Society & Environment

ENVIRONMENTAL DEGRADATION & WASTE MANAGEMENT

Environmental Degradation & Waste Management

AIR POLLUTION AND ITS CONTROL

Pollution may be defined as any chemical or material out of place. Example : ground level ozone

Air Pollution is the presence in ambient atmosphere of substances, generally resulting from the activity of man, in sufficient concentration, present for a sufficient time and under circumstances which interferes significantly with the comfort, health or welfare of persons or with the full use or enjoyment of property.

Air Pollutants

Particulates: Particulates are tiny solid or liquid particles suspended in the air. Examples are smoke, haze, fog, fume, dust etc. sources are dust storms, forest fires, emission industries, automobile exhaust etc. Sources for particulates are open burning of reuse, industrial stacks, dust storms, forest fires, automobile exhaust etc.

Various effects of particulate matter are

- Dust particles cause respiratory diseases such as black lung disease in coal mine workers.
- Smog, dust etc. reduce the amount of light reaching the leaf and hence reduce CO intake to some extent and thus interfere with photosynthesis.
- Eye irritation
- ”Pollen” causes asthmatic attacks
- Heavy metals like led may enter the body through lungs and cause poisoning.
- Beryllium causes “*berylliosis*” at the inhaling of dust from broken “*fluoroscent*”. Its symptoms are weight loss and coughing.

Carbon Monoxide (CO): Carbon Monoxide reduces the blood's Oxygen carrying capacity which can reduce availability of Oxygen to key organs. Extreme levels of exposure, such as might occur due to blocked flues in domestic boilers, can be fatal. At lower concentrations CO may pose a health risk, particularly to those suffering from heart disease.

Carbon Dioxide: Major amount of carbon dioxide is released in the atmosphere from burning of fossil fuel (coal, oil etc) for domestic cooking, heating etc. and the fuel consumed in furnaces of power plants, industries, hot-mix plants etc. From fossil fuels alone more than 18×10^{12} tones of CO_2 is being released into atmosphere

each year. In our country, on an average, thermal power plants are likely to release around 50 million tonnes of CO_2 each year in the atmosphere.

To some extent an increase in CO_2 level in atmosphere increases the photosynthesis rate and consequently plant growth, acting as fertilizer especially in hot tropical climates. This potential of fertilizer effect may be exploited by using modified crop varieties and agricultural practices. However, an increase in CO_2 concentration in atmosphere may result into disastrous effects also. This is called *greenhouse* effect (will be discussed later).

Sulphur dioxide: The major source of $S0_2$ emission are burning of fossil fuels (coal) in thermal power plants, smelting industries (smelting sulphur containing metal ores) and other processes as manufacture of sulphuric acid and fertilizers. These account for about 75% of the total $S0_2$ emission. Most of the rest 25% emission is from petroleum refineries and automobiles. It is believed that about 10^9 million tons of S02 are added each year into the global

In our country, also SO_2 emission is on the increase over the years. This is due to a corresponding increase in coal consumption in the country.

SO_2 causes intense irritation to eyes and respiratory tract. It is absorbed in the most moist passage of upper respiratory tract, leading to swelling and stimulated mucus secretion. Moist air and fogs increase the SO_2 dangers due to formation of H_2SO_4 and sulphate ions: H_2SO_4 is a strong irritant (4 - 20 times) than SO_2.

SO_2 is also involved in the corrosion of building materials as limestone marble, the slate used in roofing, mortar etc.

Nitric oxide (NO): The chief source of this gas are the industries manufacturing HNO_3 and other chemicals, and the automobile exhausts. At high temperature, combustion of gasoline produces this gas. A large amount of this is readily converted to more toxic NO_2 in the atmosphere by a series of chemical reactions.

NO is responsible for several photochemical reactions in the atmosphere, particularly in the formation of several secondary pollutants like PAN, O_3, carbonyl compounds etc. in the presence of other organic substances. There is little evidence of the direct role of this gas is causing a health hazard, at the levels found in urban air.

Nitrogen dioxide (NO_2): A deep reddish brown gas, Which is the only widely prevalent coloured pollutant gas. This gas is the chief constituent of photochemical smog in metropolitan areas. NO_2 causes irritation of *alveoli*, leading to symptoms resembling *emphysema* (inflammation) upon prolonged exposure to 1 ppm level. Lung inflammation may be followed by *edema* and final death. The MAC for occupational exposure are set at 5 ppm for an 8 hour period. Smokers may readily develop lung diseases as the cigarettes and cigars contain 330 - 1500 ppm nitrogen oxides. NO_2 is highly injurious to plants. Their growth is suppressed when exposed to 0.3 - 0.5 ppm for 10 - 20 days. Sensitive plants show visible leaf injury when exposed to 4 to 8 ppm for 1-4 hours.

Hydrocarbons: From amongst many, the chief air pollutants are benzene, benzpyrene and methane. Their chief source are the motor vehicles, being emitted by evaporation of gasoline through carburetors, crankcase etc. In

India, two and three-wheelers are the main contributors, and in Delhi and Bangalore, their emission from these accounts for about 65% of the total hydrocarbons. If unchecked this may go up to 80% of the total hydrocarbons of air. About 40% of the vehicular exhaust hydrocarbons are unburnt fuel components, the rest are the product of combustion.

They have carcinogenic effects on lung. They combine with NOx under UV component of light to form other pollutants like PAN and O_3 (photochemical smog) which cause irritation of eye, nose and throat, and respiratory distress.

Benzene a liquid pollutant is emitted from gasoline. It causes lung cancer. *Benzpyrene* is most potent cancer inducing hydrocarbon pollutant. It is also present in small amounts in smoke, tobacco, charcoal boiled stakes, and gasoline exhaust. *Methane* (marsh gas) is a gaseous pollutant, in minute quantity in air, about 0.0002% by volume. In nature this is produced during decay of garbage, aquatic vegetation etc. This is also released due to burning of natural gas and from factories. Higher concentrations may cause explosions. The excess of water seepage in filled up well and pits may lead to excess production of methane which bursts with high sound and may cause local destruction

Aerosols: Aerosols refer to the dispersion of solid or liquid particles of microscopic size in the air. It can also be defined as a colloidal system in which the dispersion medium is gas and the dispersed phase is solid or liquid. The term aerosol is applicable until it is in suspension and after settlement due to its own weight or by addition with other particles (agglomeration) it is no longer an air pollutant. The diameter of the aerosol may range from 0.01 (or less) micron to 100 micron. The various aerosols are as follows:-

Dust: Dust is produced by the crushing, grinding and natural sources like windstorms. Generally the dust particles are over 20 micron in diameter. They do not flocculate but settle under gravity, but smaller particles like 5 micron form stable suspensions.

Smoke: Smoke is made up of finely divided particles produced by incomplete combustion. Generally it consists of carbon particles of size less than 1.0 micron.

Mists: Mist is a light dispersion of minute water droplets suspended in the atmosphere ranging from 40 to 400 micron in size.

Fog: Fog is made up of dispersion of water or ice near the earth's surface reducing visibility to less than 500 m. In natural fog the size of particles range from 1.0 to 40 micron.

