

POLLUTION ACTIVITIES

What's in the Air?

Currently, in India, air pollution is a major problem in urban areas. Vehicles are the major contributors to this. At the all-India level, the percentage of motor vehicles has increased from 0.3 million in 1951 to 37.2 million in 1997. Industries also contribute. Highly air-polluting industries include integrated iron and steel, thermal power plants, cement, oil refineries, petrochemicals, pesticides and fertilizers unit. Sometimes, these units are located in urban densely populated areas, thereby affecting large number of people.

Objective

To help students understand the extent of air pollution around us.

Activity

- 1) Ask the students to take two sheets of white paper and smear them with petroleum jelly on one side. They could try this either at home or at school.
- 2) Place these sheets on a window sill, or paste them on the outer wall of the building next to each other (side by side). The side with the jelly should be exposed.
- 3) Ask them to take in one sheet at the end of one day and to observe how dirty it looks compared with any other clean sheet.
- 4) Keep this dirty sheet in a safe place (for e.g. in a paper bag or between two blank/plain paper).
- 5) Take the other sheet in after a week. Ask the students to compare it with the first sheet. Is it dirtier than the first one? What does this suggest? How dirty is the air in their neighbourhood?

Discuss which of the six pollutants they think is responsible for most of the pollution in the neighbourhood? (See page 200 for 'Air Pollutants: Sources and Effects')

Extension/Variation

Different students of the class could perform this activity in their neighbourhood and compare their observations. Which area/locality is more polluted? Why?

Subject

Social Science, Science

Place

Outdoor

Duration

30 minutes and actual survey time

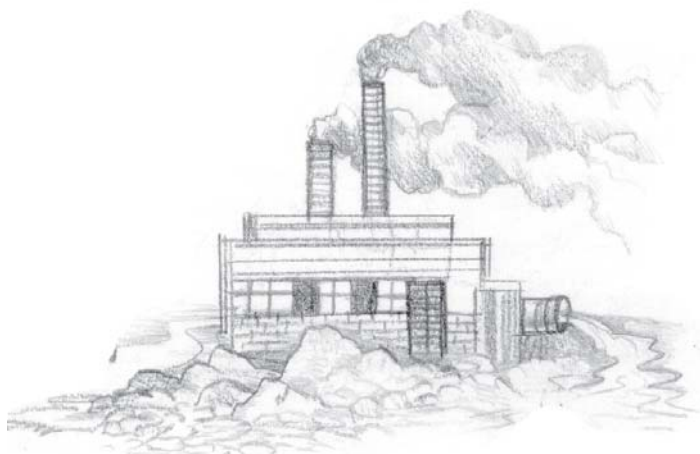
Group size

Entire class

Materials

White sheets, petroleum jelly

Ask the students to collect leaves from different location, from gardens, streets, a wooded forest, school campus, any industrial site. Ask them to compare the dust accumulated on these leaves by observing the colour or the dust and its thickness by wiping it with finger. If there is any difference, they should try to find out the reason.



Over the last few decades, there has been a significant increase in the generation of solid waste and garbage. The example of Mumbai is a case in point. The population of Mumbai increased from around 8.2 millions in 1987 to 12.3 millions in 1991, a growth of around 49 per cent. The waste generation however grew from 3200 tonnes per day to 5355 tonnes per day in the same period, a growth of around 67 per cent. This clearly indicates that the growth in waste generation in our urban centres has outpaced the growth in population in recent years. The reasons for this could be changing lifestyles, food habits and change in the standard of living. This could be understood by analyzing the characteristics of the solid waste generated. The characteristics of solid waste collected from any area depends on a number of factors such as food habits, cultural traditions, lifestyles, climate, etc.

Objective

To understand that change in lifestyles and habits has contributed to waste problems.

Activity

Ask the students to list down the items which they use daily. For example, soap, shampoo, cleanser, eatables (snacks, cold drinks, etc.), rexin bags, leather belt, pencil box, etc.

Ask them to note down the raw material that has gone into the preparation of this items, the packaging material used, etc.

Now ask them to list down the waste generated through these items.

After listing down this, ask them to do a survey of their parents, grandparents and neighbours to find out what they used when they were young, which is equivalent to their list. Let them use a format similar to that given on page 186.

Ask them the following questions to provoke discussion:

Do the items found in the column 'What I use' and 'What my parent/ grandparent used' reflect any changes in life-styles?

How was each item produced, what raw material went into production, what waste is generated?

Subject

Social Science, Science

Place

Indoor as well as Outdoor survey

Duration

30 minutes and actual survey time

Group size

Entire class

Materials

Writing materials



Do the older people still use the same items?

What factors influenced them (parents, grandparents and neighbours) not to use the things that they were using earlier? List down this factors and discuss.

What I Use	What are Environmental Impacts	What My Parent/ Grandparent Used	Environmental Impacts
Tooth brush			
Shampoo			
Plastic bag			

What's in the Water?

Activity

Pesticides and fertilizers, leaks of sewage from septic tank, leaching from landfill sites, release of industrial effluents, mining, etc. find their way to water bodies. Water bodies have been used for dumping wastes which results in water pollution.

When the pollutants in water increase, dissolved oxygen decreases and this reduces plant and animal life in water.

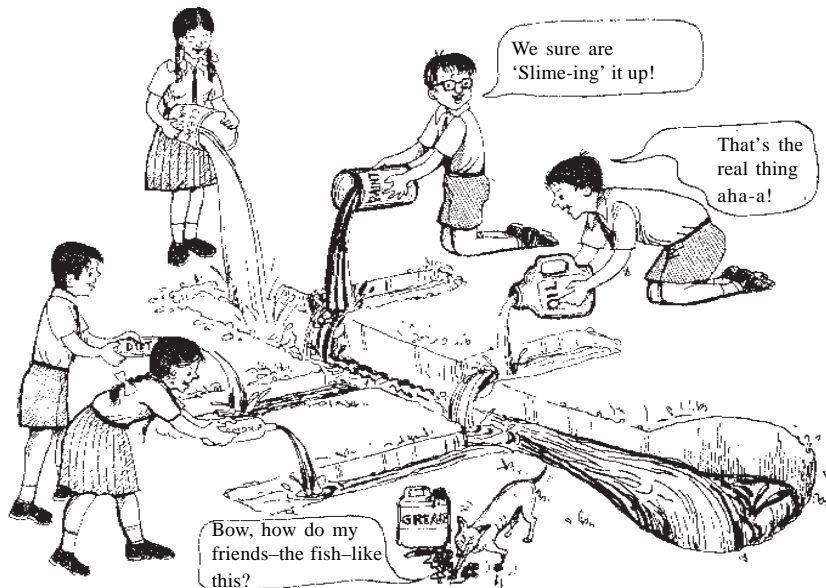
Objective

To help students understand how a river gets polluted.

