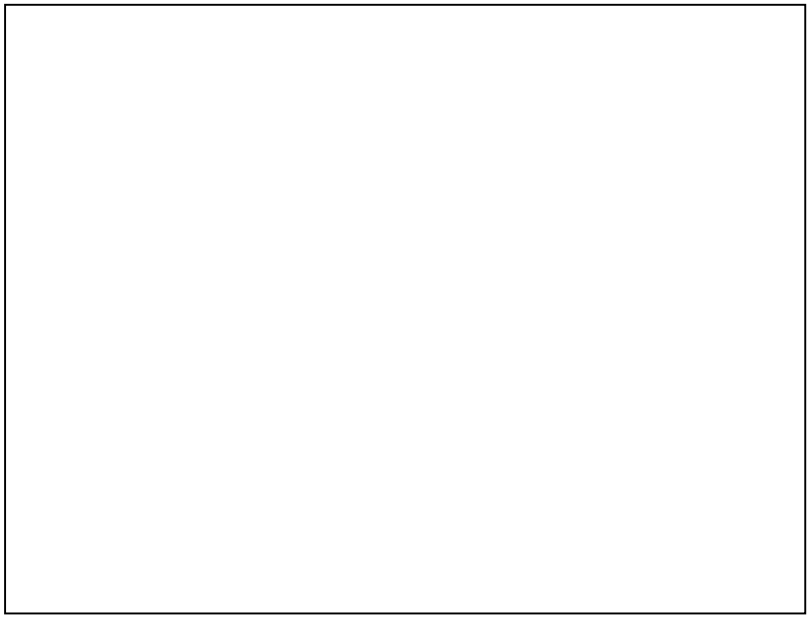
(i) General characteristics of each horizon of the soil profile.

Horizon	Horizon height (cms)	Moisture W-wet M-moist D- dry	Structure R-regular B-blocky P-platy C-columnar Cy-cylindrical G-grainy	Colour	Soil consistence*	Soil Texture C- clay S- silt Sa- sand L- loam Combinations	Presence (+) or Absence (-) of: Rt-Roots Ro-Rocks		Anthropogenic material		
							+/-	Few Many Nil	+/-	Type*	Few Many Nil

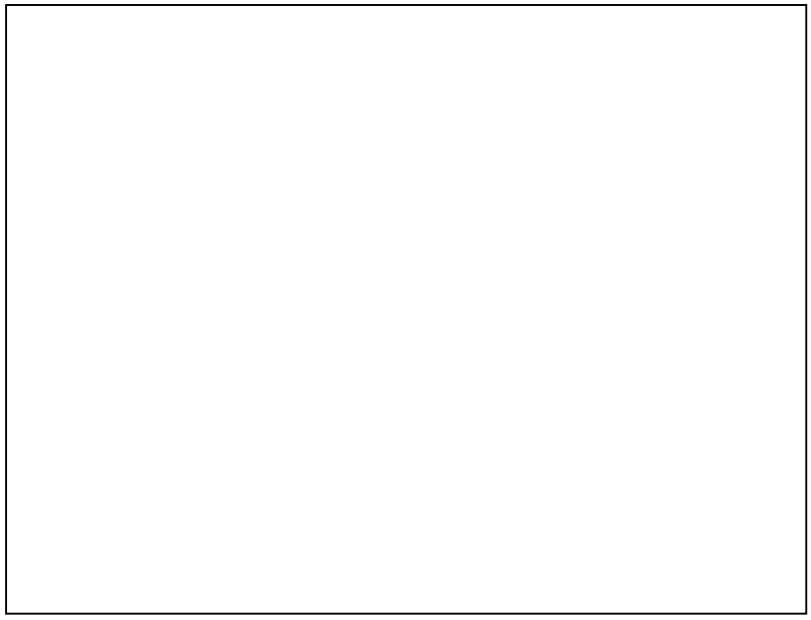
*Soil consistence: Loose, friable, firm, extremely firm.

*Type of anthropogenic material: plastic, glass, metal, rubber, etc.

(ii) Draw a labeled diagram (appropriately scaled) of the different layers/horizons of the soil profile.



(iii) Represent the soil texture data of the different horizons as a pyramid. This representation will be based on the rough distribution of different soil textures in the entire soil profile. The most frequent soil texture will be at the bottom of the pyramid, and the least frequent at the top.



Activity 3: Soil Temperature

Type of soil thermometer used: _____

Rain within last 24 hours: Yes___, No____

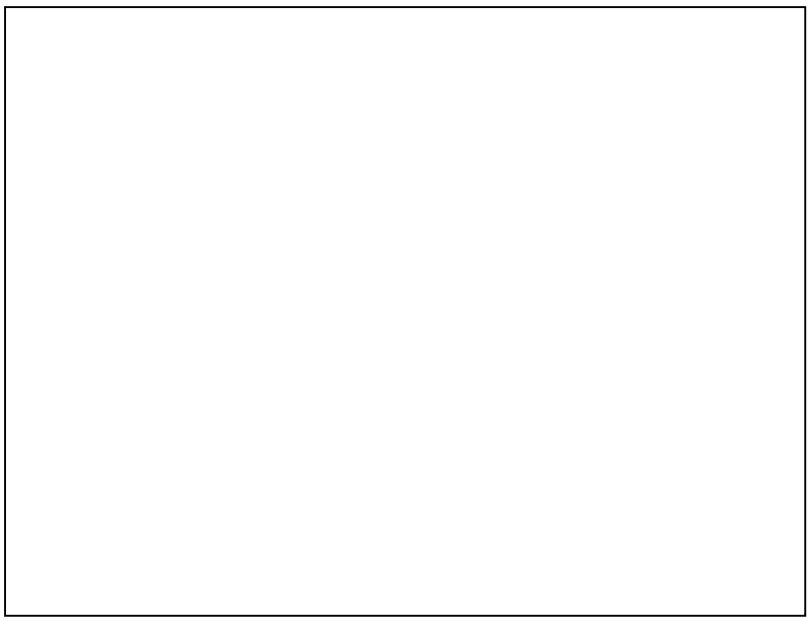
(i) Record of soil temperature at different depths

Serial no.	Date	Time of measurement		Temperature in ^{0}C		
		Hours	Minutes	5 cm	12 cm	20 cm

Average temperature at : 5 cms. _____; 12 cms _____; 20 cms. _____

(Report the average temperature in the final soil data sheet.)

(ii) Plot the temperature(s) against different depths



(iii) Compare soil temperatures of garden and open bare soil (green versus brown gardens). Correlate with the presence or absence of vegetation.

Activity 4: Soil Moisture

Date of sampling: Date of performing the experiment:

Current condition: Wet_____; Dry_____

Drying temperature: _____; Average drying time: _____ hours or minutes

(i) Record of the moisture content of the soil

Sample no.	Sample depth	A Wet-weight in gms	B Dry-weight in gms	C Water weight in gms (A-B)	D Container weight in gms	E Dry soil weight in gms (B-D)	F Soil water content (C\E)×100
1	0-5 cm						
	20 cm						
2	0-5 cm						
	20 cm						
3	0-5 cm						
	20 cm						

Average soil moisture content at : 5 cms _____, 20 cms _____

(Report the average soil moisture in the final soil data sheet)

(ii) Graphically represent the above data.

Activity 5: Soil Infiltration Capacity

Date of sampling: Date of performing the experiment:

Distance from the soil moisture study site: _____metres

Width of the reference band (R):_____

(i) Observations for soil infiltration capacity

Sr no.	A Start time (min)(sec)	B End time (min)(sec)	C Time interval (B-A)	D Mid-point (mins) (A+C/2)	R Water level change (mm)	F Flow rate mm/min (R/C)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						

Repeat the experiment three times, until consecutive readings are obtained.

Average flow rate: _____

(Report the average flow rate in the final soil data sheet .)

Plot the flow rate against the time interval.

Activity 5 (Ii): Flow Rates Of The Different Types Of Soil

Sr. no.	Soil characteristics			Infiltration time		Characteristics of water			
	Nature M-Moist D-Dry	Colour	Type C-clay S-sandy S-silt L-loam O-others	Start time (min)	End time (min)	Clarity C-clear M-muddy		pH	
						Before expt.	After expt.	Before expt.	After expt.

Plot a bar graph to illustrate the flow rates of different types of soil.

Activity 5 (Iii): Water Holding Capacity Of The Soil Samples.

Drying temperature: _____˚ C; Time of drying: _____hours

Wt. of empty container **(X gms): _____**

Wt. of wet soil + container (**Y gm**): ____; Wt. of wet soil **A** (**Y-X gm**): _____

Wt. of dry soil + container (**Z gm**): ____; Wt. of dry soil **B** (**Z-X gm**): _____

(iii) Record of soil moisture

Soil type	**Weight of wet soil (A in gm)**	**Weight of dry soil (B in gm)**	**Water content of the soil (A-B gms)**

Represent the results of (iii) graphically.

Combine both the infiltration time and the water content of all soil types in ONE graph.

The correlation noticed between the two properties of the soil?
Positive____; Negative____; Partial____;
Inverse____; Others___

Activity 6: Soil pH

Date and time of sampling: Date of performing expt:

pH measured with: _____; pH value of soil sample: ____

Observer 1: ___, Observer 2: ____, Observer 3: ____, **Average pH:_____**

(Report average pH reading in the final soil data sheet)

Activity 7: Soil carbonates

Solution in the pipette: _____ Solution in the flask: _____

Indicator used: _____End point:_____

Titration readings for calcium carbonate:

For sample **For blank:**

Serial No.	Vol. of NaOH in ml			Constant reading (S)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

Serial No.	Vol. of NaOH in ml			Constant reading (B)
	Initial (A)	Final (B)	Difference (A-B)	
1				
2				
3				

$$\% \text{ of } CaCO_3 = \frac{(B-S) \times N \times 0.05 \times 100 \times 100}{\text{Volume of sample} \times 5} = \text{gm \%}$$

(Report the average value in the final soil data sheet)

2 mole of NaOH ≡ 2 moles HCl ≡ 1 mole $CaCO_3$; 1 mole NaOH ≡ ½ mole $CaCO_3$

1000ml of 1N NaOH ≡ 50 gm of $CaCO_3$ 1ml of 1N NaOH ≡ 0.05 g of $CaCO_3$

(B-S) ml 1N NaOH ≡ (B-S) × 0.05 × N = gm of $CaCO_3$ (B= blank reading; S= sample reading)

$$\frac{(B-S) \times 0.05 \times N \times 100}{\text{Volume of sample}}$$

$$\frac{(B-S) \times 0.05 \times N \times 100}{\text{Volume of sample}} \quad \text{gm of } CaCO_3$$

$$\frac{(B-S) \times 0.05 \times N \times 100 \times 100}{\text{Volume of sample} \times 5} \quad \text{gm of } CaCO_3$$

Hence 100 gm of soil = = % of $CaCO_3$

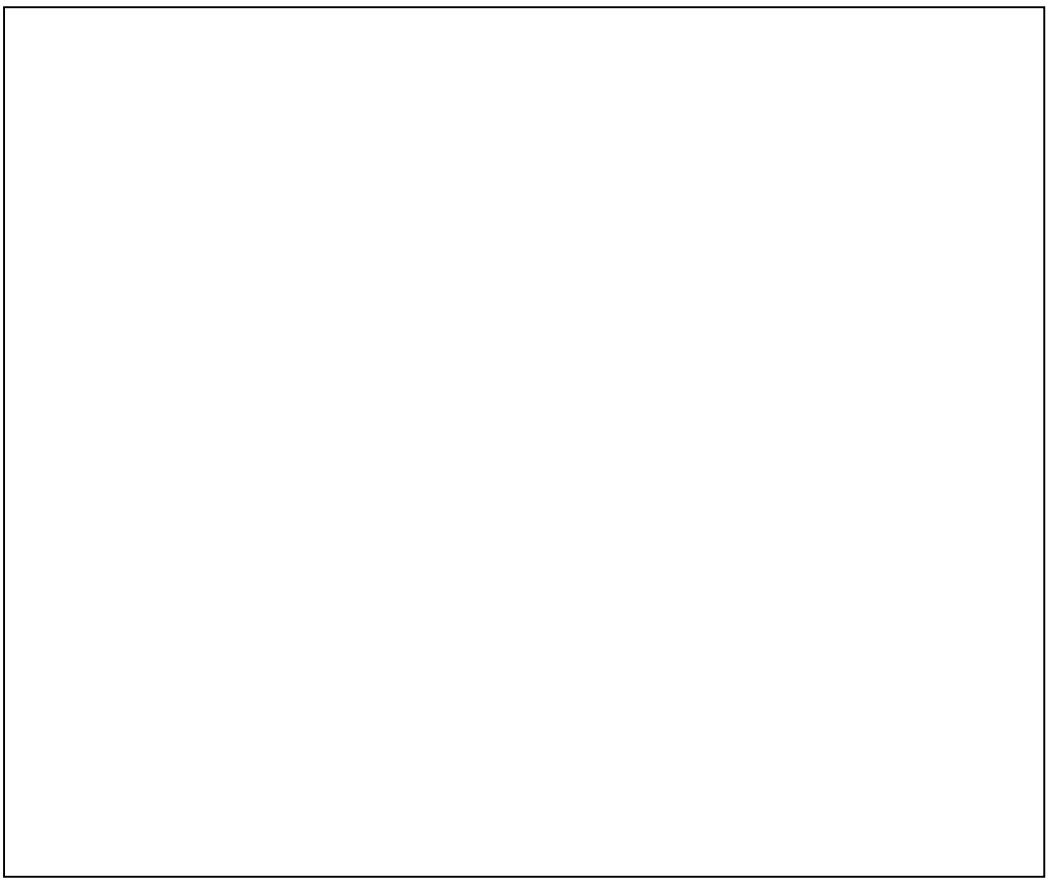
Activity 8: Iron

Date and time of sampling: **Date of performing the experiment:**

Observations:

Concentration of iron in the sample observed by comparing the colour developed against the colour grid: (**C, H, P, L)** _____

Plot and read the concentration of the sample from the standard graph.



Observer 1=_____; Observer 2 =_____; Observer 3 =_____

Average value of iron in the sample =_____ppm

(Report the average value for iron in the final soil data sheet.)