Important Air Pollution Phenomenon

Greenhouse effect (Global warming): Since CO_2 is confined exclusively to the troposphere, its higher concentration may act a serious pollutant. Under normal conditions (with normal CO_2 concentration) the temperature at the surface of the earth is maintained by the energy balance of the sun rays that strike the planet and heat that is radiated back into space. However, when there is an increase in CO_2 concentration, the thick layer of this gas prevents the heat from being re-radiated out. This thick CO_2 layer thus functions like the glass

panels of a greenhouse (or the glass windows of a motor car), allowing the sunlight to filter through but preventing the heat from being re-radiated in outer space. This is the so-called greenhouse effect. Thus most heat is absorbed by CO_2 layer and water vapours in the atmosphere. which adds to the heat that is already present. The net result is the heating up of the earth's atmosphere. Thus increasing CO_2 levels tend to warm the air in the lower layers of atmosphere on a global scale. Nearly 100 years ago the CO_2 level was 275 ppm. Today it is 350 ppm. and by the year 2035 and 2040 it is expected to reach 450 ppm. Imagine the earth's temperature. CO_2 increases the earth temperature by 50% while CFCs are responsible for another 20% increase. There are enough CFCs up there to last 120 years. What will be if we do not stop CFC release?

Antarctica ice sheet could begin to melt. A rise of five degrees would raise the sea level by five meters within a few decades, threatening all the densely populated coastal cities from Shanghai to San Francisco. It is suggested that North America would be warmer and drier. The U.S. would produce less grains. On the other hand, North and East Africa, the Middle East, India, West Australia and Mexico would be warmer and wetter, enabling them to produce more grain. Rice- growing season as well as area under rice cultivation could increase. However, this may not happen as higher surface temperature will increase the evaporation of water, thus reducing grain yield. According to U.S. Scientist, George Woodwell, India's annual monsoon rains may even cease altogether.

What are the Effects of global warming on the ecosystems?

With global warming on the rise, and species and habitats decreasing, the chances for ecosystems adapting naturally are diminishing. Many different parts of ecosystems are being affected. Global warming could have many impacts on fish and other aquatic species. Some bodies of water may become too warm for the fish who inhabit that area.

The global warming can also change the chemical composition of water, therefore the amount of oxygen in the water may decline, leaving pollution and salinity levels to increase. more than 20% of world's freshwater fish have become extinct, endangered, or threatened in the recent decades.

Plants also have little ability to adapt to the changing climate. If global warming continues to grow- growing seasons, rainfall patterns, storms, and cycles of flood and drought will occur causing rapid changes in the range and distribution of plants worldwide. Scientists have proven that global warming is real and under way. The effects on the Earth's ecosystem could be devastating. All plants and animals everywhere will be affected in some way.

Global warming can be controlled by adopting following measures:

- **Use Public Transport**: Public transport, public transportation, public transit or mass transit comprises all transport systems in which the passengers do not travel in their own vehicles. While it is generally taken to include rail and bus services, wider definitions would include scheduled airline services, ferries, taxicab services etc. any system that transports members of the general public. A further

restriction that is sometimes applied is that it should take place in shared vehicles, which would exclude taxis that are not shared-ride taxis.

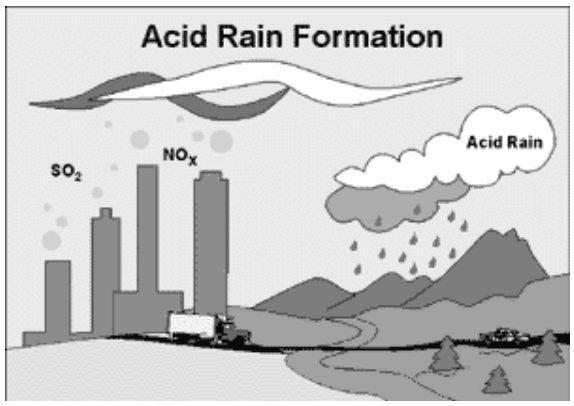
- **Use Renewable Energy Like Wind Power**: One means of reducing carbon emissions is the development of new technologies such as renewable energy such as wind power. Most forms of renewable energy generate no appreciable amounts of greenhouse gases except for biofuels derived from biomass.
- **Burn Methane**: Burning Waste Methane. Methane is a much more powerful greenhouse gas than carbon dioxide. Burning one molecule of methane generates one molecule of carbon dioxide. Accordingly, burning methane which would otherwise be released into the atmosphere (such as at landfills, coal mines, waste treatment plants, etc.) provides a net greenhouse gas emissions benefit.
- **Use Smart Cooler, Heater & Air Conditioner** About half the energy we use in our homes goes to heating and cooling. Changing air filters annually, having your system checked annually and useing a programmable thermostat are all easy things you can do. Just by using a programmable thermostat, you can save about 1,800 pounds of carbon dioxide a year and about $100 a year in energy costs. If you want to go the extra mile, see “Bonus Tips” below for how to purchase green power.
- **Tune up and maintain vehicles properly** Unscientific maintain of vehicle leads to environment pollution. Vehicles, regardless of category are increasing day by day all over the world. The smoke released by these vehicles damage ozone layer. But it is impossible to stop the arrival of new vehicles. What can be done to the maximum is, to maintain the vehicles properly. Adopting scientific method to maintain your loved cars and bikes will play predominant role in controlling global warming.
- **Clean the air in your house.** Cleaning the air inside the house is most important thing. By doing so you will automatically contribute for global warm control. There are many things you can do to clean your house. Use proper vacuum cleaner for the purpose. Clean regularly and continuously. Put dust avoiding curtains and use houseplants. Do not keep the dustbin unchecked. lso don’t mess the surroundings of your house. Even take maximum care while dispatching waste materials. Try to grow as much as saplings inside your compound.
- **Reduce electricity usage to the maximum** Switch off unwanted electric equipments immediately. Or do not use them if not necessary. Often we find shining tube, unning fan, running TV…etc. One may be sound enough to pay the electric bill in the end of the month, but what about the energy that has been wasted? Replace the old ones with energy efficient lighting. Also, improve the efficiency of ome appliances. If not possible, go for an energy saving appliances.
- **Prefer recycling** Preferring reusable products instead of disposables will help in reducing the waste. When you buy a product, make sure that the packing is quite reasonable one. In other words, packing should not exceed the size of the product. Always try to recycle household waste. By recycling the

household waste, one can save 2,400 pounds of carbon dioxide annually.Here both the entrepreneurs and public should join hands together for a cause. Always try to educate others on preferring recycling products.

Acid Rain: We have seen that the oxides of sulphur and nitrogen are important gaseous pollutants of air. These oxides are produced mainly by combustion of fossil fuels, smelters, power plants, automobile exhausts, domestic fires etc. These oxides are swept up into the atmosphere and can travel thousands of kilometers. The longer they stay in the atmosphere, the more likely they are to be oxidised into acids. Sulphuric acids and nitric acid are the two main acids, which then dissolve in the water in the atmosphere and fall to the ground as *acid rain* or may remain in atmosphere in clouds and fogs.