Activity

Help students to dig a long shallow gully to represent a river and place the white plastic sheet in it. The end of the plastic sheet should be put in a large tub placed at a lower level.

Dig small gullies on either side of 'this river' to represent the various drains that enter the river with waste and sewage. The river should look as below.



Subject

Science

Place

Outdoor

Duration

One hour

Group size

Entire class

Materials

Thick white plastic sheet, 4 m long, mud, grease, oil, ash, different coloured water made by adding poster paints, mugs, jugs, large tub

Prepare different 'toxic materials' by mixing different colours in small quantities of water. Now, dig as many gullies as the number of 'toxic materials'.

Ask two students to stand at the beginning of the 'river' with large jugs of clean water. One student should stand at the head of each gully, with a 'toxic material' prepared by them.

Let the students holding the jugs of clean water, start pouring it down the 'river' and continue the process till the experiment is over.

As the water is being poured, other students should begin pouring their 'toxic materials' like coloured water, mud, ash, grease/oil etc. into their *nallahs* of the 'river'.

After this is done, prepare a poster on this and share with other group members.

Extension/Variation

Ask the students how the river was when the two students were pouring the clean water.

What happened when the 'toxic materials' from different gullies started pouring in? How was the river then?

Can you compare this scenario in real life?

Ask them to find out about 'point' and 'non-point' sources of pollution. Let them cite examples of each. Which of these two did this activity demonstrate?

Surveying Garbage

Activity

Waste is of three types—solid, liquid and gaseous. Non-gaseous, non-liquid wastes generated by various human activities are called solid wastes. Solid wastes are unwanted material disposed off from homes, schools, industries, shops, offices, hospitals, etc. Approximately 15 million tonnes of solid waste is generated in India every year. The daily per capita generation of solid waste in India ranges from about 100 gms in small towns to 500 gms in large towns. The increasing quantity of waste as well as the composition of waste reflects wastefulness and growing consumerism.

Objective

To help students become aware of how growing consumption has led to increase in garbage.

Activity

Ask the students to observe the garbage thrown out daily by their family and fill the chart given below:

Home Garbage Survey Sheet

Day	Types of Garbage					
	Paper	Glass	Aluminium/ tin foil	Plastic	Kitchen waste	Other (batteries, etc.)
Mon						
Tue						
Wed						
Thu						
Fri						
Sat						
Sun						

Subject

Social Science, Science

Place

Outdoor

Duration

30 minutes

Group size

Entire class

Materials

Writing materials

Before filling the chart, ask the students to set a unit of measurement for each item, that is, glass or cans could be counted by number of items. Paper may be counted by number of pieces or sheets. Kitchen waste (vegetable peels, egg shells, tea leaves, left-over food etc.) may have to be weighed or measured in a standard measure: e.g. cup or small pan.

Ask them to do this exercise for a week. At the end of the week let them add up the totals. Ask them to review the findings.

Discussion

What makes up the maximum part of the waste?

How much of what was thrown out could have been reused or recycled?

Could the amount of garbage be reduced?

Note: Care should be taken while sorting the garbage. Students must wear gloves or wash hands well after the exercise.



At present in neighbourhoods, waste is stored in community bins, containers and public dustbins which are supposed to be cleared periodically. This waste is collected, transported, unloaded and disposed off at open dumps, landfills or sanitary landfills. Once these are filled up, the land is leveled and covered with inert material. In India, in addition to this, there is an informal sector of people who play an important role in the solid waste management chain. They are the ragpickers, *kabariwallahs* and the sweepers.

Kabariwallahs buy old newspaper, packaging material, containers, bottle, tins, etc. from houses and sell it to middlemen or to recycling units.

Ragpickers play an important role in segregating the reusable and recyclable waste from garbage. By salvaging recyclables from the rubbish pile, they play an important role in reducing the volume of waste to be disposed. Also, using waste materials leads to large energy savings as they cost much less to transform than original raw material, and also reduce the exploitation of natural resources.

However, ragpickers work in extremely unhealthy conditions as they rummage through the waste with their bare hands without protective covering of any kind. They run the risk of infection and disease from the infected waste in the waste heap. Ragpickers are usually from the poorest and lowest strata of the society. Moreover ragpickers are usually women and children. Often they are cheated and exploited by the buyers and wholesalers.

It is important that we understand and acknowledge the significant role played by the sweepers, *kabariwallahs* and ragpickers.

Subject

Social Science, Science

Place

Outdoor

Duration

30 minutes and actual survey time

Group size

Entire class

Materials

Writing materials

Objective

To help students realize the fact that garbage cannot be managed just by throwing it out.

Activity

Ask the children how garbage is collected in each of their homes.

Who removes the garbage from the garbage bin?

Have they observed some others who take from the garbage bin only that garbage which they want? What about ragpickers? Who are these people and what do they pick from the garbage bins and why?



Open dump

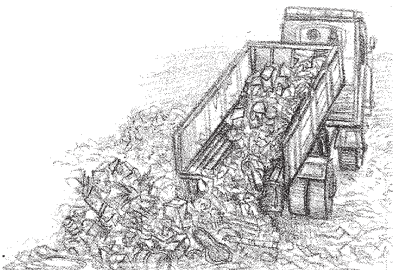
An open dump is an uncovered piece of land used for depositing municipal solid waste. The garbage is not segregated or covered.

Landfills

Landfill is generally an engineered pit in the ground, provided with liners which do not allow any leachate from the garbage to pollute the soil or the underground water.

Sanitary landfills

Sanitary landfill sites are lined with impermeable materials such as clay or plastic and built over impermeable soil to contain leachate.



Based on the discussion, ask them to do a survey in their home as well as society to find out how the garbage is removed from their home and society. Tabulate the data in the following format.

Sr. No.	To Observe	Findings
1.	How many garbage bins are there? At your home On your street In your colony In your area	
2.	Are they sufficient?	
3.	How frequently do corporation/ panchayat or private waste removers come to your house/area? Everyday Every alternate day Once a week Other (specify)	
4.	How many workers come at one time? No. of men No. of women	
5.	What implements do they use for cleaning the bin and putting the collected waste in the lorry or truck?	
6.	What vehicles are used to transport the garbage?	
7.	Where do these vehicles dump the garbage? Open dump or landfill site?	
8.	How may ragpickers come to the bin? No. of ragpickers—men and women Are there children of your age?	