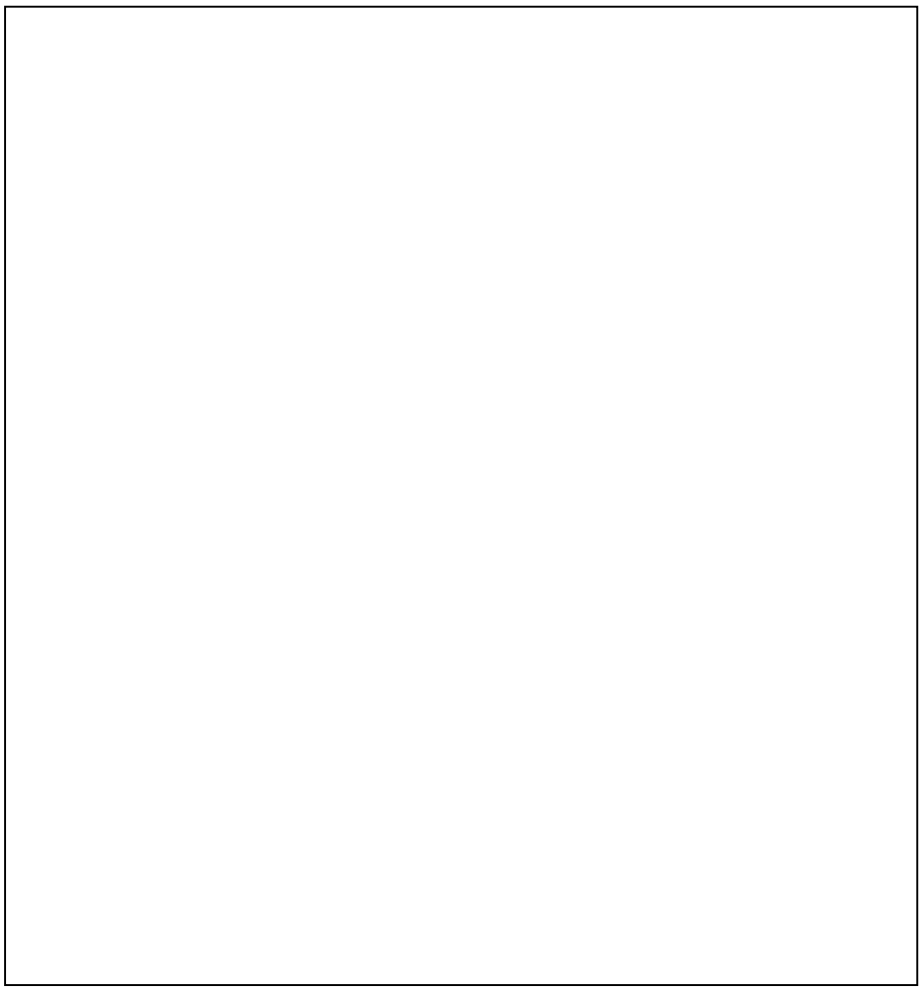
Activity 9: Copper

Date and time of sampling: **Date of performing the experiment:**

Observations:

Concentration of copper in the sample observed by comparing the colour developed against the colour grid: (**C, H, P, L)** _____

Plot and read the concentration of the sample from the standard graph.



Observer 1=_____Observer2 =_____ Observer 3 =_____

Average value of copper in the sample =_____mg\l of Cu

(Report the average value for copper in the final soil data sheet.)

Final soil data sheet:

Note the average values of your observations to give a comprehensive view of the soil characteristics

Site details:

Characteristics	**HORIZONS OBSERVED**						
	O	**A**	**B**	**C**	**D**	**E**	**R**
Horizon observed							
Height /depth							
Colour							
Wet/Dry							
Soil structure*							
Texture*							
Consistence*							
Presence of root/rocks							
Presence of anthropogenic waste +/-							
Temperature							
Moisture content (10 cm)							
Average infiltration rate (mins)							
pH							
% $CaCO_3$							
Iron							
Copper							

*Denote one of the following for structure, consistence and texture:

- Structure: Structureless, mixed, granular, rocky, massive, platy, columnar and prismatic.
- Texture: Sand, silt, clay, clay-loam, sandy-loam, silty-clay
- Consistence: Loose, friable, firm, extremely firm.

‘Green’ watch…

for good health

INTRODUCTION:

Natural vegetation in any area is often referred to as land or green cover. The quality and quantity of this vegetation is a good indicator of the changes in the environment. This is especially true with respect to climate, which can vary greatly and most noticeably with increasing pollution. Human induced changes in the land cover (such as, deforestation and increased concrete surfaces and constructions vis-a-vis green cover), affect not just the plants but also the different ecological and energy cycles.

Tracking changes in the quality, quantity and type of the land cover can give valuable information about the state of our environment and pollution, and indirectly about health. For instance, the diminishing canopy cover, the reduced tree growth, failure of flowering and changes in the leaf colour are all indicators of poor quality of the environment.

For detailed study of the land cover, scientists often make use of the modified UNESCO classification system, often called the MUC system, to identify the type or class of land cover. This classification makes use of ecological principles and the different vegetation types found in different climatic zones. Under this MUC system, every land cover type is classified as a separate class, with each class being further sub -classified into three or four levels. For instance, in the original MUC system, “Cultivated Land”, at MUC Class 8, at Level 1, is further divided into Agriculture (81) and Non agriculture (82) at Level 2. The sub-class 81—Agriculture-- is further classified as: “row crop or pasture” (811), orchard or horticulture (812), confined livestock feeding (813) and other agriculture category (814), at level 3. Similarly, non agriculture (82) at level 2 has four sub categories at level 3: parks and athletic fields (821), golf courses (822), cemeteries (823) and other non agriculture (824). The following table gives ten major MUC classes with their characteristics.

Perhaps at a later stage, this MUC system could be used to classify the area under study.

The MUC levels for green cover identification

Class no	MUC class	Characteristics of the class
0	Forest	> 40% trees, 5 mt tall, crowns interlocking
1	Woodland	> 40% trees, 5 mt tall, crowns not inter locking
2	Shrub land	> 40% shrubs, 0.5-5 mt tall
3	Dwarf shrub land	> 40% shrubs under 0.5 mt tall
4	Herbaceous vegetation	> 60 % herbaceous or broad leaved plants, grasses
5	Barren	< 40% vegetative cover
6	Wet land	> 40% vegetative cover, includes marshes, swamps and bogs
7	Open water	> 60% open water
8	Cultivated land	> 60% non-native cultivated species
9	Urban	> 40% urban land cover (buildings, paved surfaces)

(Courtesy: GLOBE)

The recommended green cover for an urban site is 3 acres of green cover for every thousand people living in that site.

Ideally, the investigation of land cover involves, calculating percentages of ground and canopy cover, and identification of the type of vegetation and the dominant and less dominant species of an area. Mangrove stretches, if present, could also be monitored.

Interested students/teachers can monitor the same site on a continuous basis. Green cover, tree numbers, heights and circumferences could also be monitored over time; for this it is imperative to tag/label the trees and keep a

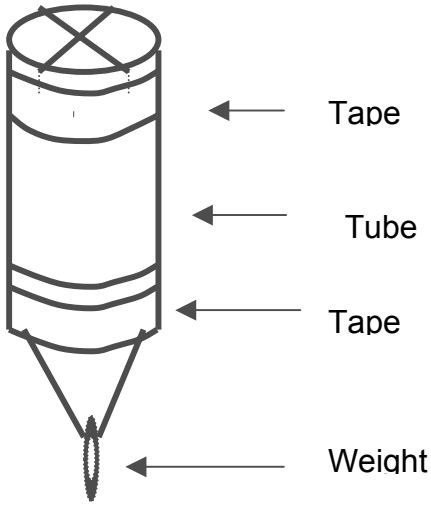
proper record of the observations. For further understanding, these data can be linked to the soil and air profiles of that area.

STUDY SITE FOR QUANTITATIVE MEASUREMENTS OF GREEN COVER: Activity 1 to 3

1. Select a homogeneous area with some natural vegetation. Starting from any point on the study site, mark out a square of about 20 × 20 mt. using a measuring tape. (The selected site could be a circle or of any shape. But remember to calculate the area accordingly.)
2. If the above dimensions are not possible, take convenient dimensions.
3. As an exercise, get some idea about the type of vegetation in that area. Hence, at a gross level, identify the land cover type (from MUC table).
4. The selected area will be used for making measurements of canopy and ground cover density with a densiometer.

Making of a Densiometer:

1. Take a tube approximately 4 to 6 cm in diameter and 7.5-10 cm long.
2. At the top end of the tube, attach two firm strings or a thin wire (at perpendicular angles), to form a cross at the intersection.
3. At another end, attach an 18 cm piece of thread with a metal nut hanging loosely from it, as shown in the figure below. This is a working densiometer.



A typical Densiometer

OBSERVATIONS AND MEASUREMENTS OF CANOPY COVER:

Activity 1 (i)

One or more students walk along the diagonals of the square (circle) with the densiometer in the hand. After every two steps, the student looks up at the canopy through the densiometer.

Make sure that the metal weight (ring) is in line with the intersection point of the cross.

1. Presence of vegetation, twigs or branches touching the cross hair intersection, is recorded as '+'. If no vegetation is seen, record as '-' in the 'Green cover' work sheet [GCWS: Activity 1(i)].
2. For accuracy, repeat the readings twice with different students at the same site.
3. Enter average values in the worksheet.
4. Calculate the percentages of canopy cover for the selected area.

   (All +'s/ total observations) × 100

OBSERVATIONS AND MEASUREMENTS OF GROUND COVER: Activity 1(ii)

Take two steps along the diagonals, as in Activity 1 (i), but here the student should look down on the ground.

1. If the vegetation is underfoot or touches the foot or leg below the knee, record it as +G for GREEN vegetation; and +B if the vegetation is BROWN.
2. If there is no vegetation observed, note it as '-'.
3. For accuracy, repeat the readings twice with different students at the same site. Enter average values in worksheet {GCWS: Activity 1 (ii)}.
4. Calculate the percentage of ground cover for the selected site.

   (All +'s/ total observations) × 100
5. Similarly, calculate the percentage of green and brown ground cover.

Note: Think of ways of extending this method to find out the green cover for built up and other areas. Interesting results can be observed by recording and

monitoring the extent of green cover of the same site on a regular and continuous basis. If interested, adopt the selected site, build up the green cover and keep meticulous record of the green cover.

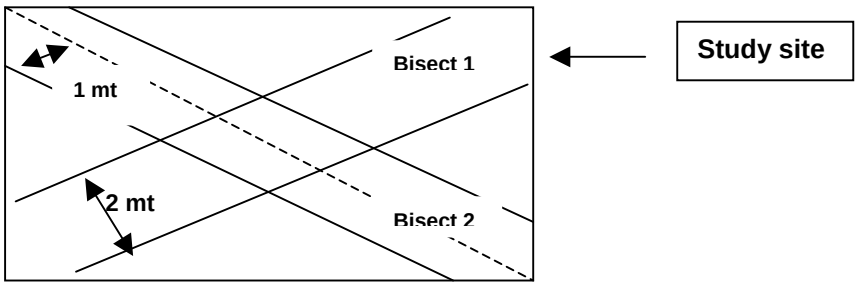
Qualitative And Quantitative Observations Of Green Cover:

Activity 1 (iii, iv)

Canopy cover measurements include trees that have a canopy (umbrella). However, this eliminates trees without overarching canopies. To take care of such situations, counting of individual trees along bisects \diagonals of the chosen study site area is carried out.

(III): QUALITATIVE AND QUANTITATIVE OBSERVATIONS OF GREEN COVER (TREES AND SHRUBS) AT GROUND LEVEL

1. Extend 1meter area (total 2 mts wide bisects) on either side of the diagonals (now called bisects). Now the tree and ground cover measurements will be made along these bisects.



2. First, take an overall view of the study site and note down the type of trees and shrubs in your rough book.
3. Walk along the two bisects, one after the other, and identify the different types of trees\shrubs.
4. Count the number of individual tree types in each bisect.
5. Enter the observations in green cover worksheet {GCW: Activity 1 (iii)}.
6. Calculate the percentage of each tree and shrub type. (No. of individual tree type\ total no. of trees counted χ by hundred.)

Note: Different tree types could be considered along different families (mimosae, ficus, palms, etc) or along leaf morphology (broad, narrow or simple and compound leaves, etc). Shrubs can be grouped based on their heights.

(IV): QUALITATIVE AND QUANTITATIVE OBSERVATIONS OF GREEN COVER (HERBS : GRASSES)

1. The above method can also be extended for the ground (grass) cover.
2. The spread of grass along the entire bisect is difficult to count. Hence bisects will be divided into small samples/quadrants of 1mt X 1 mt. (Mark the four corners of the quadrants with big nails or sticks. Pass a string around the nails to demarcate the quadrant.)
3. Count the grass cover in alternate quadrants; add them up to give the grass cover for the bisect. (For this, grass tufts are counted : lift a bunch of leafy blades and observe: if they have a common root \origin, it is counted as one tuft. This is continued for the entire quadrant.)
4. The grass cover could be of many types; try to identify each type and count how many of each type is present in a quadrant.
5. If the identification is not possible, report the observation as grass type 1, grass type 2…
6. Calculate the percentage of each type of grass as for the tree cover.
7. If the place is well maintained, the growth of grass will be well spread out and luxuriant. This type of growth could be reported as 100% cover with Type 1=__%; Type 2=__%, etc.

IDENTIFICATION OF SPECIES TYPE: Activity 1 (v)

1. Identify the different plant species in the study area as dominant and co-dominant species.
2. While the most frequently occurring species (most common) in an area is termed as the dominant, the next dominant species (second most common) is recognized as the co-dominant.
3. Identify the origin of plant species as endogenous (originating in an area) or exogenous (brought from outside).

4. Identify the species by using both common and botanical names.
5. It is an interesting exercise to find out the common names of plants in different Indian languages.
6. For the ground cover, identify the cover as shrubs, herbs with broad or narrow leaves and narrow leaved grass.
7. Note the observations in GCWS: Activity 1 (i and ii) respectively.
8. Help of experts in botany can be sought for precise identification.