"Dad, what's acid rain?"

Acidification of environment is a man-made phenomenon. The acid rain is infact a cocktail of H_2SO_4 and HNO_3 and the ratio of the two may vary depending on the relative quantities of oxides of sulphur and nitrogen emitted. On an average 60-70% of the acidity is ascribed to H_2SO_4 and 30-40% to HNO_3. The acid rain problem has dramatically increased due to industrialization. Burning of fossil fuels for power generation contributes to almost 60- 70% of total SO_2 emitted globally. Emission of NO_x from anthropogenic sources ranges between 20-90 million tons annually over the globe. Acid rains have assumed global ecological problem, Because oxides travel a long distance and during their journey in atmosphere they may undergo physical and chemical transformations to produce more hazardous products.



Acid rains create complex problems and their impacts are far reaching. They increase soil acidity, thus affecting land flora and fauna; cause acidification of lakes and streams thus affecting aquatic life, affects crop productivity and human health. Besides these they also corrodes buildings, monuments, statues, bridges, fences, railings etc. British Parliament building also suffered damage due to H_2SO_4 rains. Due to acidity, levels of heavy metals as aluminium, manganese, zinc, cadmium, lead and copper in water increases beyond the safe limits. Over 10,000 lakes in Sweden have become acidified. Thousands of lakes in U.S.A., Canada, Norway have become unproductive due to acidity. Fish population has decreased tremendously, and there are deaths of *salman* trout etc. The fish less areas (lakes) are now fish graveyards.

Many bacteria and blue green algae are killed due to acidification, thus disrupting ecological balance.

Ozone Layer Depletion: Cholorfluromethane and CFC's rise into upper atmosphere where they release chlorine atoms which then chain-react with ozone, converting ozone to oxygen. Electric discharge reactions including lighting and electric sparks from motors, also convert oxygen into ozone. So far about 1% ozone has been depleted and likely to be depleted by 16% in next 25 years. If this should occur, it would allow more UV radiations from sun to earth to cause human skin cancer and rise in surface temperature of our planet.

$$CO_2 + H_2O = (CH_2O)n + O_2 \quad \text{(In the presence of light)}$$

Ozone shield depletion means :

- Increase of cancer patients
- Adversely affect environment and vegetation: In plants, O_3 enters through stomata. It produces visible damage to leaves, and thus a decrease in yield and quality of product products. O_3 alone and in combination with SO_2 and NO_x, is causing crop losses of over 50% in several European countries.
- Destroy DNA in living organisms

Causes of Ozone shield depletion :

- CFC's : In case of Panasonic planes(planes faster than sound) the chlorine contained in the CFC which are used as propellants in aerosols, as refrigerants and coolants in air conditioners is chiefly responsible for the depletion in ozone layer.
- Use of nitrogen manure : It emits NO(Nitric Oxide) which too depletes Ozone(O_3).
- Explosion of nuclear and thermo nuclear by experiments and otherwise.
- Deforestation which cause depletion in oxygen and finally in O_3.
- Automobile and transportation is also a cause for Ozone depletion.

What is ozone?

Ozone (O_3) is a highly reactive gas composed of three oxygen atoms. Depending on where it is in the atmosphere, ozone affects life on Earth in either good or bad ways.

Stratospheric ozone is formed naturally through the interaction of solar ultraviolet (UV) radiation with molecular oxygen (O_2). The stratospheric "ozone layer" extends from approximately six to thirty miles above the Earth's surface and reduces the amount of harmful UV radiation reaching the Earth's surface.

Tropospheric, or ground-level, ozone forms primarily from reactions between two major classes of air pollutants: volatile organic compounds (VOCs) and nitrogen oxides (NO_x). These reactions depend on the presence of heat and sunlight, meaning more ozone forms in the summer months.

Photochemical smog: It is highly oxidising polluted atmosphere comprising largely of O_3, NO_x, H_2O_2, organic peroxides, PAN etc. This is produced as a result of photochemical reaction among NO_x hydrocarbons and oxygen. During 1940s, the Los Angeles, U.S.A. smog was primarily the result of pollution by domestic fires (50%) and by the exhaust from the motor vehicles (50%). This pollution caused eye irritation and reduced visibility. The mystery was unraveled only in 1950 that the smog was due to an oxidising mixture of NO_x and hydrocarbons emitted from fumes and exhaust of automobile in presence of UV radiation of sunlight. The photochemical smog formation occurred only during night or cloudy days. The word smog is coined by combining smoke and fog which characterized air pollution episode in London, Glasgow, Manchester and other cities of U.K. where sulphur-rich coal was used. The U.K. smog was a mixture of reducing pollutants and has been called reducing smog, whereas Los Angeles smog, a mixture of oxidising pollutants is called oxidising smog or photochemical smog.

In our country, situation in Mumbai, Kolkata, Delhi, Chennai, Bangalore, Ahmedabad and Kanpur seems to be alarming, as the chief source of air pollution in these cities are automobiles and industries. In 1987, Bombay experienced a heavy smog for about ten days. The formation of oxidants, particularly of O_3 when exceeds 0.15 ppm for more than an hour in atmosphere indicates the photochemical smog formation.

Photochemical smog adversely affects plants, human health and materials. The oxidants enter as part of inhaled air, and alter, impair or interfere with respiratory process and other processes. Serious outbreak of smog occurred in Tokyo, New York, Rome and Sydney in 1970, causing spread of diseases as *asthma* and *bronchitis* in epidemic form. Tokyo- Yokohama asthma occurred in 1946 in some American soldiers and families living in smoggy atmosphere of Yokohama, Japan. Another serious disease caused by smog is *emphysema*, a disease due to structural breakdown of alveoli of lungs. The total surface area available for gaseous exchange is reduced and this causes severe breathlessness.

Sulfurous Smog Sulfurous smog (also called winter smog and London smog) was first noted in London during the industrial revolution. Sulfurous smog is a mixture of sulphur dioxide and smoke that is trapped by fog over cities during the winter months. Industrial Revolution-era households primarily used coal for cooking and heating, clogging the air with sulfurous smoke. Also, factories at the time did not have laws governing pollutant dispersion. Tougher emissions restrictions and modern technology means that sulfurous smog is no longer so prevalent.

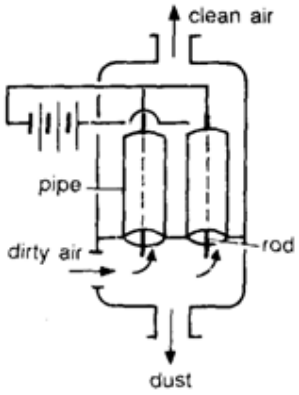
One well-known characteristic of sulfurous smog was its dense, dark haze, starkly impairing visibility in industrial cities during the 18th and early 19th centuries. Sulfurous smog in London at the time often grew so thick that seeing across the street was difficult to impossible on some days. The impact on the population's health has been well-documented, with cases of asthma, emphysema, bronchitis and severe lung infection cited during that time. In 1952, when automobiles became commonplace in the city, therefore adding to the deteriorating air conditions, a 5-day sulfurous smog was responsible for more than 4,000 deaths in the city of London.