Discussion

After this survey and observation, generate a discussion in classroom on

- What will happen if these wastes are not collected from your locality?
- What happens when the open dump is filled up with garbage?
- What would happen if there were no ragpickers?
- Do open dumps, landfills or sanitary landfills present any problem?
- People living on islands—where do they dump their garbage?
- Once the landfill is full, more land is needed for further landfills. Where is the land?

Subject

Social Science, Science

Place

Outdoor

Duration

15 minutes for a week

Group size

Entire class

Materials

For making pulp—old paper such as newspaper, stirring spoon, container, water, corn starch (optional)

For making paper—a flat dish (basin), pulp, an old net stretched over a picture frame and secured with pins or a fine sieve (the kind used in the kitchen to sieve flours)

Newspapers, various kinds of paper packaging, gift boxes, heavy corrugated cartons, cereal boxes, grocery bags and other paper products account for a huge chunk of waste. Paper is biodegradable, but when dumped in landfills with other waste, it is cut off from the natural elements such as air and microbes needed for decomposition, and hence cannot degrade as fast as it should. The best way to handle all the paper waste is by reusing and recycling it. Recycling paper saves a lot of energy, water and resources which are utilized in manufacturing or using virgin paper. For every ton of recycled paper used, an estimated ten to seventeen trees are spared. Recycling helps prevent pollution by reducing the amount of solid waste that must be dumped or burned. It can help reduce water pollution by as much as 35 per cent and air pollution by as much as 74 per cent.

Objective

To encourage students to make paper out of waste material.

Ask each of the students to contribute by bringing one thing from the required materials. The rest of the students should contribute by bringing old newspapers, old notebooks, used papers.

How Paper is Made

Paper is made from wood-fibre, and/or non-wood fibres such as straw, bamboo and sugarcane bagasse. Paper can be made from waste paper and other waste materials such as old clothes, rags and crop leftovers (stalks). The process of making paper involves making pulp. When a piece of paper is torn, at the torn edge, fine, thread-like wisps are seen. They are clearer if a magnifying glass is used. These are fibres. Paper fibres consist of cellulose—the material of which plants and trees such as wheat, rice, sugarcane is made. The materials can be used to make paper by breaking the fibres loose and free from the substance that binds them. This process is called pulping and the mass of fibres suspended in water ready to be made into paper is called pulp.

Activity

a) Making the pulp

Procedure

1. Ask the students to remove any kind of staples or pins in the paper and tear the paper into small pieces (may be two square cms). Place these scraps of paper in a container.
2. Pour warm water in the container such that the water stands about 1 cm above the paper layer. Let it soak for 3-4 days. Stir the mixture everyday to help break the paper fibres down.
3. When the shredded paper suspended in the water looks like a thick soup, it is ready for use.
4. Corn starch may be added to the mixture for smoothness and stability.

b) Making paper

Procedure

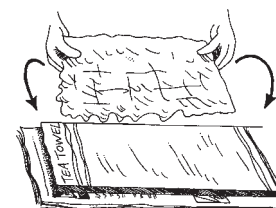
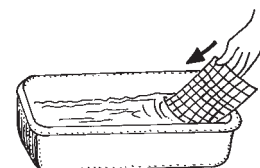
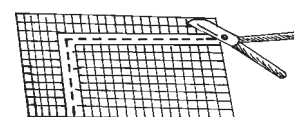
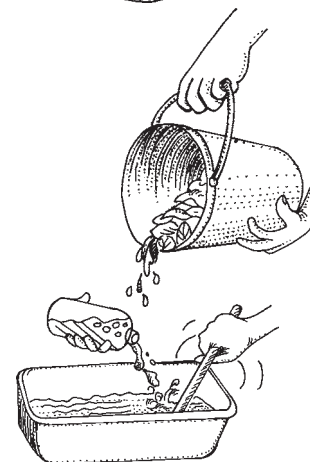
1. Take a basin (it should be able to accommodate the sieve). Pour some pulp in the basin.
2. Slide the sieve into the basin and move it around in the basin until it is evenly covered with pulp. Lift out the sieve which is now covered with a layer of pulp.
3. Place a sheet of paper, preferably blotting paper, over the pulp on the sieve and press out as much water as you can.
4. Turn the sieve upside down on top of a sheet of paper or wooden block and lift the sieve away.
5. Dry this sheet of handmade paper in the sun for about 2 days. When dry, peel the sheet off the paper or wooden block.

Extension/Variation

- Add small amounts of shredded/grated vegetables wastes (for example: orange peels, carrot tops) the paper pulp and observe the colour and smell of the paper made.
- Add turmeric to the pulp for yellow coloured paper, kum-kum for red coloured paper and so on.

Discussion

- a) Use the recycled paper for painting or drawing with charcoal pencil or ink. How is this paper different from other writing or drawing paper?
- b) How are energy and natural resources conserved by using recycled paper instead of new paper?



More About Pollution



The word ‘pollution’ is derived from the Latin word ‘pulluere’, which means ‘to soil or defile’. Any alteration to air, water, soil or food that threatens the health, survival capability or activities of humans or other living organisms, is called pollution.

Pollution has been around for a long time—in fact for as long as humans have been around. In the past, it was not a problem. Most of the waste from human activities could be handled by the earth’s natural systems. That was because many of the things thrown away in the past centuries were made of natural materials, which decompose easily. Also, there were fewer people around. So the total amount of waste created was not too large.

Gradually, as settlements grew larger and turned into cities with large populations, the wastes increased too. Technological inventions made life easier than before. Factories sprouted up and began producing goods in large quantities. But they also began to spew out their wastes into the air, into the water, and on to the land. Transportation was revolutionized with the invention of the internal combustion engine, which burned fossil fuels and added to air pollution. More and more synthetic chemicals were invented. Plastics began to replace almost every kind of natural material. Thus the amount, as well as the kind of waste generated, changed a great deal.

A century ago people were dealing with pollution mainly from animal waste, household waste and coal ash from burning some of this waste. Today, pollution is generated through many sources, and is of many types—from pesticides, fertilizers, carbon monoxide, radiation, and an army of new chemical and synthetic materials. Combined with ever-exploding populations, and ever-increasing consumption, pollution has become a threat to the fragile life-support systems of the earth.

Today almost every human activity—from how we get around, to how our goods are produced, to how we grow our food—creates some type of pollution. Let’s see how.

What Causes Pollution?

Pollutants which cause pollution may be solid, liquid or gaseous. These pollutants enter the system as by-products or as waste in the process of extraction of natural resources (mining), processing of raw materials, manufacture of products, agriculture, the generation of energy, etc. Pollution also takes place in the form of the emission of excess noise, heat, or radiation.