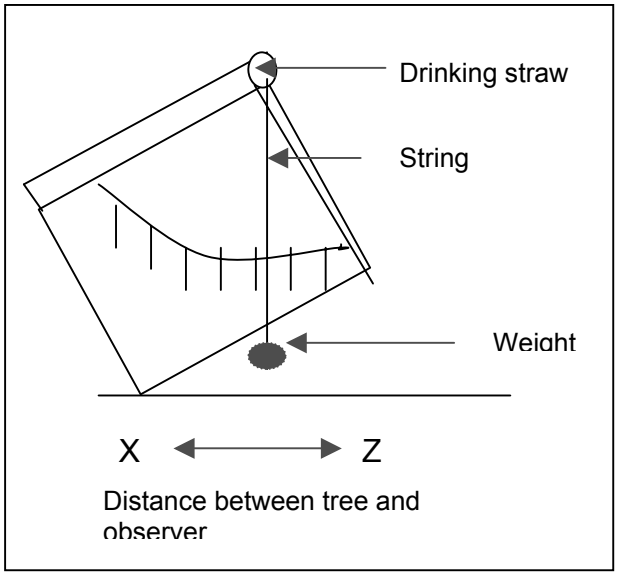
MEASUREMENTS OF THE TREE CIRCUMFERENCE:

Activity 2 (i)

1. Use a bendable tape to measure the circumference of the tree.
2. The circumference of the tree trunk is usually measured at 1.35 m above the ground level.
3. Repeat the process with different students twice for all the dominant and co-dominant trees of the study site.
4. Record the circumference in cms.in worksheet (GCWS: Activity 2(i) (ii).
5. Remember to tag the trees in the area, if interested in monitoring the green cover over time.

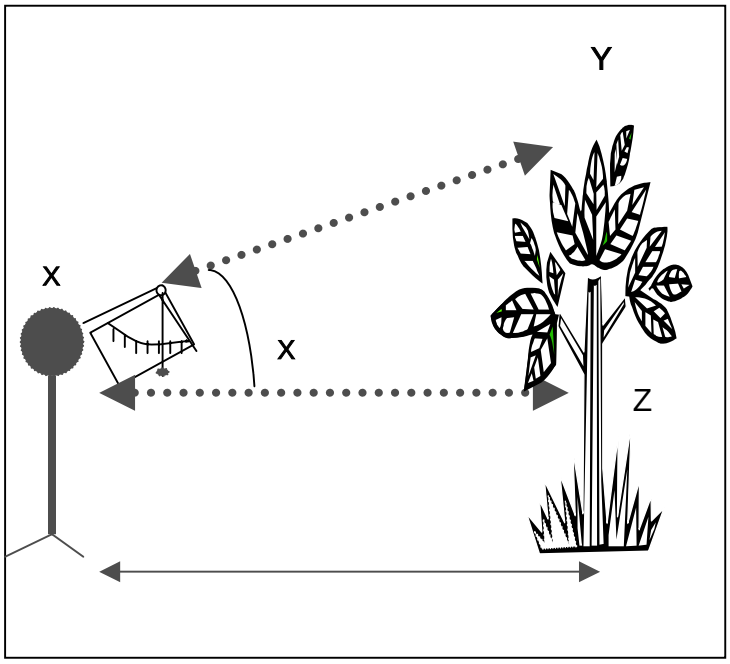
MEASUREMENT OF TREE HEIGHT: Activity 2 (ii)

1. A clinometer is used to measure the height of a tree.
2. Making of a clinometer is as follows:
   - Stick the clinometer sheet to a cardboard of the same size.
   - Make a hole at the encircled mark on the clinometer and pass a 15 cm string through it, with a knot at one end to avoid slippage.
   - Tie a metal bolt at the other end of the string.
   - At the demarcated area of the sheet, paste a broad drinking straw or any narrow tube/pipe. This is the working clinomenter.

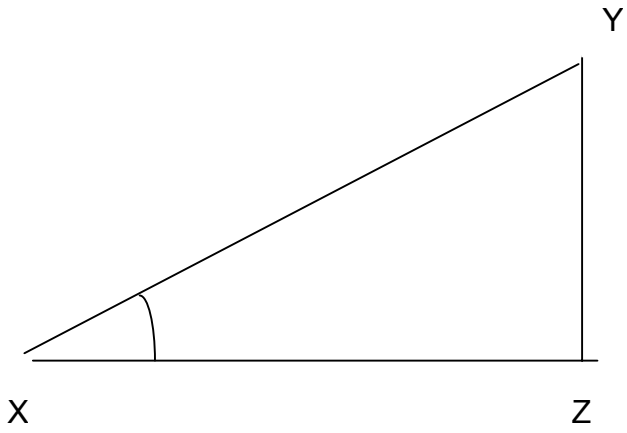


A clinometer

3. To measure the tree height, hold the clinometer at eye level and stand at a fixed distance from the selected tree. Note this distance (XZ in fig).
4. Note the distance of the observer's eye from the ground, which is a known quantity (height of the observer).
5. Before making measurements make the zero adjustment for the clinometer. For this allow the string to hang loosely and set it parallel to the vertical (y-axis) line on the clinometer chart.
6. To measure tree height, look through the straw and view the tree tip.
7. Another student or partner should then note the angle made by the string on the clinometer (angle X); take care not to move or shake the string during the observations. Using the tan sheet and the formula, calculate the height of the tree.
8. Repeat the procedure twice with different students and record the average readings in the GCWS: Activity 2 (i) and (ii).



Measuring tree height with a clinometer



Tan angle X= YZ/XZ; YZ =(XZ) X (tan < X)

Hence, actual tree height = YZ + distance of the observer's eye from the ground.

Remember to tag the trees in the area, if interested in monitoring the green cover over time.

MEASUREMENTS OF GRASS BIOMASS: Activity 3

1. In the study site, mark a square of about 1 meter, where there is natural vegetation.
2. Using a garden scissor cut all the grass vegetation in that square.
3. Collect the grass in bags; do not collect any other loose material/ leaves.
4. Sort the grass clippings into green and brown.
5. Place the two portions in separate labeled paper bags.
6. Weigh the grass in both the bags. Note the weights.
7. Next, dry the bags containing grass over a period of days in an oven at a temperature not higher than 50-70^{o} C.
8. Weigh each bag once a day.
9. The grass in the bags is completely dry when two consecutive weights are similar.
10. Next, empty the contents and weigh the empty bags.
11. Subtract the weight of the empty bags from the weight of the filled ones. This will give the weight of the grass clippings.
12. Repeat this procedure in more patches such that the grass cover in the entire study site is represented.
13. Report the weights for both green and brown grass in the green cover work sheet [GCWS: Activity 3].

QUALITATIVE CHARACTERISTICS OF CANOPY AND GROUND COVER: Activity 4

To determine the quality of the land cover, certain characteristics are checked for both canopy and ground cover.

1. Identify the type of canopy cover (trees: deciduous or evergreen) and ground cover (grass, weeds, shrubs or herbs).
2. Check for the colour of the leaves of the canopy cover. Observe for any insect or fungal infections, too.

3. Note the tree\ grass growth). Check if the green cover is well maintained.
4. Check if tree\ ground cover exhibits regular flowering and fruiting.
5. Finally, identify the green cover of the study site as healthy or diseased.
6. Record your observations in land cover data sheet [GCWS: Activity 4].

A FEW QUESTIONS TO THINK ABOUT:

- Recall the total area of your study site: Is the observed and recorded percentage of green cover adequate for that area?
- Calculate the percentage of green cover for the defined area/garden. Report the results considering the foll: (i) measure the total area of the garden using a tape; (ii) measure the areas covered with: trees with canopy + trees without canopy + shrubs + grass.
    - To measure the area covered by canopy e.g., canopy of banyan tree, consider the area covered by the entire canopy; multiply this area by the no. of banyan trees (look out for young and old trees). Similarly, carry out this measurement for other tree types. And calculate the total green cover in an area.
- From the Town Planning department of your municipality/district, find out the ideal / adequate green cover percentage for urban areas?
- Check out the diversity of the tree cover.
- On similar lines, mangrove cover could also be monitored. Find out if there is an increase or decrease in the mangrove cover, say over a period of three to four years.
- Find out the absence/presence of green cover along the roads and at the road dividers.
- In the final analysis, try to link up the pollution data obtained to the green cover study.

Green cover Worksheets

Date And Time Of Experiment:

Name Of The Site: Location:

Activity 1: Observations And Measurements Of Canopy Cover

(i) Canopy cover--qualitative and quantitative observations

Densiometer observations + = tree - = nil	**Canopy type E=evergreen S=seasonal**	**Botanical name of the trees**	**Common name of the trees**	**Canopy type is: D=dominant C= co-dominant**	**Origin of species E=exogenous N=endogenous**

% Canopy cover:_____

(Report the average value for canopy cover in final green cover data sheet.)

Determining canopy cover:

Total observations= total no. of (+) and (-)_____

% Canopy cover: (All **+**'s\total observations) ×100 =_____

Activity 1(Ii): Observations And Measurements Of Ground Cover

(ii) Ground cover---qualitative and quantitative observations

Densiometer observations of ground cover: **+ = grass** **-- = no grass**	**Colour of ground cover** **B= brown cover** **G = green cover**	**Ground cover type** **Grass/ herbs/ shrubs**

% Ground cover: _____

(Report the percent ground cover in final land cover data sheet.)

Determining ground cover:

Total observations = Total no. of (**G**) + (**B**) + (-) = _____

% Ground cover = (All **G**+ All **B** \ total observations) × 100 =_____

Activity 1 (Iii): Qualitative And Quantitative Observations Of Green Cover (Trees And Shrubs) At Ground Level

Name of plants	Nos. in Bisect 1	Nos. in Bisect 2	Total Nos.	% of each plant type

Activity 1 (Iv): Qualitative And Quantitative Observations Of Green Cover (Herbs = Grasses)

Name/type of herbs	Nos. in Bisect 1	Nos. in Bisect 2	Total Nos.	% of each herb type

Activity 2 (I) And (Ii): Measurements Of Tree Circumference And Height

Date:

Name of the site: **Location:**

(i) and (ii) Tree circumference and height

Name of the plant	Dominant species		Co-dominant species		Tree girth (cms)	Height of tree in metres (m)				Average readings of:	
	Endogenous	Exogenous.	Endogenous	Exogenous		Dist. of observer from tree (XZ)	Angle on clinometer (X)	Tan angle <X	Tree height (cms)	Tree girth (cms)	Tree height (cms)

Tan angle X= YZ/XZ;

YZ = (XZ) x (tan < X)

Hence, actual tree height = YZ + distance of the observer's eye from the ground

(Report average tree girth and height for at least <u>two</u> dominant or co-dominant species in the final data sheet.)

Activity 3: Measurements Of Grass Biomass

Date:

Name of the site: Location:

Sr. no.	Wt of bag + dried green lgrass. (X gm)	Wt. of empty bag (Y gm)	Wt. of bag + dried brown grass (A gm)	Wt. of empty bag (B gm)	Wt. of dried green grass (X-Y= Z gm)	Wt. of dried brown grass (A-B= C gm)	Total grass biomass (Z+C gms)

Total grass biomass: _____

(Report the total value for grass biomass in final green cover data sheet)

Activity 4: Qualitative Characteristics Of Green Cover

Date:

Name of the site: Location:

Qualitative observations of green cover:

Characteristics:	Ground cover	Canopy
***Type of cover:**		
Distribution of green cover U: uniform R: random		
***Colour**		
Maintenance + = maintained -- = not maintained O = other		
Presence or absence of flowers (+\-)		
Presence or absence of fruits (+\-)		
Overall condition of green cover: H: healthy D: diseased O: other		

*Green cover type:

Ground cover: grass, weeds, shrubs, barren or other.

Canopy: deciduous, evergreen or other

*Colour: brown, green, yellow or other

If possible, identify if the plants are infected with fungal or insect infestation:

Yes_____/No_____

Final Green - Cover Data Sheet:

Date:

Site details:

Green cover characteristics	Observations
MUC class	
Dominant species	
Co-dominant species	
% Canopy cover	
% Ground cover	
Average tree circumference (cms) **(of at least two dominant/co-dominant species)** **(i)** **(ii)**	
Average tree height (cms) **(of at least two dominant/ co-dominant species)** **(i)** **(ii)**	
Grass biomass	

‘Waste’ watch…

for good health

INTRODUCTION:

Rapid urbanization and industrialization, combined with increasing population, has resulted in generation of large volumes of waste, both liquid and solid. The situation is further aggravated by our consumerist lifestyles, scarcity of dumping grounds and fast filling up of these dumping sites in urban areas. These sites with limited land area cannot accommodate the increasing volumes of waste. Further, unscientific management of waste poses threats to health and environment. All developing societies need regulations and strict implementation for scientific disposal of their wastes. Practicing the concept, ‘Reduce, reuse and recycle’ will go a long way in managing our waste, without compromising on the development process.

Manufacturing practices, in all fields, demand that the inventors / manufacturers are made ‘liable’ / responsible for their products. This would include: chemicals of all types, including cosmetics, textiles, electronics, automobiles, paper and food industry. The final products should not be solely judged by their uses or profits earned. Attempts should also be made to check out the waste generated by the manufacturing process of this product or its byproducts/ residues. In turn, these should not pose any threat to the environment in their destruction /degradation. There is an urgent need to introduce and implement the concept of “Polluters Pay” in the country.

There are a variety of industries (metals, chemical and dyes, cement, fertilisers, leather, distilleries, sugar, pharmaceuticals, paper pulp, etc), with each having a specific type of waste, and requiring special treatment and disposal methods. This topic is complex and requires detailed study in the country. An effective watchdog body is the need of the hour. There is also an urgent need for different groups – government, industries, scientists, engineers and consumers-- to work together to minimize pollution without affecting development in the country. In one such move, the ‘Ecomark’

scheme of the Government of India formulated in 1991, classifies different consumer items according to their impact on environment. The different criteria for obtaining an ecomark rests on the basic concept of cradle-to-grave approach, i.e., the environmental impact of the product, right from raw material extraction, its manufacturing to its final disposal. In recent years, many more schemes have evolved to keep a check on industries, but much more needs to be done. Unfortunately, sufficient attention has not been given to the scientific management of waste, both in urban and rural areas. We are ignoring this problem at a great risk to our health.