The 1952 tragedy prompted Great Britain to impose The Clean Air Act of 1956. The act moved factories from city centers to less populated areas and introduced the use of tall factory chimneys for better pollutant dispersion. It also imposed smokeless zones where only smokeless fuels could be burned and introduced cleaner fuels such as gas, electricity and cleaner coals for household use. Later in the United States, the Clean Air Act of 1963 gave the EPA the power to set limits on certain air pollutants and limit emissions from such industries as steel mills and utility plants.

Air Pollution Control Equipments

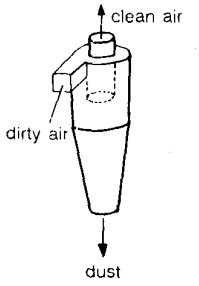
Filters : Filters are the devices of removal of particulate matter (dust etc.) from gas stream and retention of the particle in or on an a porous structure through which gas flows. Common filter media used are cotton, wool, nylon, or long, Teflon etc. The design of fabric filters is based on filtering rates or air to cloth ratios.

Electrostatic Precipitators (ESP): In ESP, electrical charge is imparted to the particulate by passing the particles through a high voltage direct current (DC) corona.



The high voltage field ionizes the gas molecules in the air stream, which in turn become attached to the particulate matter and give them a negative charge. After being charged, the negative particles move toward positive electrodes and are collected there. ESP are extremely efficient (99%) can handle large volume of gas and has low pressure drop. But the cost of ESP is very high (For 30 MW thermal power plant its cost is about 3 crores).

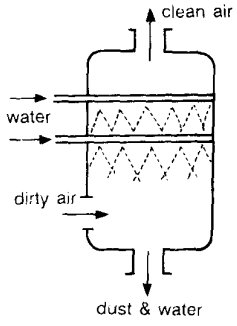
Cyclones: In cyclones, organized vortex motion is created within the collector providing force to propel particles to a location from where they may be removed.



cyclone

A cyclone collector consists of o cylindrical shell, conical base, dust hopper, and an inlet from where dust laden gas enters tangentially. Cyclones are relatively inexpensive to construct and operate.

Scrubbers: Scrubbers are the devices in which contact liquid with collector is the main means of collection of particles from carrier gas stream. The operational range for particle removal by scrubbers include material less than 0.2 micron in diameter to large particles which can be suspended in the gas phase.



wet scrubber

The efficiency of scrubber is dependent to a great extent upon impingement and Brownian diffusion. Common types of scrubbers are spray towers, venturi scrubbers, cyclone scrubbers etc.

Euro I and Euro II Norms

The imposition of Euro I and Euro II norms has not come a day too soon. A petrol driven four wheeler which adheres to Euro II norms, depending upon its engine capacity, would emit 2-3 times less carbon monoxide and 3-4 less hydrocarbons and nitrogen oxides than the currently stipulated levels.

Its diesel counterpart, depending upon the gross vehicle weight, would be required to meet emission norms that compared to present levels, are 1.2-2 times stricter for carbon monoxide and double this value for nitrogen oxides (NOx). Notably, for the first time in India, emission norms would also be set for particulate matter.

Air Pollution Due to Automobiles

The current set of diesel vehicles on our roads emits inordinate amounts of particulate matter, NOx and sulphur dioxide. Of highest concern are the fine, respirable particles of sizes 10 and 2.5 microns (PM10 and PM2.5) which are highly carcinogenic and carry toxic heavy metals with them.

Given the poor maintenance of vehicles in India, there is a tendency for vehicles to pollute more as they get older. Solution could lie in mandatory periodic fitness certification for all such vehicles.

A rigorous maintenance schedule by the owner and genuine certification by authorized service stations would be the key elements of any such effort.

Even with the best of maintenance standards, the older vehicles may still cause an unacceptable level of pollution.

The government could create a set of fiscal incentives for purchase of a new vehicle in lieu of the polluting relic.

The time has also come to shift part of the air pollution debate to the prevailing fuel quality standards. The oil refineries still produce diesel with high levels of sulphur, and leaded petrol is even now a reality.

Moreover, fuel adulteration is rampant. For vehicles to conform to Euro I and II norms, it is imperative that petrol and diesel adhere to specific fuel properties.

Substituting lead in petrol by oxygenates such as methyl tertiary butyl ether would boost its octane value and reduce the emissions of toxic substances such as benzene, toluene, and xylene.

Further, increased use of clean substitute fuels such as oxygenated blends, compressed natural gas, and propane in captive fleet vehicles (buses, taxis, 3-wheelers) should be vigorously promoted. Thus, the crucial role of oil refineries in improving air quality cannot be overstated.

The solution, thus, lies in collaboration among the automotive and oil companies.

CARBON FOOTPRINT

A carbon footprint is defined as:

The total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO_2).

In other words: When you drive a car, the engine burns fuel which creates a certain amount of CO_2, depending on its fuel consumption and the driving distance. (CO_2 is the chemical symbol for carbon dioxide). When you heat your house with oil, gas or coal, then you also generate CO_2. Even if you heat your house with electricity, the generation of the electrical power may also have emitted a certain amount of CO_2. When you buy food and goods, the production of the food and goods also emitted some quantities of CO_2.

Your carbon footprint is the sum of all emissions of CO_2 (carbon dioxide), which were induced by your activities in a given time frame. Usually a carbon footprint is calculated for the time period of a year.

The best way is to calculate the carbon dioxide emissions based on the fuel consumption.

WATER POLLUTION AND ITS CONTROL

Causes of Water Pollution

When toxic substances enter lakes, streams, rivers, oceans, and other water bodies, they get dissolved or lie suspended in water or get deposited on the bed. This results in the pollution of water whereby the quality of the water deteriorates, affecting aquatic ecosystems. Pollutants can also seep down and affect the groundwater deposits.

Water pollution has many sources. The most polluting of them are the city sewage and industrial waste discharged into the rivers. The facilities to treat waste water are not adequate in any city in India. Presently, only about 10% of the waste water generated is treated; the rest is discharged as it is into our water bodies. Due to this, pollutants enter groundwater, rivers, and other water bodies. Such water, which ultimately ends up in our households, is often highly contaminated and carries disease-causing microbes. Agricultural run-off, or the water from the fields that drains into rivers, is another major water pollutant as it contains fertilizers and pesticides.

Domestic sewage refers to waste water that is discarded from households. Also referred to as sanitary sewage, such water contains a wide variety of dissolved and suspended impurities.

Water Pollutants

Inorganic Solids: Sources are (i) industrial waste (ii) nature.

- make water hard.
- interfere with dyeing in textile industries and quality of the product in canning industries
- *Mg* has a cathartic effect on people
- *Iron* causes spots and stains on white goods manufactured by textile and paper mills.
- growth of *algae* takes place in surface waters due to presence of nitrogen and phosphorous.

Acids: Sources are chemical and other industries.