Pollutants may be:

Degradable pollutants—those which can be broken down or reduced to acceptable levels by physical, chemical or biological processes. Most natural substances are degradable e.g. vegetable waste, etc.

Non-degradable pollutants—those which cannot be broken down by natural processes e.g. plastics, Styrofoam container. Once these are released into the environment, it is difficult to get rid of them, and they continue to accumulate.

Slowly degradable or persistent pollutants—are those substances which take a very long time to degrade e.g. aluminum cans, chemical insecticides like DDT, and chemicals like CFCs. These linger on, and have long-lasting and far-reaching effects on the environment.

Much of the natural pollution (e.g. from a volcanic eruption) is generally diluted, dispersed or rendered harmless by natural processes. But pollution caused by human activities (e.g. burning of fossil fuels like coal or petroleum), occurs over a small area (e.g. an urban or industrial area), and so the pollutants become concentrated in the air, water and soil

there. The quantity and quality of such pollutants do not allow for their dilution or dispersal by natural processes.

Pollution may come from single identifiable source such as the chimney of a factory, or the drainage pipe of a mill, or the exhaust pipe of a vehicle. Such sources are described as **point sources**. When the original source is difficult to pinpoint it is described as a **non-point source**. For example, chemical sprayed into the air, or fertilizer run-off from various fields which enters a river or lake. The control of this kind of pollution is difficult, as the original source is often difficult to pinpoint.

What Can Pollution Do?

Pollution can affect the very survival of our planet as its effects are felt not only by humans, but by all the life-supporting systems of the Earth—air, water, soil, flora and fauna. The effects of a pollutant may vary depending on a number of factors. These are:

- The nature of the pollutant—how active and harmful it is to living organisms?
- The concentration of the pollutant—the amount per unit volume of air, water, soil or unit of body weight. When there is too much of a pollutant, or when it is piling up too fast, it starts having harmful effects.
- The persistence of the pollutant: how long it stays in the air, water, soil or body.

Types of Pollution

Depending on the component getting polluted and/or the kind of pollutant, pollution may be classified as: air pollution, water pollution, land pollution, noise pollution and radiation pollution. Let us see what are the sources and effects of various types of pollution.

What is Air Pollution?

Air is found everywhere. Air may get polluted by natural causes e.g. volcanic activity, which releases ash, dust and sulphur compounds; forest or grass

fires caused by lightning; and/or through man-made causes such as industrial activities, transportation, etc.

Sources of Air Pollution

Air pollution consists of gases, liquids or solid present in the atmosphere in high enough levels to harm humans, other organisms or materials (See box 'Air Pollutants: Sources and Effects' on page 200).

Pollutants in the air may be in the form of solid particles or gases. The solid particles that remain suspended in the air are called suspended particulates. They may reduce visibility or damage human health. Air can also be polluted by trace metals such as lead, nickel, iron, zinc and copper. There are several types of gaseous pollutants which have different impacts on human health and the environment.



Often air pollutants are divided into two categories: primary and secondary. Primary air pollutants are emitted or discharged from the source directly into the atmosphere, while secondary air pollutants are the products of chemical reactions involving primary air pollutants. The sources and effects of air pollution are varied and complex. Some sources of man-made air pollution are vehicular emissions, industrial processes and burning of fuels in homes.

Vehicles: There has been a tremendous increase in the number of motorized vehicles including cars, buses, truck and three wheelers (autorikshaws) in the past few decades. Most of these vehicles run on petrol or diesel, which are fossil fuels. The burning

of fossil fuels, and their often incomplete combustion in engines, leads to the release of a number of polluting gases such as carbon monoxide, carbon dioxide, nitrogen oxides, oxides of sulphur, hydrocarbons, lead etc. into the atmosphere. These gases have serious ill effects on human health, on vegetation, materials, etc.

Apart from the concentration of vehicles in urban areas, other reasons for increasing vehicular pollution are the types of engines used, age of vehicles, congested traffic, poor road conditions, and outdated automotive technologies and traffic management systems.

Vehicular pollution can be reduced by minimizing use of personal vehicles through more efficient public transport. The use of unleaded petrol also helps in the reduction of lead pollution. Using alternative fuels such as Compressed Natural Gas (CNG), battery operated vehicles instead of petrol or diesel vehicles, helps in reducing pollution. Maintaining vehicles in good condition can also contribute towards this.

Photochemical Smog

When vehicular traffic is heavy, the atmosphere appears hazy. This is due to photochemical smog which is caused by a mixture of suspended particles and gases formed by the reaction (in the presence of sunlight) of nitrogen oxides and hydrocarbons from automobile exhaust. This smog can affect eyes and the respiratory system.

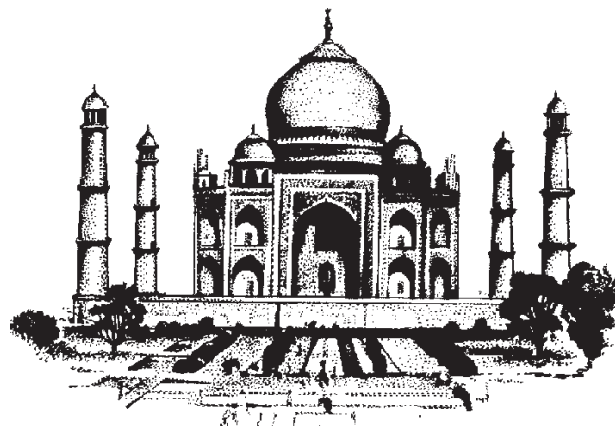
Industries: Increased industrial activity since the Industrial Revolution is one of the main causes of air pollution. The great leaps in industrial production have been achieved by the mushrooming of industrial establishments such as steel and chemical plants, paper plants, refineries, petrochemical plants, power plants and more. With this has come the increase in the pollutants discharged by industries. The emissions from these contain not only smoke and soot, but other particulate as well as gaseous

pollutants. These pollutants can have serious consequences not only on human health, but also on flora and fauna, as well as on soil, water and on man-made structures.

With growing population and industries, the need for energy has increased multifold. To meet this increased power requirement, mega power projects have come up. The use of coal in thermal power stations has led to the increase in air pollutants such as various oxides of carbon, sulphur, nitrogen, etc. Apart from these, thermal power stations produce large quantities of fly ash as a by-product, which covers large areas of land with a fluffy, sooty layer.

The oxides of sulphur and nitrogen emitted from industries combine with water vapour in the air to form compounds which are highly corrosive. These chemicals descend to earth in wet form as acid rain or snow. Acid rain can damage foliage of trees and weaken them, making them susceptible to other environmental stresses (e.g. cold, diseases, insects, etc.). It can also contaminate soil and water, affecting food chains. In the 1970s large tracts of forests in Europe were dying due to the effects of acid rain.