Liquid waste:

Large volumes of liquid waste are primarily contributed by untreated sewage, agricultural run-off and industrial liquid discharges. Often these are released directly into rivers, creeks or *nallahs*, or even in storm water drains meant for carrying rain water, which finally empty into seas or bigger rivers or lakes, causing serious problems of water pollution. This also causes serious degradation of water bodies thereby changing the water or shore ecology. These effluents may also gain entry into the drinking water supply pipes leading to health hazards. Along with a heavy load of disease causing microorganisms (pathogens), these liquid wastes often contain high concentrations of nitrogen and phosphates causing excessive growth of algae and weeds. These produce characteristic bad odours. These wastes\effluents also contain harmful toxins, which can permeate into the soil and the air causing pollution.

Solid waste:

Solid waste is commonly classified as dry, wet and medical. Materials like paper, plastics, glass, rubber, metals, packing materials, cloth and polythene bags form a large proportion of dry waste. These are not easily degraded in the soil. In fact, the time taken for degeneration\breakdown of each type of waste varies from a few days to several years.

Degradation time taken for different materials:

Organic wastes: vegetable and fruit peels, leftover foodstuff → 7-14 days

Paper → 10 -30 days Cotton cloth → 2 - 5 months

Woolen items → 1 year

Wood →10 15 - years (in absence of termites)

Tin, aluminum and other metal items → 100–500 years

Plastic bags and Polypet bottles → one million years or more

Glass bottles → not yet estimated

These materials are often carelessly burnt releasing poisonous gases in the air. Alternatively, they are dumped in landfills or water bodies in absence of regulatory norms or in order to avoid these norms. Many small-scale industries directly dispose their solid waste into landfills. Fly ash from thermal power plants containing toxic heavy metals like mercury, arsenic and lead, are often put into earmarked landfills. These ash-pond areas located within the plants must have impervious liners, as all these materials tend to enter and accumulate in the soil, water, and cause severe environmental deterioration. In the soil, they may also interfere with root penetration, affecting green cover.

Increase in population has also led to the generation of large volumes of wet (kitchen) waste. This includes, vegetable matter like peels, coconut shells and food leftovers and other non-vegetable matter, like bones, skins and feathers. These materials are easily degraded in the soil. However, in urban areas, availability of limited space for disposal of large volumes of this category of

waste poses problems. In turn, it raises new problem of pests (like mosquitoes, rats, pigs and stray dogs) in our society. People will have to come up with ingenious solutions for managing wet waste too. Among other options, those of vermiculture or production of fuel from wet waste are also being explored.

Another option being recommended for easing the problem of waste from plants and animals (like animal dung, wet and agriculture waste) in the country to some extent is conversion of solid waste into energy. This would require examining the different materials for their energy potential (calorific values).

Medical wastes like cotton, bandages, syringes, needles, invasive instruments like those used by dentists and surgeons and biological materials (organs, tissues, etc) need careful handling and disposal. Medical waste should not be mixed with other categories of waste; each of the above wastes needs special treatment before disposal. Sanitary napkins and the so-called disposable diapers pose a new set of problems, since they are not biodegradable. In this program, only certain aspects of solid waste disposal will be taken up via activities. With proper understanding of issues involved, one can design a series of activities for better understanding of waste management.

Dirty environment around spots of collected garbage and stagnant/still pools of water provide an excellent breeding ground for a host of pathogens, insects (mosquitoes) and animals like rats and stray dogs. These are vectors for spread of communicable diseases. For example, rats are vectors for leptospirosis, typhus and plague; infected stray dogs carry the rabies virus in their saliva; malaria and dengue are caused by parasites spread by mosquitoes.

In our battle against diseases, it is important to have a scientific understanding of different causative agents of diseases, their vectors and the places where they live and multiply. For instance, a single female mosquito

lays about 100 eggs in a stagnant pool of water, which, in turn, develop into 100 adult mosquitoes, which may spread malaria.

Hence, the best way to prevent the spread of communicable diseases, including insect-borne diseases, is by keeping the environment clean and reducing the number of breeding places. Insecticides and other pesticides are short-term remedies. A few activities are planned to bring out the linkages between dirty environment and these diseases.

Experimental Procedures:

TYPE OF SOLID WASTE GENERATED (+ PRESENT /-- ABSENT): Activity 1

1. Identify different types of waste generated in your home.
2. Suggest methods for their disposal.
3. Note the observations in Waste Management Worksheet--Activity 1.
4. Based on this survey, extend these observations to what must be happening at a larger scale in the entire sector/node/city.
5. Fill out the observations in Waste Management Worksheet--Activity 1.

WASTE SEGREGATION IN MEDICAL SET UPS: Activity 2

1. In the selected area/sector, count the number of health care centers. Or, the number of dispensaries/ hospitals, both private and public.
2. Check out if the waste is being segregated or not in these places. Fill out the details in waste management worksheet [WMW: Activity 2].

WASTE COLLECTION AT DIFFERENT SITES: Activity 3 (i)

1. Roughly estimate the area in square metres of the study site.
2. Check for the presence or absence of waste collection bins.
3. Count the number of bins in the area.

4. Note the details of the nature of bins: open, closed, spread out. And the time-interval of waste clearance. Note the details in waste management worksheet [WMW: Activity 3 (i)].

SAFETY NORMS AS PRACTICED BY RAG PICKERS: Activity 3 (ii)

Check out the details in the worksheet.

WASTE DEGRADATION: Activity 4

1. Dig about six pits in the soil, each of about 15 cms depth.
2. Bury different types of materials—paper, plastic, broken glass pieces, metallic nails, vegetables and cloth piece--in different pits. Put labels on sticks for each pit.
3. Water these pits regularly as for plants.
4. After a week, dig out and examine the buried materials.
5. Observe for any degradation, if present. Fill in the pits with the materials again.
6. Repeat the excavations, every week for about one month.
7. Note your observations in the waste management worksheet (WMW: Activity 4).
8. Repeat this activity using different types of paper, cloth, glass and vegetable matter.
9. Link up the degradation with the chemistry of the waste material.

DISPOSAL METHODS FOR MEDICAL WASTES: Activity 5

1. Different items of medical waste are listed, along with a few methods of their disposal. Match the two in the worksheet.
2. Initiate a debate in the classroom regarding each method of disposal.

SITE OBSERVATION FOR WASTE DUMPS AND PESTS: Activity 6

1. In the selected site, observe for open nallahs, sewers, stray dogs, rats and garbage collection points and dumping sites.
2. Try to trace the entire chain of garbage—right from the point of generation to its final disposal, including segregation, if practiced.

Note: The experiments and observations outlined here mostly refer to solid waste generated by citizens. At a later stage, students can also try to find out the following:

(i) Trace the path of liquid and solid domestic waste right from the point of its origins\generation (at homes, etc) to the final disposal points.

(ii) Map the sewerage system in the area.

(iii) Map the storm-water drainage system in the area.

(iv) Find out the variety of solid and liquid wastes generated by different industries in your area. (Do not miss out on small /unorganized industries.)

(v) If possible, find out if proper pollution control measures—for air, water and solid are being adopted by these industries.

(vi) Based on the type of population in an area, the amount and the kind of waste vary. Consider that per capita waste generated per day is: 0.1 kg in slums, 0.5 kg in middle class areas, and 1 to 1.5 kg in elitist areas. Survey some sites and verify the above amounts.

(vii) Have you heard about the Advanced Locality Management (ALM) in Mumbai? Work towards the formation of ALM in Navi Mumbai.

Waste Management Worksheets

Activity 1: Type Of Waste Generated (+ Presence /-- Absent)

Site details:

Type of waste		
	Presence or Absence (+\-)	**Management RE=recycled RU=reuse D=discard**
Newspapers		
Papers		
Plastic waste		
Packing materials		
Milk bags		
Coconut shells		
Vegetable and non-veg. Waste		
Cloth waste		
Rubber waste		
Metal waste		
Glass waste		
Medical waste		

Comments

Activity 2: Waste Segregation In Medical Set-Ups

Name of site	Total number of:				Name of dispensary/hospital	Waste segregation (+/_)
	Public		Private			
	Hospitals	Dispensaries	Hospitals	Dispensaries		

Activity 3 (I): Waste Collection At Different Sites

Site details:

Characteristics	Description of site area		
	Residential	Industrial	Commercial
Approximate area in sq. mts.			
Presence or absence of waste bins (+/-)			
No. of bins			
Nature of the bins: open/closed/spread out			
Time interval of waste clearance			
Type of waste: Wet/Dry/Medical/Mixed			
Waste management: Segregated/ non-segregated			

Activity 3 (Ii): Safety Norms As Practiced By Rag Pickers

Site details	No. of rag pickers				Type of protective gear			Working with:	
	Adult		Child						
	Male	Female	Male	Female	Gloves	Masks	Shoes	Hands	Tools

Activity 4: Waste Degradation

Type of materials	Degree of degradation Initiation—(+); Intermediate — (++); Complete — (+++); Absent — (--)			
	Week 1	Week 2	Week 3	Week 4
Paper				
Plastic bags				
Metal nails				
Glass pieces				
Cloth				
Vegetable matter				

Activity 5: Disposal Methods For Medical Wastes.

Match the different waste materials to the methods of disposal listed below the table.

Different materials	**Method of disposal**
Invasive surgical instruments	
Syringes: plastic and glass	
Used cotton and bandages	
Biological materials	
Needles	
Plastic saline and blood bags	
Expired medicines	

Methods of disposal:

Incineration, autoclave, dumping, exposure to low temperatures, dismantling, brushing and disinfection, boiling, breaking.

*In some cases, more than one method may be used.

Activity 6: Site Observation For Waste Dumps And Pests

Sr. No.	**Site name**	**Numbers of:**				**Presence or Absence (+/-)**	
		Open garbage collection points	**Open *nullahs***	**Open sewers**	**Dumping sites**	**Stray dogs**	**Rats**

‘Health’ watch…

for good health

INTRODUCTION:

The subject of "health" is of concern to all. Several strategies are adopted from time to time, both at the global and national levels, to promote health. Advances in sciences, especially biological sciences, have created a new awareness about health at the global level, and the focus has clearly shifted from clinical and curative approach to one encompassing preventive and sociological aspects.

An important aspect of our education at the college and school level is to make students aware of the various scientific concepts concerning health and the close linkages between our environment and health. This is particularly important in India since our record in the control of diseases (especially communicable and environment related diseases, and in improving nutrition) has been unimpressive. In indices like child-mortality, we rank with the least developed countries. The DALY loss (DALY=Disability-Adjusted Life Years is a global unit which measures productivity losses due to morbidity, including injuries and illnesses, and mortality due to premature deaths) in India caused by communicable diseases is high even among the developing countries of the world. Variety of gastro-intestinal infections, respiratory diseases, including tuberculosis and pneumonia, malaria, dengue and several other insect-borne diseases continue to claim millions of lives every year. Globally, our health status, especially with respect to the incidence of the above-mentioned diseases, ranks next only to sub-Saharan African countries. China, which has a greater population than that of India, and nearly comparable incomes (GNP), has achieved a remarkable degree of progress in the control of communicable diseases. (Refer DALY chart– Appendix 6**)**.

A major factor for this seems to be insufficient awareness among our masses, including the educated, as to how the policies and practices based on relevant scientific knowledge have been used by other countries to improve their health

standards during the last century. Sensitising the next generation to important health and environment issues is essential to improve our standards of hygiene and public health measures. This would include improving the quality of our air, water and soil, including, sanitation and scientific management of waste, housing for the poor and other related aspects.

In recent years, contrary to adopting a holistic and preventive approach to health, there has been a heavy reliance on curative aspects of health. The preventive approach to environmental health becomes more relevant, since the health and urban planners and policy makers have recognised that health cannot be divorced from environmental and social factors. J.M. Last (1983), a pioneering epidemiologist, in the Oxford Dictionary of Epidemiology, describes three distinct levels of prevention: (i) Primary prevention is defined as the promotion of health by personal and community efforts; (ii) Secondary prevention is defined as measures available to individuals and populations for the early detection and prompt effective intervention to correct treatment; (iii) Tertiary prevention consists of measures available to reduce impairments and disabilities, minimize suffering caused by existing departures from health.

With this background information, it is apparent that health of a population or society, as influenced by environment, is a complex concept to monitor. Besides causing deaths, the different environmental agents can cause sickness and variety of diseases. These diseases may occur immediately on exposure to these agents, within a few minutes, hours or a few days, as in the case of several gastro-intestinal problems and some respiratory infections. Alternatively, diseases due to polluted environment may show up only after a long time, as in several cardio-vascular problems and cancers of skin, blood and lungs.

Incidence of only certain environment-related diseases and their accompanying symptoms occurring over short time periods will be considered in this programme. There will be survey-based activities, wherein students will be approaching medical set ups, both in private and public sectors, to collect data about the presence or absence of specific diseases. This is a

'passive' approach of data collection. Students will also be conducting 'active' door-to-door surveys about the symptoms (diseases). To further validate their findings, students will also collect data of the above plus the mortality (deaths) due to these diseases from their local municipalities. Besides the absence or presence of diseases, and their symptoms, the data will include mortality caused by these diseases.

Malaria remains one of the biggest killers in our country, perhaps next only to tuberculosis. This disease also causes great economic loss in the country as millions, especially the young and employed, get affected. The parasite, *Plasmodium,* causes the disease, and these parasites complete their complicated life cycles in two hosts: the mosquitoes and a mammal, which can be humans or cattle. Female mosquitoes of the genus, *Anopheles,* transmit the parasite (disease) by biting the mammal when sucking the blood meal. Simultaneously, the parasites are released in the blood stream.

Malaria, among other vector-borne diseases, has been singled out here for three reasons: its origins lie in wet tropics (often unhygienic environment), the disease has staged a comeback in recent years in several parts of the country and its spread is accelerated by continuing migrations of peoples from endemic to non endemic areas. The incidence of malaria will increase greatly in the future as more and more people from villages migrate to urban areas and then again travel to rural areas, and also due to disturbed ecology. However, the disease has been nearly wiped out in several tropical countries by adoption of stringent water management techniques, including removal of all potential breeding places of the mosquito. This has been done with active co-operation of the people and educational advisories.