- cause eye irritation to swimmers
- cause rapid corrosion of ships
- cause deterioration of fisherman nets

- for the survival of aquatic life pH should be between 4.5 to 9.5 but industrial liquid waste contains pH between 2 to 11.

Alkalies: Sources are soap manufacturing units, textile industries, dyeing industries, leather tanning etc.

- more than 25 mg/l concentration of alkalies is deadly to fish life.
- affects yeast activity in brewing of beer
- affects taste of canned fruits

Organic Matter:

- Exhausts the oxygen resources of the river and create unpleasant taste, odour and general septic conditions. The fish and other aquatic life feel stifled by lack of O_2.
- Phenol in the water affects the taste
- Cause discomfort and disease

Suspended Solids:

- Cause depletion of oxygen
- cover spanny grounds for fish
- visible sludge gives a filthy look and destroys the use of river for swimming and bathing.
- increase turbidity of water

Floating Solids/Liquids (Oil, Grease, Etc.):

- give filthy look to water body
- interfere with natural reaeration
- toxic to certain species of fish and aquatic life

Heated Water (Thermal Pollution):

- Resulting hot stream water from the outlet of an upstream industry, is of little value for industrial cooling of a downstream industry.
- dissolved oxygen in water decreases hence aquatic life suffers.

Colour: Sources are textile, pulp and paper industries, tanneries, slaughter houses and other industries.

- colour present in waste water interferes with transmission of sunlight and hence decrease the rate of photosynthesis in water.
- colour in water focus direct public anguish against industries.

- property value decreases along a dirty water body

Toxic Chemicals:

- various pesticides viz. DDT, BHC, etc. kill fish or reduce reproductivity capacity
- chloride (< 4000 mg/l) heaxavalent chromium (< 5 mg/l) and copper (0.1 to 0.5 mg/l) are toxic to bacteria and other micro organisms.

Pathogens:

- From the public health standpoint, the bacteriological quality of water is as important as the chemical quality. A large number of infectious diseases may be transmitted by water, among them typhoid and cholera.
- Microorganisms causing diseases that characteristically are waterborne prominently include protozoa and bacteria, many of which are intestinal parasites, or invade the tissues or circulatory system through walls of the digestive tract.
- Various other waterborne diseases are caused by viruses

Quality of Water Required for Municipal Uses

Municipal water required for domestic uses, particularly the water required for drinking, must be colourless, odourless and tasteless. It should be free from turbidity or chemical compounds. Harmful micro organisms and radio activity must be absent. The quality of water for municipal supplies is ,therefore generally controlled throughout the world, and even the World Health Organization (W.H.O.) has laid down its International Standards for potable waters.

Following table shows the International Water Quality Standards specified by W.H.O., which are widely accepted all over the globe.

International water Quality Standards for Drinking Waters by W.H.O.

Substances	Highest desirable level	Maximum permissible level
Colour	5 units on platinum cobalt standard	50 units on platinum cobalt standard
Odour	unobjectionable	unobjectionable
Taste	unobjectionable	unobjectionable
Turbidity	5 units on silica scale	25 units on silica scale
Total Solids	500 mg/l	1500 mg/l
pH Range	7 to 8.5	6.5 to 9.2
Total Hardness	100 mg/l as $CaCO_3$	500 mg/l as $CaCO_3$
Calcium	75 mg/l	200 mg/l
Magnesium	50 mg/l	100 mg/l
Iron	0.3 mg/l	1.0 mg/l

Chlorides	200 mg/l	600 mg/l
Sulphates	200 mg/l	400 mg/l
Fluorides	0.5 mg/l	1 to 1.5 mg/l
Arsenic	-	0.02 mg/l

Quality of Water Required for Industries

Strictly speaking, the quality of water required for industries depends on the requirement of a particular industry. But, in general, it can be stated that 80 % of industrial water is used for cooling and need not be of high quality, while the water required for processing or for boiler feed purposes must be of high quality. Water required for raising steam in boilers must be soft, as otherwise, the hard waters will cause encrustations on the inside of boilers, thus offering resistance to heat transfer. Hard waters also cause foaming and priming and therefore boilers using hard waters do require frequent cleaning and other treatments. In certain cases, the industrial water must have lower content of dissolved salts than what is permitted in the drinking water. The water required for turbines of power house boilers should be free from corrosive action, and hence, its pH should not be less than 7.0 i.e. the water should not be acidic. The presence of sodium in water is harmful for irrigation but is generally considered useful for industrial supplies, because it makes them soft. The water quality requirement of certain industries are given below :

Quality of Water for Irrigation

Good quality water applied for irrigation improves the soil because of calcium content in the water and beneficial effects derived from leaching of any excess salts from the soil. Use of bad quality water for irrigation results in loss of the fertility and drainage characteristics of soils and also become toxic to the plant and as a consequence the soil deteriorates and crop yield reduces. The quality of water suitable for irrigation of vegetables must have relatively low soluble salts content, free from micro organisms associated with human or animal disease, sewage or spoilage of food and other organic matter. On account of this quality requirement, water from contaminated wells or streams considered suitable for irrigation of many other crops may not be of use for some vegetables.

The suitability or otherwise of irrigation water is determined on the basis of the following considerations :

- Soluble salts present as are harmful to plants.
- Chemicals present as react with the soil to produce unsatisfactory conditions.
- Nature of soil to be irrigated.
- Types of crops grown.
- Bacteria present in the water as are injurious to crops, persons or animals consuming plants.

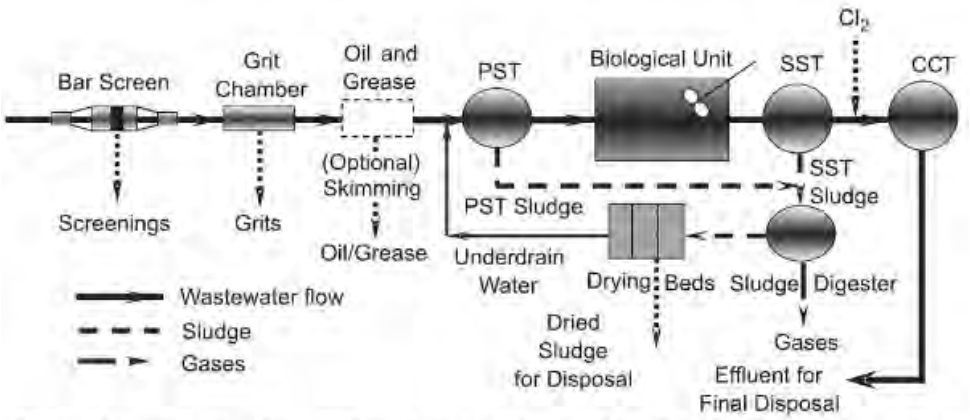
Waste Water Treatment Processes

Objectives : To reduce

- biological oxygen demand (BOD)

- suspended solids
- pathogenic organisms
- non biodegradable component
- dissolved solids

See following treatment plant flow diagram.