Acid rain can cause damage to vehicles and buildings/structures by corroding the surface. The Taj Mahal, one of the world's most famous monuments, was under threat from the damaging effects of air pollution. The fumes of sulphur dioxide from a neighbouring oil refinery, smoke from hundreds of small industries around, and vehicular emissions, led to discoloration and



corrosion of the snow-white marble of this monument. Monuments around the world are being affected by similar problems.

Air pollution due to industrial emissions can be reduced using specific emission control packages, which would involve changing processes leading to the production of lesser pollutants. Another way is to increase the height of chimneys in the factories for better dispersion and diffusion.

Indoor air pollutants: Many scientific evidences indicate that the air within homes and other buildings can be more seriously polluted than outside air because of the types of fuel, construction materials and other products being used. Many indoor air pollutants and pollutant sources have an adverse effect on human health.

Over 80 per cent of the people in rural areas of India rely mainly on solid biomass fuels for cooking and heating. This produces large amounts of smoke and other air pollutants in the confined space of the home, resulting in high exposure.

Other indoor air pollutants include asbestos, formaldehyde (which is associated with many consumer products, including certain wood products), aerosols, chloroform, paradichlorbenzene (from mothballs and air freshners), perchloroethylene (associated with dry cleaning), etc.

Accidents: Pollution through emissions from industries and vehicles creeps into the air, day after day. But when there is an accident, large quantities of pollutants suddenly enter the environment in a particular place. The effects of such accidents can

Non-fuel Indoor Pollutant	Sources	Effects from Prolonged Exposure or High Concentrations
Formaldehyde (preservative and disinfectant)	Foam insulation, resin in particleboards, plywood, paneling, fiberboard, some carpets, drapery and upholstery fabrics	Headaches, dizziness, nausea, lethargy
Lead (Pb) (metallic element)	Paint, leaded crystal and pottery, toys	Learning and behaviour problems in children, concentration problem
Biological pollutants and microorganisms (pollen, dust mites, bacteria, molds, fungi and viruses)	Wall to wall carpeting, pets and plants	Allergic diseases and skin irritations, influenza, acute cases of asthma
Nitrogen dioxide Tobacco smoke	Fireplaces, wood and coal stoves Cigarettes, pipes, cigars	Eye and respiratory tract irritations Eyes, nose and throat irritations respiratory infections, lung cancer, headaches and nausea
Volatile organic compounds (VOCs) (substances produced by synthetic chemical industry and naturally, vaporizes at ordinary temperatures)	Furniture, paint, adhesives, solvents, drapery fabrics, construction materials, felt-tipped markers, correction fluid, dry cleaned clothes, wool preservatives, tobacco smoke, etc.	Eye and respiratory irritations, kidney and liver damage in animals

Air Pollutants: Sources and Effects

Sr.No.	Pollutants	Sources	Effects
1.	Sulphur compounds including sulphur oxides, hydrogen sulphide	Biological decomposition, smelting of sulphide containing ores, combustion of sulphur containing fuels like coal	<p>Plants: Death of living tissues; decreased growth, yield</p> <p>Humans: Paralysis damage to lungs; lowering of resistance to diseases like pneumonia and influenza</p> <p>Materials: Damage to materials including corrosion.</p>
2.	Carbon monoxide	Automobile engines, incomplete combustion of fuels in furnaces	<p>Plants: Inhibition of nitrogen fixation; premature aging; inhibition of cellular respiration; initiation of roots; etc.</p> <p>Humans: Affects central nervous system; combines with the red blood cells and affects their oxygen carrying capacity.</p>
3.	Carbon dioxide	Combustion of fossil fuels	This gas has an insulating effect. Increase in concentration leads to the "Greenhouse Effect" (<i>See chapter 'Atmosphere' for more information</i>)
4.	Nitrogen oxides	Power generators, vehicles, forest fires, lightning etc.	<p>Plants: stunted growth</p> <p>Humans: Nasal irritation; breathing discomfort; pulmonary oedema and in extreme cases death</p>
5.	Hydrocarbons	Vehicles, industries, refineries	<p>Plants: Stunted growth</p> <p>Humans: Irritation of mucus of respiratory tract; may lead to cancer.</p>
6.	Particulates	Lead particles from automobile exhaust, soot, fly ash from power stations, from asbestos, fluorides, aluminium metallic dusts, etc. and other natural sources.	<p>Plants: Inhibits growth (the leaf is covered with a layer of particles, which inhibit light penetration) thereby reducing photosynthesis.</p> <p>Humans: interferes with maturation of red blood cells, disrupts functioning of cells and organs of the muscular, circulatory and nervous system, by binding with cellular enzymes; lead damages liver, kidney and gastro intestinal tract and induces abnormalities in fertility and pregnancy; respiratory disorders; asbestos dust leads to lung scarring (asbestosis); fluoride particles may affect teeth, and lead to calcification of bones.</p>

be tragic and often widespread. One such horrifying accident took place in Bhopal in 1984 when a deadly chemical, methyl-isocyanate (MIC), leaked from the storage tank at the Union Carbide Factory. The gas created havoc—killing hundreds and leaving tens of thousands with serious health problems. The health impacts are being felt even today. The Bhopal tragedy raised several important issues about safety, location of industry, litigation and compensation, public education and awareness, and access to information.

Air pollution and global climate

Global climate is dependent on the concentrations of greenhouse gases (GHGs) in the earth's atmosphere. If these concentrations increase or decrease significantly, climate will change accordingly. Vehicular and industrial emissions are adding carbon dioxide, carbon monoxide, sulphur dioxide etc. to the air. Some new man-made chemicals like CFCs which act as GHGs are being introduced into the atmosphere. This results in the gradual increase in the temperature of the earth, which is referred to as **Global Warming**. (*See Chapter 'Atmosphere' for more information on Global Warming*)

What is Water Pollution?

Water pollution may be defined as the introduction into a waterbody of substances of such character and in such quantity that the natural quality of the waterbody is altered. This alteration impairs its usefulness, affects the health of living organisms or renders it offensive to the senses of sight, taste or smell. Water pollution includes surface water pollution (rivers, lakes, ponds), groundwater pollution and marine pollution. Some of the common types of water pollutants are:

Disease-causing agents which include bacteria, viruses, protozoa and parasitic worms that enter water from domestic sewage and animal wastes. They are the biggest cause of water-borne diseases, some of which can be fatal.