Let us prevent mosquito-borne diseases, like malaria. Let us be active partnrs in the "Roll back malaria" project of the World Health Organisation, which aims by 2010 to reduce the number of malaria cases. On one hand, scientists all over the world are working on different strategies, including several molecular approaches, to kill the parasites in the blood stream; on the other

hand, public health experts advocate tracking of mosquitoes, and other methods for eradicating mosquitoes.

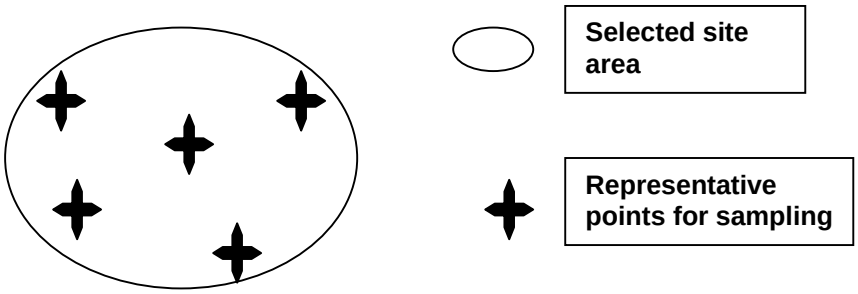
Malaria Research Centre, Delhi, has categorized malaria into five types, all due to human activities: (i) disturbed ecology in forest areas leads to tribal malaria; (ii) irrigation malaria strikes in areas with irrigation projects; (iii) urban malaria occurs due to presence of stagnant pools of water providing breeding places for mosquitoes; (iv) industrial malaria has rendered areas of the Punjab and Harayana endemic to the disease; (v) migration malaria occurs when there is large scale migration of people from endemic to non endemic areas. In reality, there may be a combination of factors leading to the spread of this disease. For instance, both migration and breeding places in urban areas (like Mumbai and Navi Mumbai) may lead to endemicity of the disease. This understanding should help in working out the few activities for malaria.

Equipped with two data sets, one of environment indicators and the other about health, students can search for correlations between the two, if possible. In addition, urban and rural profiles, both for environment and health, could also be prepared.

Focused programs on health and environment education are an important intervention, with student body playing a pivotal role in imparting and promoting scientific understanding about close linkages between health and environment.

SITE SELECTION:

The area for study could be a municipal ward, city, city-nodes or even a group of streets. In addition, health surveys need to be also carried out in rural areas. However, the chosen area for survey of health indicators should be the same as the one studied for different environmental indicators. The sampling should be representative of the entire study area, as shown in the figure.



Experimental procedure:

Two types of surveys will be carried out: Active (door-to-door) and passive surveys in medical set ups (Health Worksheets: HWS: Activity 1 and 2). These surveys would bring out the incidence of some symptoms (and diseases), which are linked or get aggravated due to different environmental pollutants.

The symptoms (diseases) surveyed in this program are mainly those which appear in a few hours or in one or two days, after the initial exposure to the environmental pollutant. (This could be contaminated air, water or food or even unhygienic habits.)

In this survey, the following situations are <u>not included:</u>

- Symptoms (diseases) caused by pathogens, which have long-term incubation periods (of about one week and more).
- Diseases due to long-term exposure to environmental pollutants like heavy metals.

- The timing of carrying out health surveys needs special attention. Activity 1 should be carried out within a week's time following the environmental surveys of a given site area. (For instance, if water and air quality are being checked on the 5th of February, then the health surveys should be on or before 10th of February, i.e., after 3-4 days of exposure to a pollutant. (For details, see under specific activities.)
- In the surveys, care has to be taken to question the residents about the onset and durations of a particular symptom (disease), during or a couple of days after the environmental surveys.

- Some preplanning would be needed for selection of medical set-ups for Activity 2. The set ups should be those frequented by the participating residents of Active survey (1). This information is also obtained from the Active survey itself. (The Health Dept. of Municipality will be requesting the doctors for cooperation in this study.)
- A copy of the data sheet (HWS: Activity 2) will also be filled out by the doctors, to validate the findings of the students. This data sheet is identical to the one used in Activity 1.
- Another level of validation will be made from the data obtained from the Health Dept. of the local municipality.

ACTIVE SURVEY: Activity 1

1. For this survey, students will have to work in groups of two's or three's.
2. Study well the survey sheets, before approaching any household.
3. The methodology of active survey involves visiting representative individual households in the study area (figure1).
4. In the worksheet, first enter the details of the address of the house. This will be the key no. to identify the surveyed resident. The key number should include: sector details, building number, flat number, and the number of family members. (Sec\Bldg no.\Flat no.\No. of members---9\JN1\42\4.) Alternatively, make your own key for correct identification of residence.
5. Briefly, explain the purpose of the survey to the householder.
6. Obtain the no. of family members and their approximate ages.
7. Find out <u>how many</u> are/were affected with any of the listed symptoms\diseases since the week before the house visit.
8. Next, note the symptoms and other related information, such as the date of onset, duration, treatment (yes/no) and outcome of treatment (recovered, still sick, etc) in the health work sheet (HWS: 1).
9. Make a provisional diagnosis, if possible, from the symptoms. An educated householder could also make this diagnosis.

10. Information about the doctor visited by the affected is essential. This entry should guide the students correctly to the doctors\medical set ups to be approached for carrying out the passive survey.
11. The same work sheet as used in active survey is issued to the doctors for entry. Fill out the details in the HWS: Activity 1.

This active door-to-door survey can provide accurate information about the health profile of individuals surveyed. This has to be carried out both in urban and rural areas.

PASSIVE SURVEY: Activity 2

The door-to-door survey is further supported / validated by Activity 2, taken from medical set ups.

1. The data worksheet (activity 2) should be given to the doctors right on the first day of the survey when the env. study is started. Groups of two to three students will visit the out-patient departments (OPDs) of public hospitals and spend 1-2 days with the concerned doctors. Alternatively, private doctors may also be contacted.
2. Students may also have to visit the doctors on the last two days of the survey, after identifying the different medical set ups frequented by the people of the study site {obtained from Activity 1 (i)}.
3. Care should be exercised when choosing the medical set ups. These set ups should be frequented by those people in the area, where the environmental data has been simultaneously collected. In other words, the people covered in the Active Survey—Activity 1 (i) —should have visited these medical set-ups.
4. Accordingly, decide on the public and private medical setups from where the health data will be obtained. This may require some prior planning, preparation and permission of the Dean/Doctors by your teachers/ Municipalities.
5. With the help of the doctor, students will be filling out the work sheet. This worksheet is the same one as used in Activity 1 (i).

(HWS: Activity 2).

6. Along with patient details (key no), age and sex, symptoms, provisional diagnosis of different diseases, under the category of gastro intestinal (GI), respiratory diseases (RD) and vector borne diseases (VBD) will be entered by the doctor as per visits of patients.
7. Collect data of any deaths (mortality) for the listed diseases for the survey period (check the dates).
8. Local municipal public health department or ward office may also be approached for this.

MALARIA AND INSECT BORNE DISEASES: Activity 3 to 7

In recent years, malaria (and other vector-borne diseases, such as dengue) has staged a comeback in the country, including in Navi Mumbai and Mumbai, due to a variety of reasons. Some of these are: the resistance developed by the parasites against various anti-malarial drugs, emergence of insecticide-resistant mosquitoes, reduction in the use of DDT, and a casual attitude of the populace to dirty environment. The disease spread is further accelerated by continuing migrations (movements) of peoples from endemic to non endemic areas and vice versa.

A few activities are included to give a scientific understanding about the spread of the disease: how the mosquitoes multiply, i.e., their life cycle, their potential breeding places, and mapping these places.

It is important to remember that mosquito breeding is seasonal, with increase in numbers observed during the winter months. This point is to be remembered when checking for the potential breeding places. The same place may give varied results at different times so the year. The real solution to the problem is removal of these potential breeding places.

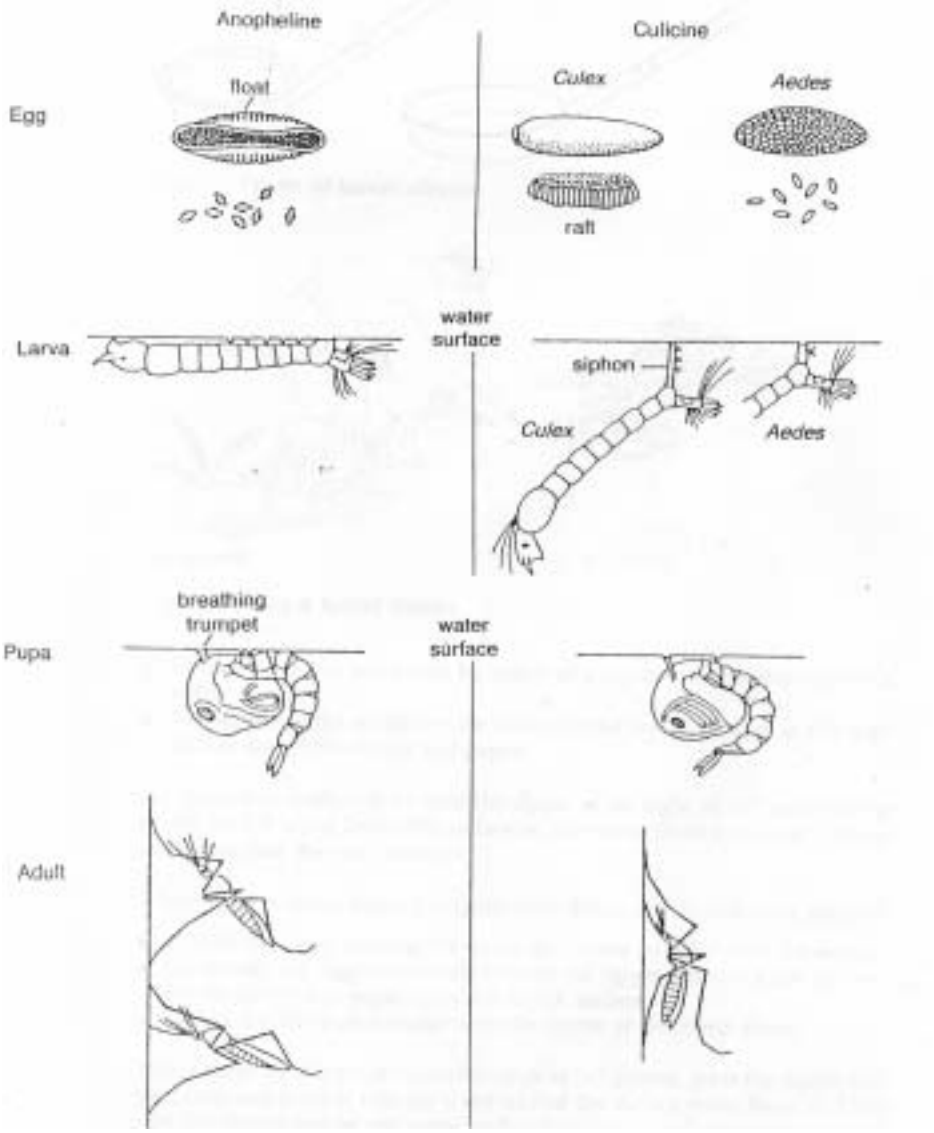
LIFE CYCLE OF MOSQUITOES: Activity 3

Experimental procedure:

1. Get blood fed female mosquitoes (when you see a mosquito, catch it with a test tube). Turgid and dark abdomen is an indication of blood fed females (gravid).
2. Once a gravid female is caught with the test-tube, transfer it to a bottle containing dilute yeast solution, preferably 100 ml of 0.1% yeast solution (about two to three yeast granules in 100 ml of water). Yeast serves as a source of food for emerging larval stages.
3. Cover the bottle with a net or thin muslin cloth.
4. Within two to three days, the females will lay eggs in the form of a raft. One female can lay more than one egg raft. (The time taken by females to lay eggs is variable, depending on seasons and salinity of water. In winter months, egg-laying may be after four to six days after capture in the bottle. Factors like humidity and temperature affect the ovi-position and the survival of larvae and pupae.) Eggs may be very tiny if the females are not well fed.
5. Each egg raft contains about 50 to 400 eggs. Transfer the egg rafts in a shallow tray of water + yeast. Keep the tray open.
6. Four different larval stages will emerge. This development period takes about 10-12 days. First instar larvae: 24-28 hrs; second instar larvae: 26- 32 hrs; third instar larvae: 28-35 hrs and the fourth instar larvae: 52-68 hrs.
7. In this above period, change the tray water by carefully transferring the larvae back and forth (with a dropper, pick up the larvae and transfer them into a bottle containing little water.) Remember to add the yeast in proper concentration in the fresh water.
8. Transfer the larvae back into the tray.
9. Pupal stage will emerge from the moulting of the fourth larval instar. Pupae are comma shaped. (One pupa from one larvae)
10. Pupae are non feeding and this is a short transient phase of about 1-3 days. (Males emerge in one day and females later.)

11. Once the pupae emerge in the tray, transfer them with a dropper in a bottle containing water and cover the bottle.
12. Mosquitoes will emerge from the pupae after about 30—35 hours. Generally, one female gives rise to an egg raft of about 100 eggs, 100 larvae, 100 pupae, and 100 adults.
13. Based on your observations, draw the complete life cycle of a mosquito, with figures and appropriate labels (HWS: Activity 3).

In our region, there are three major types of mosquitoes: *Anopheles* causing malaria, *Aedes (aegypti*) causing dengue and *Culex* forms, which are mostly nuisance mosquitoes. The accompanying figure brings out the major differences between anopheline and culicine life cycles.



Life cycles of mosquitoes

POTENTIAL BREEDING PLACES OF MOSQUITOES: Activity 4

Mosquitoes live and multiply (breed) in a variety of places, especially places, which hold water. These range from still—stagnant-- pools of clean water, slow (sluggish) moving streams and edges of water holding places, water drums, old tyres or any containers which could hold some water, even tree holes. The rate of multiplication of mosquitoes differs in different seasons, depending on temperatures and the availability of breeding places. Hence, the breeding potential, active breeding and density of larvae is constantly fluctuating. But it is important that one becomes aware about these breeding places. Elimination of these places could go a long way in our fight against malaria and other vector-borne diseases, including dengue. Mosquitoes travel long distances and travel in lifts, too!