PST — Primary Settling Tank, SST — Secondary Settling Tank, CCT — Chlorine Contact Tank

Pretreatment: Refers to screening of coarse solids, reducing size of solids in water, separating floating oil and adjusting the incoming flow (equalization).

Bar Screening	coarse solid removal
Grit chamber	Grit/Sand removal
Grease trap	floating liquid removal
Equalization tank	flow adjustment
Neutralization	pH control

Primary Treatment : Refers to removal of suspended solids in water which could not be separated in pretreatment. *Sedimentation tanks* are used most commonly for this purpose. Chemicals may also be added in primary treatment to neutralize the stream or to remove very small suspended solids.

Secondary Treatment : It involves a biological process to remove organic matter. Process design depends upon quantity of waste water, biodegradability of waste and availability of land. *Activated sludge reactor* and *trickling filters*, are two most commonly adopted processes.

Tertiary Treatment: Advance treatment methods

Chemical Coagulation	Precipitation of phosphates
Nitrification	Biological removal of nitrates
Adsorption	Removal of toxic chemicals

SOLID WASTE POLLUTION

The solid waste includes glass containers as bottles, crockery, plastic containers, polythene and other packing materials that are used and then thrown away as garbage. These pile up at public places and cause obstruction in daily life. besides these there are also other used things like automobile spares, machines, cyc1e parts etc. that are thrown as junk. The wastes from building material (during construction and demolition), sludge, dead animal skeletons, heaps of crop residues also contribute to solid waste.

In India also, several million tons of solid waste is dumped along high ways and other places in large cities as Delhi, Mumbai, Kolkata, Chennai, Ahmedabad, Jaipur etc. On an average over 2 million tons of solid state is generated in class I cities, per year, whereas in class II cities about 0.25 million tons/year.

There is problem of disposal of these wastes especially in developed countries where labour is very expensive. In India, most of junk is purchased by hawkers and resold after profit. Used vehicles are creating much problem in Western world

To solve these problems technologies have been developed to recycle most of the solid waste items. Thus paper cans, newspapers and other waste paper may be easily recycled. Metallic components of vehicle spares may be recycled by cheap methods. However, there is problem of recycle of heavy metals, plastics, nylon, polythene etc.

Classification of Solid Waste

- **Domestic/Residential waste:** This type of waste is originated from single or multifamily household units. These wastes are generated from the household activities.
- **Municipal waste:** Municipal waste includes waste resulting from municipal activities and services such as street sweepings, dead animals, market waste and abandoned vehicles.
- **Commercial waste:** This category includes solid wastes that originate in offices, wholesale and retail markets, restaurants, hotels, warehouses (godowns) and other commercial establishments.
- **Institutional waste:** These are those wastes generated from institutions such as schools, colleges, universities, hospitals and research institutes.
- **Garbage:** Garbage is the term applied to animal and vegetable wastes generated from the handling, storage, sale, preparation, cooking and serving of food. Such wastes contain putrescible (easily and quickly biodegraded with bad smell) organic matter. This attracts rats, flies, mosquito and other vermin, that is why it requires immediate attention.
- **Rubbish**: It is a general term applied to solid wastes originating in households, commercial establishments and institutions excluding garbage and ashes.

- **Ashes**: These are the residues from the burning of wood, coal, charcoal, coke and other combustible matter for cooking and heating in houses institutions and small industries. When produced in large quantities in thermal power plants (fly ash) they are known as industrial wastes.
- **Bulky waste:** Bulky wastes are large household wastes that cannot be accommodated in the normal storage containers of the household and thus they require special collection. Actually in India there is hardly any waste collected in this category as it is sold to the kabaries.
- **Street sweepings:** The waste collected from streets, walkways, parks etc. is known as street sweepings.
- **Dead animals:** This term includes the dead animals that die naturally or by accidents on roads. It does not include the animal parts from slaughter houses which are regarded as industrial waste.
- **Construction and demolition waste:** These are the wastes generated by the residue of the construction, refurnishment, repair and demolition of houses, commercial buildings and other structures. Generally, the demolition waste is used by the contractors in filling low lying areas and the plinth filling of new houses.
- **Industrial wastes:** The discarded solid material of manufacturing processes and industrial operations comes in this category.
- **Hazardous waste:** Hazardous waste is defined as wastes of industrial, institutional or consumer origin that, because of their physical, chemical or biological characteristics are potentially dangerous to human beings and the environment.
- **Sewage waste:** The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and produced from the treatment of organic sludge from both the raw and treated sewage.

Plastic Bag Pollution

Every year, around 500 billion (500,000,000,000) plastic bags are used worldwide. So many that over one million bags are being used every minute and they're damaging our environment.

India's plastics consumption is one of the highest in the world. Yet, precious little has been done to recycle, re-use and dispose of plastic waste. Plastic bags are difficult and costly to recycle and most end up on landfill sites where they take around 300 years to photo degrade. They break down into tiny toxic particles that contaminate the soil and waterways and enter the food chain when animals accidentally ingest them. But the problems surrounding waste plastic bags starts long before they photo degrade. Our planet is becoming increasingly contaminated by our unnecessary use of plastic carry bags. Big black bin liners, plastic carrier bags carrying advertising logos, clear sandwich bags, vegetable bags and a variety of other forms used to carry our daily food items and other

items are all polluting our environment. Just take a look around you. Plastic bags can be seen hanging from the branches of trees, flying in the air on windy days, settled amongst bushes and floating on rivers. They clog up gutters and drains causing water and sewage to overflow and become the breeding grounds of germs and bacteria that cause diseases.

Animals and sea creatures are hurt and killed every day by discarded plastic bags - a dead turtle with a plastic bag hanging from its mouth isn't a pleasant sight but mistaking plastic bags for food is commonplace amongst marine animals. Plastic clogs their intestines and leads to slow starvation. Others become entangled in plastic bags and drown. Because plastic bags take hundreds of years to break down, every year our seas become 'home' to more and more bags that find their way there through our sewers and waterways. Given India's poor garbage collection facilities, tons of plastic bags litter the roads, preventing rainwater from seeping into the ground. Hundreds of cows die in New Delhi alone every year when they choke on plastic bags while trying to eat vegetable waste stuffed in the garbage.

Every bag that's washed down a drain during rainfall ends up in the sea every bag that's flushed down a toilet (many mall bags are), ends up in the sea - every bag that's blown into a river will most likely end up in the sea. Besides choking drains, plastics are highly toxics. When burned they release cancer-causing gases. Lying in the garbage, polythene bags also find their way in gut of cattle, asphyxiating the animals. The cheap bags contain chemicals such as cadmium- or lead-based chemicals that are harmful to health. They leach into vegetables, meat and food.

An estimated 15 lakh computers and 30 lakh mobile phones are disposed of every year in India. "Computers, mobiles and other electronic items generate hazardous e-waste like lead, brominated flame retardants and chromium which can cause cancer," There is another problem: India has more to deal with than just the waste generated at home. The Environment Protection Authority of Britain recently said 23,000 tonnes of e-waste was dumped in India, China and Pakistan.