Oxygen demanding wastes are organic matter needing oxygen-requiring bacteria to be decomposed. Large numbers of such bacteria, while oxidizing these wastes deplete the dissolved oxygen in water, causing fish and other aquatic organisms to die.

Inorganic chemicals which are soluble in water. They consist of acids, salts and soluble compounds of toxic metals like mercury and lead, which make water unfit to drink, harm fish and aquatic life, affect crops, and corrode materials. A large number of inorganic chemicals find their way into both surface water and groundwater from sources such as industries, mines, irrigation runoff, oil drilling, and urban runoff from storm sewers.

Inorganic plant nutrients e.g. water-soluble nitrates and phosphates, cause excessive growth of algae and other aquatic plants. When these aquatic plants die and decay, they decompose. This causes depletion of oxygen in water, which is harmful for the life forms in water.

Heat and warm water released from industries as part of their cooling processes raises water temperature and affects health and life cycles of aquatic organisms.

Radioactive substances include the waste from the mining and refinement of radioactive metals as well as the pollution caused by their use. Radioactive isotopes are water soluble and capable of concentrating in food chains and can cause adverse health effects.

Organic (carbon containing) compounds found in water are synthetic chemicals, produced by human activities. These include pesticides, solvents, industrial chemicals and plastics. Some organic compounds find their way into surface water and groundwater by seeping from landfills, whereas others, such as pesticides, leach downwards through the soil into groundwater or get into surface water by runoff from farms and residences.

Sediment or suspended matter are insoluble particles of soil and other solids that become

suspended in water as a result of soil erosion, runoff from agricultural fields, from dumping of debris from building sites, solid wastes, forest soils exposed by logging, degraded stream banks, overgrazed fields, strip mines and construction, etc. Such particles make water turbid, reducing light penetration and affecting photosynthesis, disturbing aquatic life. The sediments also carry pesticides and other harmful substances into water.

Sources of water pollution

Water is found on the Earth as freshwater and marine (salt) water. Freshwater sources are surface water and groundwater. Let us see how these get polluted.

Surface water pollution

Surface water gets polluted by wastes disposed from human settlements and industries; agricultural run-off; and also natural sources like addition to water bodies of soil, plant and animal debris after a heavy downpour. Some of the sources and associated problems are:

Sewage: The waste from urban areas is usually drained into waterbodies from which drinking water supply is taken. Ideally, this sewage should be treated before being drained into the water, but we do not have adequate treatment systems to handle the large quantities of wastes produced. It is reported by a World Bank study that in India, out of the 3,119 towns and cities, only 209 have partial and just eight have full sewage treatment facility.

Untreated sewage introduces many disease-causing organisms into the waterbody. When this is the source of drinking water, this may cause serious health problems, some of which may even be fatal. Some of the diseases caused by drinking such water are cholera, gastroenteritis, typhoid and jaundice.

Industrial water pollution: Industries use water for many purposes such as processing, cooling, and the treatment of materials at various stages of production. During these processes, the water may get polluted. Sometimes water may be a by-product

Diseases from Contaminated Drinking Water		
Type of Organism	Disease	Symptoms
Bacteria	Typhoid	Diarrhea, severe vomiting, enlarged spleen, inflamed intestine; often fatal if untreated
	Cholera	Diarrhea, severe vomiting, dehydration often fatal if untreated
	Bacterial dysentery	Diarrhea, fatal in infants without proper treatment
	Enteritis	Severe stomach pain, nausea, vomiting, rarely fatal
Viruses	Infectious hepatitis	Fever, severe headache, loss of appetite, abdominal pain, jaundice, enlarged liver, rarely fatal but may cause permanent liver damage
Parasitic protozoa	Amoebic dysentery	Severe diarrhea, headache, abdominal pain, chills, fever. If not treated can cause liver abscess, bowel perforation and death
	Giardia	Diarrhea, abdominal cramps, flatulence, belching, fatigue
Parasitic worms	Schistosomiasis	Abdominal pain, skin rash, anaemia, chronic fatigue, and chronic general ill health

of the industrial process. Such polluted water released by industries may directly or indirectly reach waterbodies.

The problem of industrial water pollution occurs when inadequate measures are adopted for effluent or wastewater treatment. Major water polluting industries in India include leather, pulp and paper, textiles and chemicals. When these industries dump their wastes without adequate treatment into waterbodies, it introduces a wide variety of pollutants—both inorganic and organic—which are not biodegradable. Once introduced, various pollutants—solvents, oils, plastics, metallic wastes, suspended solids, phenols, and various chemical derivatives of manufacturing processes, cannot be removed from the water easily with available technology, thereby making the water unfit for human applications.

Certain metals like zinc, copper, chromium, tin, and particularly heavy metals like arsenic, cadmium, lead and mercury are widely used in industries, especially in metal works and in processes related to batteries and electronics. These metals are also used in the manufacture of certain pesticides, medicines, paints and pigments, glazes, inks, etc. The wastes from such industries would usually have a high amount of these materials. These are extremely toxic as ions. When present in certain



water-soluble compounds, they may enter the aquatic food chain. In humans, even small amounts of these can cause severe physiological (including neurological) problems. For example, lead poisoning is known to cause mental retardation, and mercury poisoning to cause insanity and crippling birth defects.

The danger of pollution from heavy metals and synthetic organic compounds that are not biodegradable is compounded by the fact that these have a tendency to accumulate in organisms. They may accumulate in the body of the organism over a long period of time, and produce toxic effects at a later stage.

Another pollutant from industries, specially power plants, is the heat (a by-product of industrial activity) which is released into water bodies. This heat causes not only direct harm to life forms, but may also catalyze chemical reactions between the various chemicals that are already present in the water body. The unnatural heating can also cause disturbances in the natural life cycles of aquatic organisms.

Water pollution is mainly due to sewage and industrial wastes. Having a proper sewage treatment system and treatment of industrial effluents before they are discharged into a water body are a few of the steps that can be taken to reduce this.

Modern agricultural practices: With ever-growing demand to increase food production, there has been an increase in the use of artificial fertilizers and pesticides to increase crop production. The chemicals in fertilizers and pesticides pollute soil and water, and affect animals and humans. Runoff from agricultural fields which may have high amounts of fertilizers and pesticides, add to the problem of **eutrophication**, **bioaccumulation** and **biomagnification**. (See chapter 'Agriculture' for more information on bioaccumulation and biomagnification)

The quantity of fertilizers applied in a field is often many times more than what is actually required and

Eutrophication

Excess fertilizer from agricultural fields finds its way into ponds, lakes and rivers through run-off water from the fields. This makes water bodies nutrient rich. This speeds up the growth of algae in the pond, lake and river waters. When these die, they begin to decompose. Their decomposition causes depletion of dissolved oxygen, which is very important for aquatic life. This may ultimately lead to the death of fish, etc. due to suffocation. This phenomenon is known as eutrophication.

what the plants will be able to incorporate. As a result, much of the fertilizer is washed off into waterbodies, wherein it causes eutrophication and related algal blooms, which affect aquatic life.