Experimental protocol:

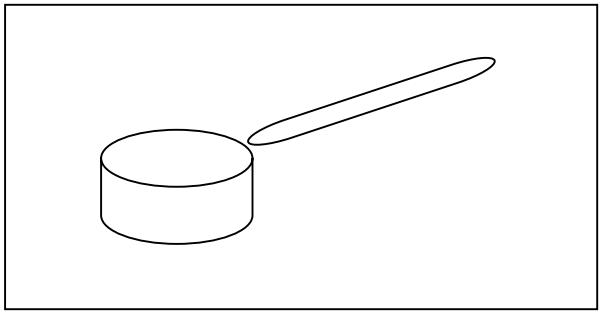
1. This survey too, has to be conducted during Activity 1.
2. Take a rough survey of the study site.
3. Try to identify the potential breeding places of mosquitoes in and around houses in the selected site. Check out different items and places, howsoever insignificant they might appear.
4. These data could be obtained when students are checking up for symptom surveillance {Activity 1 (i)}. Residents could be specifically asked for the absence or presence of different items, as listed in Activity 4 (i).
5. Try to cursorily check for at least one or two potential breeding places <u>in</u> homes. Students could request to see vases, tanks, pots, etc, as listed in HWS: Activity sheet 4 (i).
6. Check for the presence of mosquito larvae.
7. Next, check <u>around</u> the homes for potential mosquito breeding places as listed in Activity 4 (ii).
8. Make your observations in Activity 4 (ii).
9. Note the action suggested /taken on identification of a breeding place—HWS: Activity 4 (I and ii).

MOSQUITO LARVAL SURVEY: Activity 5

Different breeding places of mosquitoes have already been identified. For mosquito larval surveys, there is a method for collecting water samples.

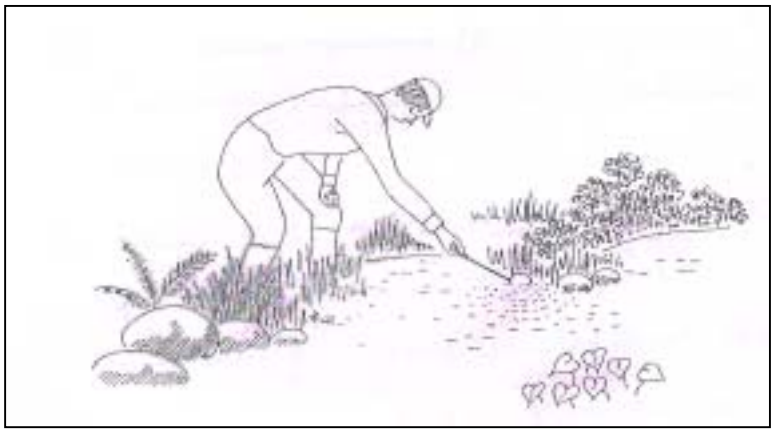
Collect the larvae with a pipette (fixed to a teat/ rubber bulb). Transfer the larvae to clear bottles and observe them.

Alternatively, use a dipper, which is like a saucepan with a long handle.



Hold the dipper at an angle of 45^0 and gently lower it just below the water surface. Allow water to flow into the dipper along with larvae/pupae.

When one is collecting the water sample from a place with dense vegetation or floating debris, first disturb the water surface with the dipper. This causes the larvae and pupae to slightly sink below the surface. Clear all the debris\ vegetation with the dipper. Slowly the larvae will resurface. At that time, collect these larvae along with the water sample with a smooth long sweep of your hand.



Experimental procedure:

Collect water samples from some of the potential breeding places, identified in Activity 4 (i) and (ii). Fill out the worksheet (HWS: Activity 5).

MAPPING THE BREEDING PLACES OF MOSQUITOES: Activity 6

It is important to know and have a pictorial representation of the areas where mosquitoes breed. This can lead to elimination of these breeding places by public health officials and by citizens' involvement, too. At some places, remote sensing techniques are employed to track the breeding sites. Later computers interpret these images as maps with colours.

Here an attempt will be made to 'map' the study site and locate the breeding sites.

Experimental procedure:

1. Get a rough estimate about the dimensions (length, overall area) of the study site in metres. Refer to the maps of your city/node/district.
2. Say, a street , circular or linear, of about 30 square metres is the study site.
3. Locate a few landmarks, and the four directions (N, S, E, W). Map the study site by using an appropriate scale (say, 1 cm square = 1 metre). Indicate the scale on the face of the map as a line –scale.
4. Draw the study site with reference marks and directions.
5. Locate (at least ten) larvae breeding points on the scaled up map. Use appropriate symbols for the landmarks, breeding places and other relevant details.
6. Label and indicate the symbols on the face of the map.
7. These breeding points could be shallow pits, old tires in a side street, or construction sites (HWS: Activity 4).
8. Use fresh worksheets if uncomfortable with the small boxes (Activity 6).

SUPERIMPOSING THE DATA OF MOSQUITO BREEDING PLACES AND DISEASE INCIDENCE: Activity 7

Here an attempt is made to establish the burden of one communicable vector-borne disease, i.e., malaria, in a given area. This involves: (i) identifying and plotting the distribution of vector breeding points and (ii) confirmed (incidence) cases of malaria in a given area, and superimposing these two sets of data. This should bring out the correlation, if any, between disease incidence and the prevailing environment (mosquito breeding spots).

Experimental procedure:

1. Refer to the number of people affected with malaria (positive cases) and the location of their residences (Activity 6).
2. Data about mosquito breeding places are also obtained (Activity 4 (i and ii).
3. Plot the data about malaria incidence on a map of the area.
4. Superimpose (overlay) the two maps –breeding sites and disease incidence—over each other. Check for correlation between the two.

Health Worksheets

Activity 1: Door-To-Door, Active Survey

Site details: **Date:**

Sr. no.	Occupants' details			Symptom-based surveillance							
	Key no. Sec\Bldg no.\Flat no.\No. of members	No. of members sick	Age of the sick*	Symptoms**	Date of onset	Duration of illness	Symptom based provisional diagnosis***	Treatment		Final diagnosis	Outcome R: recovered A: ailing D: death
								Y\N	Doctor consulted where?		

Symptoms**

Fever Head ache Vomiting Loose motions Stomach ache \ cramps Watery stools Mild diarrhoea Black stools with mucous Nausea Yellowish discolouration of urine\sclera	1
Head ache Skin rash/ itching Watering/irritation/redness of eyes Loss of sleep Cough and cold Breathlessness Giddiness Chest pain	2 & 3
Fever Fatigue/malaise Chills/shivering Body pains Loss of weight/appetite	4

Dog/Rat bites

Talking loudly, ringing in the ears, unable to hear specific sounds like S, Ch /Others

Provisional diagnosis:***

1

Acute diarrhoea

Acute gastro enteritis (including cholera)

Hepatitis A\E

Entric fever (typhoid)

2

Upper respiratory tract infections (URTI)

Acute tonsillitis

Acute pharyngitis

Rhinitis

3

Lower respiratory tract infections (LRTI)

Pneumonia

Pulmonary tuberculosis

Environmental asthma

Allergic dermatitis

4

Malaria, Dengue

Insect/Rabies/Dog bites

Noise induced hearing loss

Others

Code*	Age (in years)
A	At birth
B	0-5
C	5-14
D	14-30
E	30-60
F	60-80
G	80+

Activity 2: Passive Survey At Medical Set Ups

Site details: **Date:**

Sr. no.	Occupants' details			Symptom-based surveillance							
	Key no. Sec\Bldg no.\Flat no.\No. of members	No. of members sick	Age of the sick*	Symptoms**	Date of onset	Duration of illness	Symptom based provisional diagnosis***	Treatment		Final diagnosis	Outcome R: recovered A: ailing D: death
								Y\N	Doctor consulted where?		

Symptoms**

Fever
Head ache
Vomiting
Loose motions
Stomach ache \ cramps
Watery stools
Mild diarrhoea
Black stools with mucous
Nausea
Yellowish discolouration of urine\sclera

1

Head ache
Skin rash/ itching
Watering/irritation/redness of eyes
Loss of sleep
Cough and cold
Breathlessness
Giddiness
Chest pain

2 & 3

Fever
Fatigue/malaise
Chills/shivering
Body pains
Loss of weight/appetite

4

Dog/Rat bites

Talking loudly, ringing in the ears, unable to hear specific sounds like S, Ch /Others

Provisional diagnosis:***

1

Acute diarrhoea
Acute gastro enteritis (including cholera)
Hepatitis A\E
Entric fever (typhoid)

2

Upper respiratory tract infections (URTI)
Acute tonsillitis
Acute pharyngitis
Rhinitis

3

Lower respiratory tract infections (LRTI)
Pneumonia
Pulmonary tuberculosis
Environmental asthma
Allergic dermatitis

4

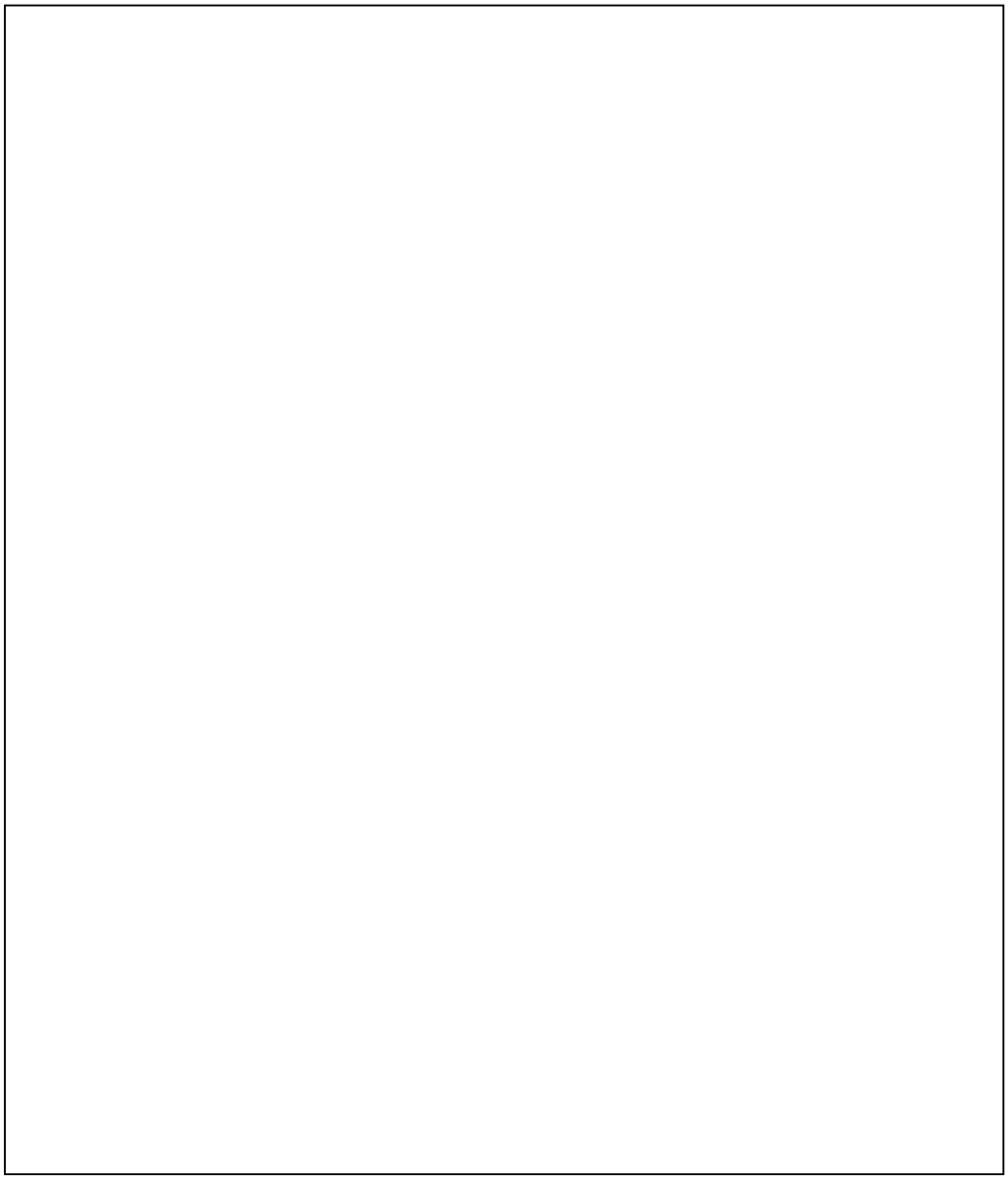
Malaria, Dengue
Insect/Rabies/Dog bites

Noise induced hearing loss
Others

Code*	Age (in years)
A	At birth
B	0-5
C	5-14
D	14-30
E	30-60
F	60-80
G	80+

Activity 3: Life Cycle Of Mosquitoes

Plan the experiment in advance by following the experimental protocol. Observe the life cycle of mosquitoes and draw the different stages with labels.



Activity 4: Potential Breeding Places Of Mosquitoes

Identify different potential breeding points/places in the selected area. Note the type of breeding points: permanent : ponds, nallahs, water tanks (overhead and underground); transitory: water-drum; flower pots, stagnant pools, etc.

Date: **Details of the study site:**

Mark the area of study as: residence: ____, industrial:____, public space:____, other_____.