Several countries have already banned their use and more will doubtless follow. Several Indian states such as Maharashtra, Delhi, Punjab, Rajasthan, Himachal Pradesh, Goa etc. banned their use. Mumbai's storm water drainage choking with accumulated plastics waste, making the floods unmanageable, is an old story. The Environment Ministry has banned manufacture and use of plastics carry bags less than 8 inches X 12 inches in size 20 micron in width. The ministry has also asked State Governments to register all plastics manufacturing unit, so that these can be regulated. However, the implementation of the order has been tardy, evident from the large number of polythene bags strewn in every major town and city.

The alternative to plastic bags are paper bags, jute bags and cloth bags. Paper, Jute and Cloth are eco-friendly. Jute bags are most suitable substitute then paper and cloth, because it is cheaper then cloth and reusable. Though paper bags are cheaper then jute bags but less durable. The West Bengal Government, which has decided to ban plastic bags in Kolkata and other prominent towns and cities in the State, intends to make use of jute bags mandatory through suitable legislation.

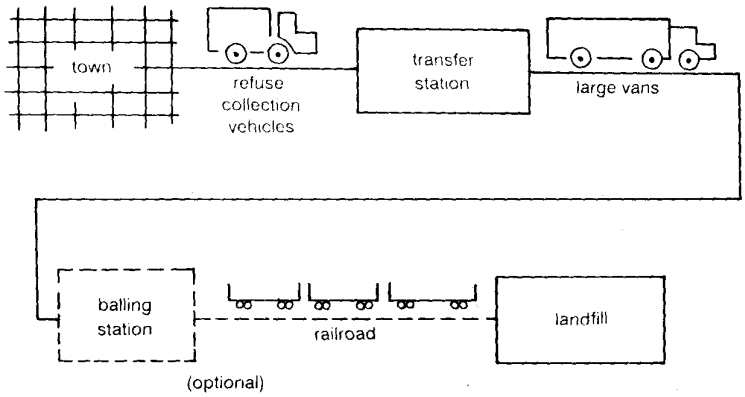
Solid Waste Collection

Solid waste can be disposed to land or oceans. Solid wastes can also be recovered and reprocessed, a procedure popularly known as *recycling*. Before disposal or recovery, however, the waste must be collected. All these i.e. collection, disposal and/or recovery form a part of the solid waste management system.

The common method of collection is by covered truck. Much time is spent in loading and its transport to dumping or recovery site. Many new devices and methods have been proposed to cut collection cost. These include the following.

Garbage grinders reduce the amount of garbage in refuse. If such grinders are used, this cuts the frequency of collection in communities.

Pneumatic pipes have been installed in small communities, mostly in Japan and Sweden. The refuse is ground at home and sucked through underground lines. One system in U.S.A. is in the Walt Disney ,World in Florida. Pneumatic pipes receive the refuse from Park and deliver the waste to a central processing plant.



Garbage collection

Compactors in the kitchen also reduce cost collection. Stationary compactors have also been installed in commercial establishments.

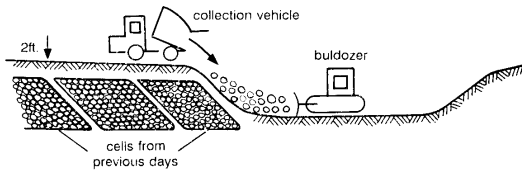
Transfer stations are applicable to larger communities. A typical system (see figure) involves several stations scattered around a city to which collection trucks bring the waste. The drive to the nearest station is fairly short. At transfer station bulldozers cram this refuse into large vans, which in turn take the material to final disposal.

Solid Waste Disposal

Dumping: It is the most inexpensive and most popular means of solid waste disposal.

Sanitary landfills: It differ markedly from the open dumps. Whereas open dumps are simply dumping places, sanitary landfills are engineered operations, designed and operated according to acceptable standards. The basic

principle of a landfill operation is to deposit the refuse, compact it with bulldozers, and cover the material (see figure) with at least 15 cm. of dirt at the conclusion of each days' operation arid a final cover of 60 cm. when the area is full. The engineering aspects include (i) drainage - rapid runoff to lessen mosquito problems, (ii) wind - it is preferable that the landfills be downwind from the community, (iii) distance from collection, (iv) size - a small site with limited capacity is not desirable, (v) ultimate use -area be utilised for public use or private use after the operation is complete.



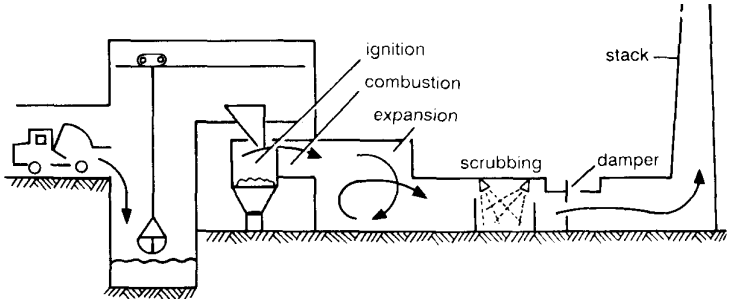
Sanitary landfill

The landfill operation is in fact a biological method of waste treatment. Under anaerobic condition, organics are degraded to more stable forms. The end products are mostly gases, CO_2, CH_4, NH_3 and a little H_2S. These are allowed to escape through small vents.

Solid Waste Volume Reduction

Since land may be expensive, the cost of land filling can be high. Accordingly various methods are adopted to reduce the volume of Waste. These are as follows.

Incineration: It reduces the volume of waste to 20 to 30% of the original volume and makes the product stable. A schematic of a typical incinerator is shown in figure.



Incineration

Disadvantages of incineration are as follows:

- The incineration process produces two types of ash. Bottom ash comes from the furnace and is mixed with slag, while fly ash comes from the stack and contains components that are more hazardous.
- Toxics are created at various stages of such thermal technologies, and not only at the end of the stack.

- The pollutants which are created, even if trapped, reside in filters and ash, which need special landfills for disposal. Such projects disperse incinerator ash throughout the environment which subsequently enter our food chain.
- Waste incineration systems produce a wide variety of pollutants which are detrimental to human health.
- Dioxin is a highly toxic compound which may cause cancer and neurological damage, and disrupt reproductive systems, thyroid systems, respiratory systems etc.

Shredding: In this method, solid wastes are shredded and then speeded the material on fields.

Pyrolysis: It is the combustion in *absence of oxygen*. The residues of this process are of economical value. The combustible gas, tar and charcoal are to be accepted as raw material. Pyrolysis not only reduces the volume but also produces stable end products.

Recycling

After the material has been collected from consumers, it must be cleaned, sold to an industry, transported, remanufactured and (most important) sold once again to consumers. The two basic reasons for recycling are, (i) conservation of resources, and (ii) reduction in volume of refuse to be disposed. Some of the common materials, suggested as paper, metals, glass and organics.