Some of the pesticides which have been proved to be hazardous, like DDT and benzene hexachloride, even though they are banned in India for agricultural use and are officially to be used only for malaria eradication, are still used in the fields because they are cheap. Excess pesticides also find their way into waterbodies, These are proven carcinogens (cancer causing). One of the effects of accumulation of high levels of pesticides such as DDT is that birds lay eggs with shells that are much thinner than normal. When the parent birds sit on the eggs to incubate them, the eggshells break, killing the chicks developing inside. Hawks, eagles and other fish-eating birds are specially affected by such pollution.

In Punjab where high quantity of fertilizers and pesticides were applied in fields, breast milk samples collected from women were found to contain high levels of these pesticides.

Groundwater pollution

Water pollution is not restricted to surface water alone. There have been cases where groundwater is found to have been contaminated. Solid waste dumping is one cause for groundwater pollution. Various kinds of harmful material (chemicals, metals, etc.) present in the solid waste may get dissolved or

leached out into water. The pollutants dissolved in water percolate down into the soil and contaminate the groundwater. This is a serious problem, as groundwater is one of the main sources of drinking water. (See Chapter 'Water' for more information on surface water and groundwater)

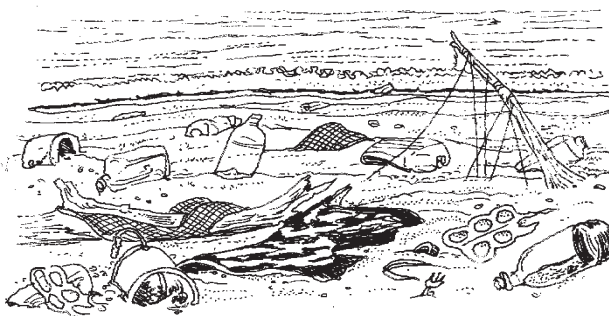
Another emerging cause of groundwater pollution is nuclear dumping. Nuclear wastes are buried deep inside the ground. The possibility of these leaking out and then contaminating the water with radioactive elements cannot be ruled out.

Marine pollution

70 per cent of pollution of the oceans has its source in human activities on land. These sources include oil spills, refinery effluents, industrial waste, sewage, agriculture activities, pollution of beaches, agriculture, industry, urban activities, etc. and resulting outputs. Rivers carry pollution from far-off places to the sea. In addition, activities on the coast pollute the seas.

The marine route is often used for transporting huge shipments of oil and petroleum. There have been numerous accidents, leakages, etc. in this process. Pollution due to oil spills arising from accidents, refinery effluents, losses from pipelines, offshore production platforms, ship washings, etc. have adversely affected the marine ecosystem.

Plastics are thrown along the beaches by visitors. Or they may reach there from garbage dumping into the seas. The waste disposed from the ships into the sea may also contain plastics. Plastics do not decompose or break down. Fishes and turtles



suffocate from plastic they have swallowed, mistaking it for something edible. It is estimated that thousands of sea birds and marine mammals die each year from plastic-related causes.

The consequences of marine pollution are already being felt in the form of decreasing fish stocks around the world. The tourism industry, which itself is one of the main reasons for marine pollution, is also affected by polluted beaches, marred coral reefs and otherwise degraded coastal waters.

Coral reefs are among the most diverse and biologically productive ecosystems in the world. They also play a role in protecting the land shoreward of the reefs. The reefs attract different varieties of fish and shellfish and are therefore important to the local people for fishing. They are great tourist attractions too.

But coral reefs too are being affected by pollution. Rise in temperature of waters around the reefs leads to coral bleaching. Sedimentation destroys the corals, as it clogs the corals and also obstructs the light needed for photosynthesis from reaching the algae. Increased inflow of sewage into the water leads to excessive growth of macroscopic algae and other submerged vegetation, which shade the coral and also reduce the oxygen supply to the coral animals. The corals then become brittle and stunted.

What is Land Pollution?

Land gets polluted due to contamination by chemicals, particulates and solid waste, and mining activities. The main sources of land pollution are agriculture, industrial activities, mining and solid waste dumping.

Sources of land pollution

Agriculture: In earlier times, people practiced 'shifting agriculture' where land on which the crop was grown for one or few seasons would be vacated and allowed to lie fallow while the cultivator shifted to cultivating another plot of land for the next season's planting. Now such movements or shifting are not possible. With increase in population and

urbanization and the resulting scarcity of agricultural land, land cannot be left uncultivated for any length of time. The same land is cultivated frequently without giving it time to replenish on its own. Due to over-cultivation, the soil loses its nutrients. Fertilizers are added to increase the fertility of the soil and to replenish the lost nutrients and to increase the yield. Pesticides are used to kill/suppress the plants and animals that are harmful to the crops. The more the fertilizers and pesticides used, the more they accumulate in the soil and in water bodies. (*See chapter 'Agriculture' for more information on Fertilizers and pesticides*)

Industries: Power plants produce huge amounts of fly ash, which is one of the major causes of land pollution in surrounding areas. Other industries like paper and pulp mills, oil refineries, chemical and fertilizer manufacturing, iron and steel plants, plastic and rubber-producing complexes, etc., produce large amounts of solid waste which are dumped on land. These may contain chemicals which may affect the soil quality and life in it.

Mining: Mines are another significant source of land pollution. The area around mines is usually contaminated with metals such as cadmium, zinc, lead, copper, arsenic and nickel which are toxic to plants and inhibit their growth. Their accumulation in plants makes the plants unsafe for human and animal consumption.

Urban solid waste: Another major pollutant is garbage. In urban areas most of the pollution is caused by human sewage and household garbage. The attitude of 'use and throw' and a disposable culture have not only increased the quantity of waste but also changed the quality (quality here means composition) of the waste generated. In urban areas, most of the waste generated in the house is not biodegradable and it remains on the land for a long time. These wastes contaminate air, water and land with toxins. During the rains, toxic leachates (toxins released from the toxic waste when it comes into contact with water) run off into nearby water bodies and also percolate into the groundwater table polluting both the sources of water.

The problem of solid wastes, can be reduced if the three 'R's, reduce, reuse and recycle are seriously adopted. This will result in production of lesser garbage. The excess use of fertilizers and pesticides can be reduced by educating farmers about organic fertilizers and biological pest control or integrated pest management.