(i) Potential mosquito breeding places inside homes (in your societies)

Key No.	Type of breeding points in (and around) residential premises											
	Water tank Loft Overhead Under-ground			Water drum			Flower pots			Potted plants (with plates)		
	Nos.	Presence of larvae (+\-)	*Action suggested \taken	Nos.	Presence of larvae (+\-)	*Action suggested\ taken	Nos.	Presence of larvae (+\-)	*Action suggested\ taken	Nos.	Presence of larvae (+\-)	*Action taken

***Action suggested/ taken: E=emptied; C=cleaned; El= eliminated**

(Ii) Potential mosquito breeding places in open public spaces

Study-site name	Type of breeding point															
	Puddles (B-*Big S-Small)			Construction sites			Nullahs			Tyres			Water bodies			Others
	Nos.	Presence of larvae (+\-)	Action suggested \ taken**	Nos.	Presence of larvae (+\-)	Action suggested\ taken**	Nos.	Presence of larvae (+\-)	Action suggested\ taken**	Nos.	Presence of larvae (+\-)	Action suggested\	Nos.	Presence of larvae (+\-)	Action suggested\ taken**	

***Big – Puddle area larger than 30 cm^2**

****Action suggested / taken: E=emptied; C=cleaned; El= eliminated**

Activity 5: Mosquito Larval Survey

Date: **Site details**

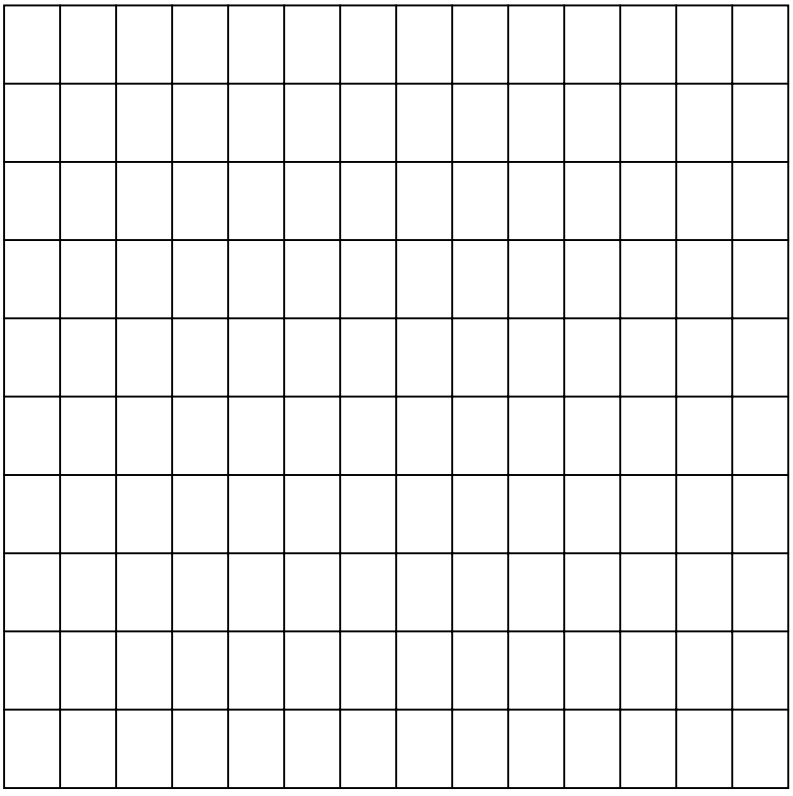
Location	Type of breeding places	No. of places checked	Larvae observed per dip/sweep	Action suggested/taken

Comment:

Activity 6: Mapping The Breeding Places Of Mosquitoes

Locate at least ten potential breeding points on a map of the study site.

Out line map of the study area

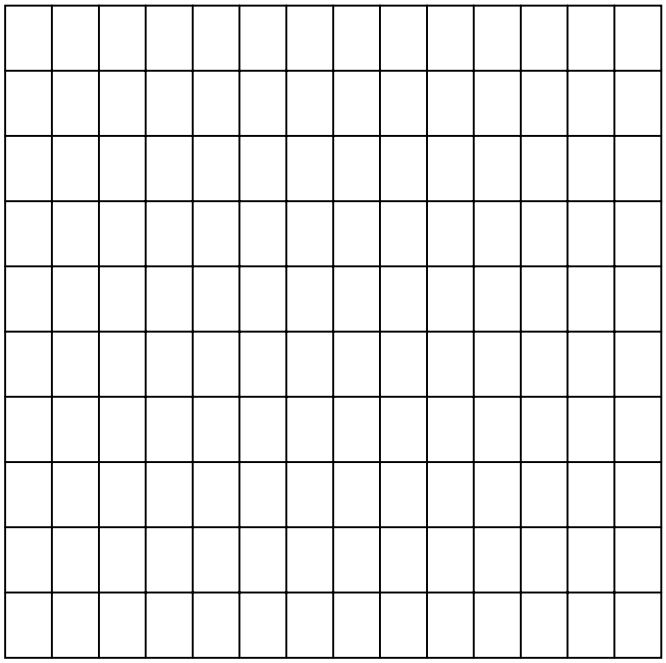


Map of the study site showing potential breeding places.

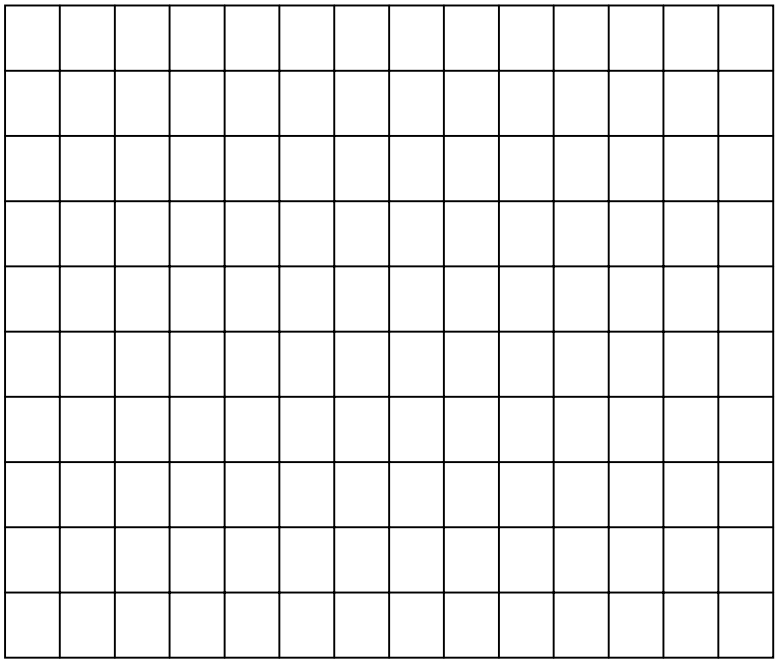
Activity 7: Overlay Two Sets Of Data On A Map -- the malaria distribution and the mosquito breeding places

(i) Plot the distribution of confirmed malaria cases on the map of the selected area (refer to Activity 6). Use different colours to indicate zones of high, medium and low incidence. Provide a proper key for the map.

Out line sketch of the selected area.



(ii) Super-impose the two maps over each other: one of breeding places (Activity 6) and the other of disease-distribution.



Appendix 1

PREPARATION OF SOLUTIONS

CONDUCTIVITY:

0.01M standard potassium chloride solution:

Dissolve 74.56 mg of anhydrous potassium chloride in 10 ml distilled water. Make the volume to 100 ml. store the solution at 25^0C.

ALKALINITY:

0.02 N standard H_2SO_4:

Dilute 2.8ml of conc. sulfuric acid to 1 liter of distilled water to form 0.1N sulfuric acid. Standardise this solution against 0.1N sodium carbonate.

> For standardization of 0.1N H_2SO_4, take 50ml of 0.1N sodium carbonate in a conical flask and add 2-3 drops of methyl orange. Titrate against the 0.1N sulfuric acid solution taken in a burette. The end point is the colour change from yellow to orange.

Use appropriate volume of 0.1N sulfuric acid and dilute to 100 ml using distilled water to prepare 0.02 N sulfuric acid.

1N sodium carbonate solution:

Weigh accurately 13.25 gm of anhydrous sodium carbonate and dissolve it in distilled water. Make up the volume to 250 ml in a volumetric flask.

0.02N sodium hydroxide solution:

Dissolve 0.08gm of sodium hydroxide in 100ml of distilled water.

Phenolphthalein indicator:

pH 8.3 indicator solution. If the solution is not available, dissolve 0.5 gms of phenolphthalein in 50 ml of 95% methyl alcohol. Add 50 ml DW, 0.02 N NaOH dropwise till faint pink colour appears. Store in a dark bottle.

Methyl orange indicator:

Dissolve 0.1gm of methyl orange in 50ml-distilled water and dilute to 200ml with distilled water.

DISSOLVED OXYGEN:

Manganese (II) sulphate solution:

Dissolve 100 gm of $MnSO_4.4\ H_2O$ in 200 ml of freshly boiled distilled water, filter if necessary after cooling.

Akaline potassium iodide- azide reagent:

- Dissolve 50 gm of sodium hydroxide pellets and 15 gm of potassium iodide salt in distilled water.
- Dissolve 2.5 gm of sodium azide salt in 10 ml of distilled water.
- Mix the above two solutions and dilute it to 100 ml.

Sulphamic acid:

This is a solid salt and is used in that form.

Starch solution:

Prepare a paste of 2.0 gm of soluble starch powder and 0.2 gm salicylic acid (preservative) in distilled water. Pour this paste to 100 ml boiling water. Heat the solution to boil. Cool and then use.

Sodium thiosulphate solution :

Dissolve 6.21 gm of $Na_2S_2O_3\ .\ 5H_2O$ in freshly boiled and cooled distilled water. Make up the volume to one litre. Keep the solution in a dark coloured bottle after adding a pellet of sodium hydroxide as a stabilizer.

BIOCHEMICAL OXYGEN DEMAND:

All reagents used in determination of dissolved oxygen as discussed earlier.

BOD-free water:

Pass water through a column of activated carbon and redistill it. If this is not available, use double distilled water.

Phosphate buffer solution:

Dissolve 33.4 gm of disodium hydrogen phosphate and 1.7 gm of ammonium chloride in 500 ml distilled water. Adjust the pH to 7.2 and dilute to 1000 ml.

Magnesium phosphate:

Dissolve 22.5 gm of magnesium sulphate in 100 ml distilled water and dilute to 1000ml

Calcium chloride:

Dissolve 27.5 gm of anhydrous $CaCl_2$ in 100 ml distilled water and dilute to 1000ml.

Ferric chloride:

Dissolve 0.75 gm of ferric chloride in 50 ml distilled water and dilute to 1000 ml.

Preparation of dilution water:

First aerate BOD free distilled water in a glass container for about half an hour using an aerator. Add 1ml each of phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride solutions to 1000 ml of aerated distilled water.

Seeding mixture:

Supernatant from domestic wastewater after settling for at least one hour at room temperature. Add a fixed volume of 0.3 ml of this mixture per 300ml of sample

CHEMICAL OXYGEN DEMAND:

1N Potassium dichromate ($K_2Cr_2O_7$) **stock solution**:

Dissolve 24.5 gm of $K_2Cr_2O_7$ in distilled water and make the volume to 500 ml with distilled water.

0.25N Potassium dichromate solution:

Dissolve 250 ml of 1N $K_2Cr_2O_7$ in distilled water to make up to 1L .

1N Ferrous ammonium sulfate solution:

Dissolve 322.9 gm of $Fe(NH_4)_2$ (SO4). $6H_2O$ in distilled water and then add 20 ml of concentrated H_2SO_4 to it. Cool the solution, dilute to 1000 ml with DW, and store it in dark.

0.25N Ferrous ammonium sulfate solution:

250 ml of 1N FAS and make up the volume to 1000ml in volumetric flask. Standardize this against 0.25N potassium dichromate as described below.

Standardization 0.25 N FAS solution

Pipette 2.5 ml of 0.25N potassium dichromate solution into 250ml conical flask. Dilute to 25 ml with DW and add 7.5 ml of concentrated sulfuric acid. Cool to room temperature. Add 5 drops of Ferroin indicator and titrate against FAS solution. The end point is reddish brown.

$$N_1(FAS) = \frac{V_2(K_2Cr_2O_7) \times N_2(K_2\ Cr_2\ O_7)}{V_1(FAS)}$$

Ferroin indicator:

Dissolve 1.485gm of 1,10 phenanthroline monohydrate in 5-10 ml water; if the crystals do not dissolve add a few drops of concentrated hydrochloric acid. Next add 0.695 gm of ferrous sulfate and make the volume to 100ml with distilled water.

Mercuric sulfate

Crystals or powder of $HgSO_4$

Concentrated sulfuric acid.

CHLORIDES:

Potassium chromate indicator:

Dissolve 25 gm of potassium chromate in 100ml of distilled water and add silver nitrate solution till a definite red colour ppt is formed. Allow standing for 12 hours and filtering the solution. Dilute to 500ml with DW.

0.0282N Silver nitrate solution:

Dissolve 4.791 gm of silver nitrate in distilled water and dilute to 1000 ml. Standardize against 0.0282 N sodium chloride.

Standardization of silver nitrate:

Take 10 ml of sodium chloride solution in a conical flask and adjust the pH between 7.0 to 8.0 (either with NaOH or conc. H_2SO_4). Add 1ml of potassium chromate. Titrate this against silver nitrate until a brown ppt is formed. Find the normality of silver nitrate.

0.0282 N sodium chloride:

Dissolve 1.648 mg sodium chloride and dilute to 1000 ml.

Aluminum hydroxide suspension:

Dissolve 125 gm aluminum potassium sulfate or aluminum ammonium sulfate in 1 L distilled water. Warm to 60^0C and add 55 ml concentrated ammonium hydroxide slowly with stirring. Allow to stand for about one hour and transfer to a large bottle. Wash the precipitate by successive additions, thorough mixing and decanting with distilled water, until free from chloride ppt. Freshly prepared suspension occupies a volume of 1L.

AMMONIA:

Stock ammonium chloride (NH_4Cl) solution (100 ppm):

Weigh 38.2 mg of NH_4Cl salt and dissolve it in 100 ml distilled water.

10% solution of $ZnSo_4$. 7 H_2O:

Dissolve 10 gm of $ZnSo_4$. 7 H_2O in distilled water and dilute it to 100 ml.

6N solution of NaOH:

Dissolve 24 gm NaOH in distilled water and dilute it to 100 ml.

50 % solution of EDTA:

Dissolve 10 gm of NaOH in 60 ml of distilled water. Weigh 50 gm of EDTA and dissolve it in the 60 ml of NaOH. Cool and dilute the solution to 100 ml. (* if the EDTA does not dissolve keep adding NaOH pellets few at a time till the EDTA salt completely dissolves. This is because EDTA dissolves in water only at a particular pH of 8.5).

Nessler's reagent:

Dissolve 70 gm KI + 160 gm HgI_2 in distilled water. Add this mixture to cooled solution of 160 gm NaOH in 500 ml distilled water. Dilute to 1 liter. Keep the solution overnight. Store the supernatant in amber\ dark coloured bottle. Use the supernatant for the experiment.

FLUORIDES:

Stock sodium fluoride solution (100 ppm):

Dissolve 22.1gm of anhydrous sodium fluoride in 100 ml distilled water.

Fluoride standard solution:

Dilute 100 ml of stock solution to 1000ml in a volumetric flask, with distilled water.

Alizarin red solution:

Dissolve 0.7 gm of alizarin red S in 100 ml of DW.

Zirconyl acid solution:

Dissolve 0.45 gm of zirconyl chloride in 100 ml of distilled water

Sulfuric acid solution:

Add 70 ml of conc sulfuric acid to 700 ml of water in a beaker and cool the solution.

Mixed reagent:

Pour slowly alizarin red S to zirconyl acid solution and then add sulfuric acid. Make the volume up to 1000ml. Store in dark and use after 24 hours.

PHOSPHATES:

Preparation of standard phosphate solution (100 ppm):

Dissolve 14.3 gm of dried anhydrous KH_2PO_4 in distilled water and make up the volume to 100 ml.

Preparation of ammonium molybdate solution:

- Dissolve 31.4 gm of $(NH_4)_2Mo_4$ in 200 ml of distilled water.
- Add carefully 252 ml of concentrated H_2SO_4 to 400 ml of distilled water and cool. Add 3.4 ml conc. HNO_3
- Mix the above two solutions and dilute it to one litre with distilled water.

Preparation of stanous chloride solution:

Dissolve 2.5 gm of $SnCl_2.2H_2O$ in 100 ml glycerol by heating on water bath for rapid disolution.

IRON:

Preparation of stock iron solution (50 ppm):

Dissolve 35 mg of [$(NH_4)_2$ Fe $(SO_4)_2$. $6H_2O$] in distilled water and make up the volume to 100 ml.

10% solution of hydroxylamine HCl (NH_2OH):

Dissolve 10 gm of (NH_2OH) in distilled water and dilute to 100 ml.

Ammonium acetate buffer ($NH_2C_2H_3O_2$):

Dissolve 25 gm $NH_2C_2H_3O_2$ in 15 ml distilled water. Add 70 ml glacial acetic acid. The final volume will be slightly more than 100 ml.

Phenanthroline solution:

Dissolve 100mg of phenanthroline monohydrate in 100 ml distil water. Warm slightly or add 2 drops of concentrated HCL if necessary for complete dissolution.

COPPER:

Preparation of stock iron solution (200 ppm):

Dissolve 20 mg of copper metal salt in 10 ml distilled water. To this add 5 ml of concentrated HNO_3. (Exercise caution while handling acids.) The reaction is slow, wait for 10 minutes for completion of the reaction. Warm the solution gently for complete dissolution. Cool the solution in a water bath and add 50 ml water. Finally, dilute to 100 ml.

15% solution of citric acid:

Dissolve 15 gm of citric acid salt in 100ml of distilled water.

1% solution of sodium diethyl dithio carbamate:

Dissolve1 gm of sodium diethyl dithio carbamate salt in 100 ml distilled water.

1% solution of isoamyl acetate:

Mix one ml of isoamyl acetate solution in 99 ml of distilled water.

CHROMIUM:

Stock potassium dichromate solution (100 ppm):

Dissolve 28.26 mg $K_2Cr_2O_7$ in water and dilute to 100 ml with distilled water.

Standard Chromium solution :

Dilute 1 ml of stock chromium solution to 100 ml.

0.2N sulfuric acid:

Dilute 17 ml of 6 N H2 SO4 to 500 ml of distilled water.

Potassium permanganate solution:

Dissolve 4 grams ofKMnO4 in 100 ml distilled water.

Sodium azide solution:

Dissolve 0.5 grams NaN3 in 100 ml distilled water.

Diphenylcarbazide solution:

Dissolve 250 mg of 1,5-diphenylcarbazide in 50 ml acetone. Store in a brown bottle. Discard when solution becomes discoloured.

CALCIUM CARBONATES:

1N HCL:

Dilute 3.6 ml oh concentrated HCL in 100 ml of fresh diatilled water.

1N NaOH:

Dissolve 4 gm of sodium hydroxide pellets in 1000 ml fresh distilled water.

Bromothymol blue indicator:

Dissolve 0.1 gm of Bromothymol blue in 16 ml of 0.1 N NaOH and make up the volume with 250 ml distilled water.

Appendix 2:

MATERIALS AND APPARATUS

Apparatus:

U-shaped thermometer
Air suction pump
Whatman filters 0,1,2,4
pH paper
Alcohol thermometer
Sechi disc
Oven
Weighing balance
Colorimeter
Burners\UV hood
Digital probe thermometer
Infiltrometer

Glass ware:

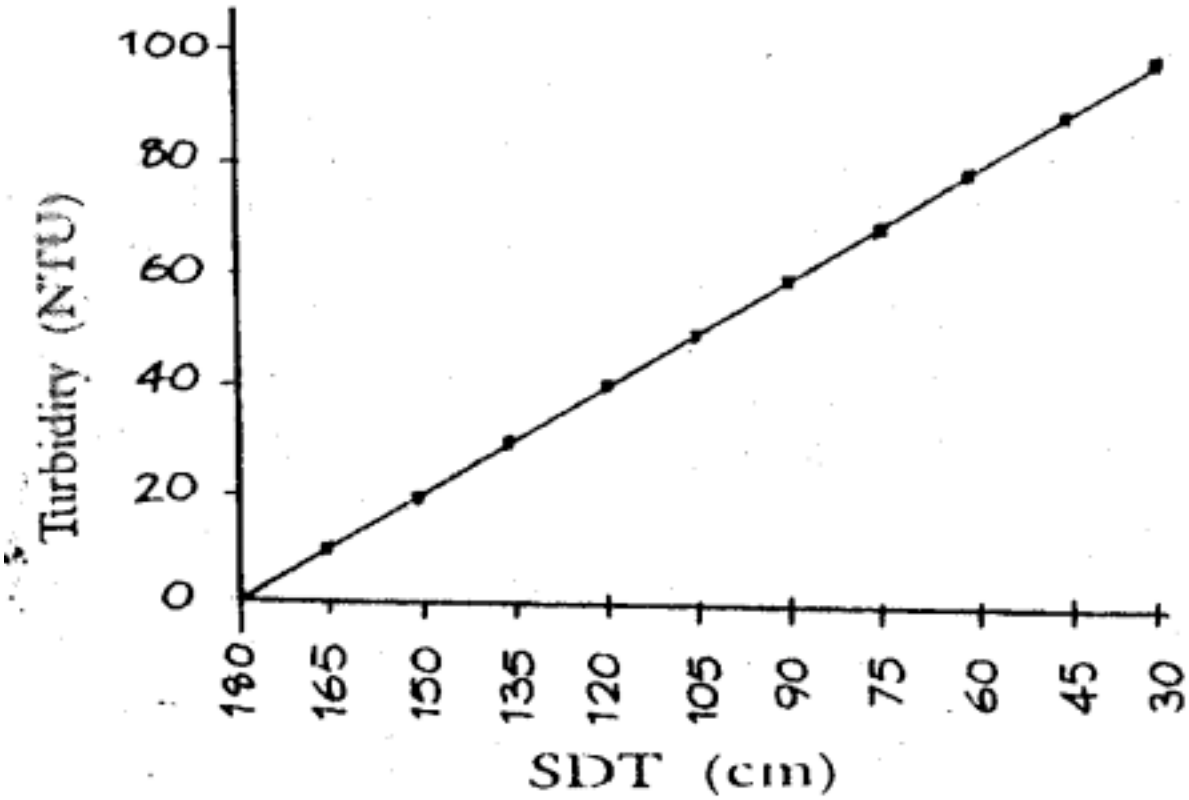
500 ml bottles with screw caps
Glass beakers
Glass funnels
Conical flask
Do bottle
Pipette
Dropper
Testtubes
Petriplates
Glass rods

Others:

A block of wood
Hammer
Wooden stick
Water:
Buckets
Rope
Sealing tape
Filter papers
Syringes Swabs
Garde trowels
Small spade
Water bottle
Plastic sheets
Nails\board pins
Measuring tapeWater proof markers
Garden clippers\tools
Bags

Appendix 3

CONVERSION CHART OF SDT TO NTU



Conversion chart (SDT to NTU)

Appendix 4

MOST PROBABLE NUMBER (MPN):

MPN of coliform bacteria present in 100 ml of water for different positive combinations.

Number of tubes giving a positive reaction out of:			**MPN index per 100 ml**
3 of 10 ml each	**3 of 1 ml each**	**3 of 0.1 ml each**	
0	0	1	3
0	1	0	3
1	0	0	4
1	0	1	7
1	1	0	7
1	1	1	11
1	2	0	11
2	0	0	9
2	0	1	14
2	1	0	15
2	1	1	20
2	2	0	21
2	2	1	28
3	0	0	23
3	0	1	39
3	0	2	64
3	1	0	43
3	1	1	75
3	1	2	120
3	2	0	93
3	2	1	150
3	2	2	210
3	3	0	240
3	3	1	460
3	3	2	1100
3	3	3	2400

Appendix 5

TAN SHEET:

Angle	Tan value		Angle	Tan value		Angle	Tan value		Angle	Tan value		Angle	Tan value
1	0.02		17	0.31		33	0.65		49	1.15		65	2.14
2	0.03		18	0.32		34	0.67		50	1.19		66	2.25
3	0.05		19	0.34		35	0.70		51	1.23		67	2.36
4	0.07		20	0.36		36	0.73		52	1.28		68	2.48
5	0.09		21	0.38		37	0.75		53	1.33		69	2.61
6	0.11		22	0.40		38	0.78		54	1.38		70	2.75
7	0.12		23	0.42		39	0.81		55	1.43		71	2.90
8	0.14		24	0.45		40	0.84		56	1.48		72	3.08
9	0.16		25	0.47		41	0.87		57	1.54		73	3.27
10	0.18		26	0.49		42	0.90		58	1.60		74	3.49
11	0.19		27	0.51		43	0.93		59	1.66		75	3.73
12	0.21		28	0.53		44	0.97		60	1.73		76	4.01
13	0.23		29	0.55		45	1.00		61	1.80		77	4.33
14	0.25		30	0.58		46	1.04		62	1.88		78	4.70
15	0.27		31	0.60		47	1.07		63	1.96		79	5.14
16	0.29		32	0.62		48	1.11		64	2.05		80	5.67

Appendix 6

A table showing distribution of DALY loss in some regions of the world, with emphasis on per capita health and public sector health expenditure

	SUB-S AFRICA	INDIA	CHINA	FSC	MDC
Total Population (m)	510	850	1134	346	798
Total DALY Loss (m) (1990)	293	292	201	58	94
DALD* loss/Person/Year	210	125	65	61	43
Days	150 / 60	63 / 62	16 / 49	5 / 56	4 / 39
Per capita health expenditure ($)	**24**	**21**	**11**	**142**	**1860**
Public sector health expenditure (%)	**55**	**22**	**59**	**71**	**60**

(○) **Due to Communicable Diseases** (□) **Due to Non-communicable Diseases/Accidents**

DALY = Present value of the future years of disability-free life that are lost due to:
(i) premature deaths; and
(ii) disability occurring in a particular year.

* DALD = Disability - Adjusted Life Day

$$DALD/Person/Year = \frac{DALY}{Total\ population} \times 365$$

DALD loss\Person\Year and other calculations computed from tables on pp 27 and 52 in Ref. 2 (see p 92)

Appendix 7:

ABBREVIATIONS

Abbreviation	Full form	Unit of:
Km	Kilometer	Length
m	Meter	Length
cms	Centimeters	Length
µm	Micro meter	Length
l	Liter	Volume
ml	Milliliter	Volume
µl	Micro liter	Volume
µ	Micron	Size
gm	Gram	Weight
mg	Milligram	Weight
µg	Microgram	Weight
mg\l	Milligram per liter	Concentration
µg\l	Microgram per liter	Concentration
ppm	Parts per million	Concentration
ppt	Parts per thousands	Concentration
N	Normality	Concentration
M	Molarity	Concentration
^{0} C	Degree centigrade	Temperature
Min	Minutes	Time
Sec	Seconds	Time
Db	Decibel	Sound
%	Percentage	

Abbreviation	Full form
UV	Ultraviolet rays (type of radiation received from the sun)
VOC	Volatile organic compounds
TPM	Total particulate matter
RPM	Respirable particulate matter
TSPM	Total suspended particulate matter
RSPM	Respirable suspended particulate matter
WS	Work sheets
SS	Soil work sheets
WWS	Water work sheets
AWS	Air work sheets
CPCB	Central pollution control board
Nos.	Numbers
DO	Dissolved oxygen
PVC	
ppt	Precipitate

:

Appendix 7 (cont)

Symbol\chemical formula	**Type of formula** **A:** atomic **M:** molecular	**Full form of the chemical**
N_2	M	Nitrogen
O_2	M	Oxygen
Ar	M	Argon
NO_x:	M	Nitrogen oxides
Cu	A	Copper
HNO_3	M	Nitric acid
$Cu(NO_3)_2$:	M	Copper nitrate
H_2O	M	Water
NO_2	M	Nitrogen dioxide
NH_4Cl	M	Ammonium chloride
NH_3	M	Ammonia
Cl_2	M	Chlorine
H	A	Hydrogen
FeS	M	Ferrous sulphide
H_2SO_4	M	Sulphuric acid
$FeSO_4$	M	Ferrous sulphate
H_2S	M	Hydrogen sulphide
CO_2	M	Carbon dioxide
SO_x	M	Sulphur oxides
NO_x	M	Nitrogen oixides
HCl	M	Hydrochloric acid
NaCl	M	Sodium chloride
CO	M	Carbon monoxides
SO_2	M	Sulphur dioxide
SO_3	M	Sulphur trioxides
NO	M	Nitric oxide
$Mn(II)SO_4$	M	Manganese sulphate
KOH\KI	M	Alkaline iodide solution
KOH	M	Potassium hydroxide
KI	M	Potassium iodide
NH_2SO_3H	M	Sulphamic acid
$Na_2S_2O_3$	M	Sodium thio sulphite
I^2	M	Iodine
NaN_3	M	Sodium azide

Air watch...

Water watch...

Soil watch...

Green watch...

Waste watch...

Health watch...

APPENDIXES

Air Worksheets

Water Worksheets

Soil Worksheets

Green cover Worksheets

Waste -management Worksheets

Health Worksheets