Bio-medical waste: This consists of large quantities of discarded bottles, blood transfusion bags, urinary bags, surgical gloves, syringes, body parts, soiled sheets, and instruments used during medical procedures. Bio-medical waste is infectious and requires careful handling.

What is Noise Pollution?

Noise pollution may be regarded as unwanted sound dumped into the atmosphere without regard to adverse effects it may have. Noise pollution could occur indoors or outdoors.

Solid Waste	
Activities	Waste Generated
Agricultural	Plant remains, processing wastes, animal wastes
Domestic	Paper, plastic, glass, metal, rags, food, fruits, vegetable peels, garden litter, packaging
Municipal	Sweepings from streets, schools, colleges, offices, factories, hospitals, clinics, petrol bunks, shops, etc.
Industrial	Wastes generated from mining operations, manufacturing, construction work, thermal stations, chemical industries, paper making units, textile mills, cement factories, factories manufacturing engineering goods, etc.
Health care	Health care establishments generate wastes like needles, syringes and other potentially infectious wastes

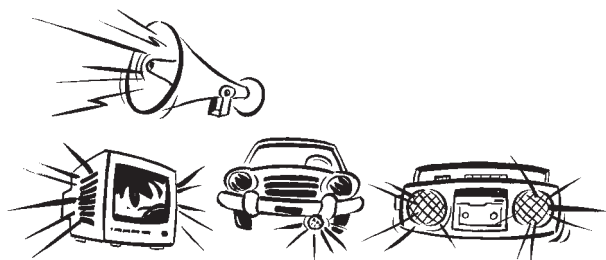
Surat: A Success Story

The plague outbreak in Surat in 1994 was a stern reminder of what negligence in the area of solid waste management can lead to. After that disaster the city diligently tried to improve its living conditions. Institutional changes were the first thing to happen when the city began its journey from a city ridden with plague to the second cleanest city in the country, a status it achieved in a short span of 18 months. The city was divided into six zones to decentralize the responsibilities for all civic functions. A commissioner was appointed for each zone with additional powers; the officials responsible for solid waste management were made accountable for their work; and field visits were made mandatory for them each day. The solid waste management department and other related departments were made to work in concert and cooperate with one another. Indeed, these are some of the very basic changes that need to be introduced in the functioning of all urban local bodies. Community participation played a key role in the rapid implementation of decisions taken by the corporation. People were issued grievance redressal cards, which they could fill in and drop at the zonal office to register their complaints. The complaint was attended within 24 hours and the card returned to the citizen. In addition to the administrative changes, the changed laws had an important role to play in improving the conditions by also making the citizens aware of and responsible for certain preventive actions. Initially, the Gujarat Municipal Act did not have the provision of imposing a penalty for littering, which was introduced later as a fine of Rs. 50/-for every offence of littering and the fine was doubled for every subsequent offence. The corporation, in an appreciable attempt, has now engaged private sweepers to cover different inner areas of the town. Private contractors are also actively involved in the transport, collection, and disposal of solid waste.

Source: State of the Environment, India, UNEP 2001

Sources of Noise Pollution

The main sources of noise pollution are the use of many modern electric gadgets in our day-to-day life. Inside the house, we use electric products like mixers, vacuum cleaners, washing machines, coolers, air conditioners, loudly play radio and music systems, etc. The noise produced by machinery inside factories is another source of noise pollution which is a major occupational health hazard. Outdoor noise pollution is usually by vehicular horns, festivities with loud band, speakers, crackers, etc. (*See Chapter 'Industries' for more information on occupational hazards*)



Noise pollution inside the house can be reduced by proper maintenance of gadgets. Outside, the reduction of use of vehicular horns can reduce the noise levels. Industries should be located away from the residential areas, so that not only noise pollution but also air pollution effects on humans can be reduced.

What is Radiation Pollution?

Radiation pollution is caused by radioactive substances, either natural or man-made. We are exposed to various kinds of radiation in our day-to-day life. Radiation causes increase in the number of cancers and other disorders. Apart from direct effect, it can cause genetic effects in living organisms.

Sources of radiation pollution

Human beings receive natural radiation from cosmic rays.

Other sources are exposure to X-rays, radium dial wrist watches, television, etc. All these are sources

of ionizing radiation. But these are usually not high enough to cause serious damage to health.

The main source of radiation pollution is the nuclear waste from the nuclear power plants and other installations related to them. The other potential source is the fallout of a nuclear bomb explosion.

Radiation pollution can be reduced only by improving the safety measures taken for storage and to prevent accidents in reactors and storage facilities, and by minimizing tests of nuclear weapons.

Dealing with Pollution

Pollution clean-up or pollution control, has in the past been the primary way of tackling the issue. This approach looks at ways by which the effects of pollution which has already occurred can be mitigated. The common measures include: steps to clean or treat wastewater and gaseous emissions from industry, introduction of emission and effluent standards, etc.

In the last few years, it has been increasingly realized that such measures are only ways of reacting to situations with solutions which are not sustainable. They fail to tackle the root cause of the problem.

Today, it is being recognized that “end of pipe” solutions are not adequate. The need is for pollution prevention or input pollution control, that is, reducing or eliminating the input of pollutants and wastes into the environment. Pollution prevention involves changes at many levels in all areas of production— industrial or agricultural; and use—domestic or commercial.

The new strategies focus on the entire production process, examining where wastes are generated, and exploring how they can be reduced. This could involve numerous possibilities—changing manufacturing processes, using different raw materials, finding substitutes for hazardous substances, improving operations and maintenance of the units, and practicing recycling and reuse.

There are some types of pollution that can be controlled by individual action, and there are others which would need many instruments (policies, laws, financial, technological) and the involvement of various sections of society including policy makers, industrialists, etc.

The effective implementation of pollution control measures requires cooperation of different people. It has to start at the policy level. Once the government's policies are in place, laws are made. Implementing the laws is the next step. The challenge is to find ways to make the implementation economically viable. Often technologies have to be improved for this, which would involve research into problems and finding suitable solutions. Education is essential for all these changes.

The Government of India in its efforts to reduce pollution, has introduced various legislations/Acts from time to time, depending on the need of the hour and keeping sustainable development in mind. The Acts/Rules/Laws have made industries more responsible, as they are liable to be fined or may even be closed down, if they are found to violate emission or pollution standards. (*See Annexure I 'Environmental Laws'*)

Some of the measures like—reducing vehicular pollution or garbage dumping—can be taken at an individual level. This can then be extrapolated to the community.