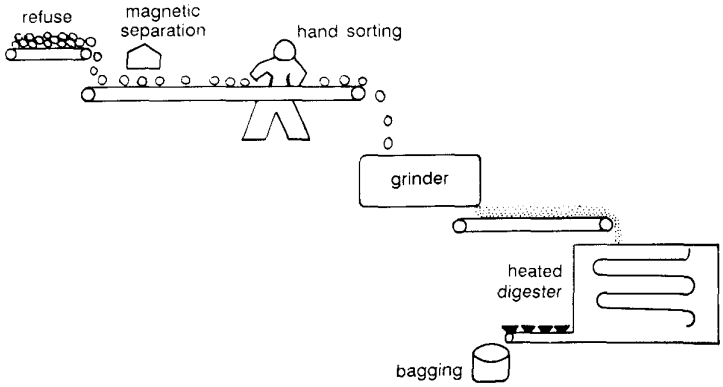
Paper is available in plentiful supply. Recycling of paper would save our forests. But this may come true provided that we are able to create a market for recycled paper, and make virgin paper artificially expensive.

Metals can be easily recycled from industrial scrap, which is the largest source of secondary metals. Another important source of the waste material are wrecked automobiles and aluminium cans.

Glass is the perfect product for recycling. However, it is about as expensive to make a new glass bottle as to recycle or refill an old one. Also, the raw materials for glass are in such plentiful supply that hardly anything is gained through recycling.

Composting: Organics can be converted into several useful products. The most common process, used extensively in many countries is *composting*. Composting, in contrast to landfill, is an aerobic method of decomposing solid waste. Typically, a composting operation involves (i) the segregation of refuse into organic and inorganic components (either by household or the plant), (ii) grinding of the organic component, and (iii) stabilizing in either open piles or in mechanical digesters.

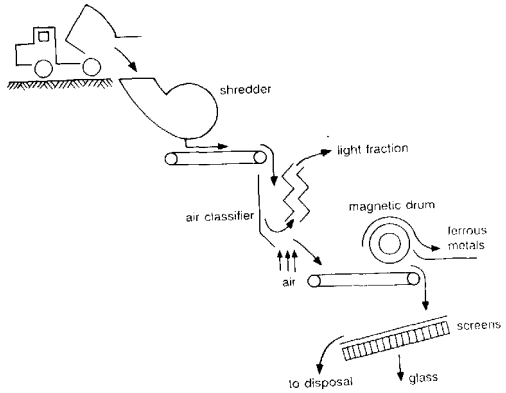
After separation of metals and grinding, the organic material is commonly placed in long piles called windrows, 3 m wide and 1.8 m high. Under such conditions, enough oxygen and moisture are available to support aerobic life. Temperature within a windrow is around 60^0 C and pH finally reaching to neutral.



Composting operation

Additional inoculants are not required. At the end of operation, the compost should have an earthy smell, similar to peat moss, and should have a dark brown colour. Most composting plants have automated windrows. These units called digesters aerate the mixture and help maintain an optimum moisture concentration (see figure).

Automatic recycling stations: Public is not involved in the separation effort, and the total refuse is put through a processing plant much like wastewater treatment plants. A typical plant is shown in figure.



Automatic recycling plant

After shredding, the light fraction (paper, plastics etc.) is separated in an air classifier, the heavy materials drop to the bottom. A magnetic drum next picks up the magnetic (ferrous) materials and a screen is used to remove the now shredded glass. The metals are sold for reprocessing and the light fraction is often burnt for heat or power.

Fly Ash and its Use

Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of coal-fired power plants, and is one of two types of ash that jointly are known as coal ash; the other, bottom ash, is removed from the bottom of coal furnaces.

The reuse of fly ash as an engineering material primarily stems from its pozzolanic nature, spherical shape, and relative uniformity. Fly ash recycling, in descending frequency, includes usage in:

- Portland cement and grout
- Embankments and structural fill
- Waste stabilization and solidification
- Raw feed for cement clinkers
- Mine reclamation
- Stabilization of soft soils
- Road subbase
- Aggregate
- Flowable fill
- Mineral filler in asphaltic concrete
- Other applications include cellular concrete, geopolymers, roofing tiles, paints, metal castings, and filler in wood and plastic products.

BIOMEDICAL WASTE

Biomedical waste consists of solids, liquids, sharps, and laboratory waste that are potentially infectious or dangerous. It must be properly managed to protect the general public, specifically healthcare and sanitation workers who are regularly exposed to biomedical waste as an occupational hazard.

Biomedical waste differs from other types of hazardous waste, such as industrial waste, in that it comes from biological sources or is used in the diagnosis, prevention, or treatment of diseases. Common producers of biomedical waste include hospitals, health clinics, nursing homes, medical research laboratories, offices of physicians, dentists, and veterinarians, home health care, and funeral homes.

The following is a list of materials that are generally considered biomedical waste:

Solids

- Catheters and tubes
- Disposable gowns, masks, and scrubs

- Disposable tools, such as some scalpels and surgical staplers
- Medical gloves
- Surgical sutures and staples
- Wound dressings

Liquids

- Blood
- Body fluids and tissues
- Cell, organ, and tissue cultures
- Sharps
- Blades, such as razor or scalpel blades
- Lancets
- Materials made of glass, such as cuvettes and slides
- Needles
- Plastic pipettes and tips
- Syringes

Laboratory waste

- Animal carcasses

Medical Waste Disposal

Incineration of medical waste, as with any waste, has the advantage of being able to dramatically reduce the volume of the waste. Disadvantages of incineration include its high costs and potential pollution hazards.

In the primary combustion chamber, waste is dried, heated, and burned in the presence of about 80% of the stoichiometric oxygen (oxygen needed for complete combustion). The combustion gases produced in the primary chamber proceed to the secondary chamber. In the secondary chamber, the gases are mixed with excess oxygen and their combustion is completed. Temperatures are controlled by air input and can range from 1,400 to 2,000 ^{0}F.

Other methods of medical waste disposal continue to be explored. The problems associated with medical waste disposal are not as large as they sound. Overall, there are many larger problems facing the world, but don't be surprised if a chemical engineer helps to solve this one.

HAZARDOUS WASTE

A hazardous waste is waste that poses substantial or potential threats to public health or the environment and generally exhibits one or more of these characteristics:

- ignitable (i.e., flammable)
- reactive
- corrosive
- toxic

Hazardous waste is a waste (usually a solid waste) that has the potential to:

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

These wastes may be found in different physical states such as gaseous, liquids, or solids. Furthermore, a hazardous waste is a special type of waste because it cannot be disposed of by common means like other by-products of our everyday lives. Depending on the physical state of the waste, treatment and solidification processes might be available. In other cases, however, there is not much that can be done to prevent harm.

By the above criteria the hazardous waste can be identified but the actual impact is based upon the quantity. It can be suggested that the most suitable method of dealing with hazardous waste is converting it into non-hazardous form, but that is not possible always, and may not be economical and technically possible also. The most commonly used method of disposing of hazardous waste is the hazardous waste landfill. The specially designed landfills are used to provide complete protection for the surface and subsurface waters from the hazardous waste. As they have to carefully deal with, such type of landfills are equipped with clay liners, monitoring wells and ground water barriers. The strategy is strict segregation from the environment and complete care in storage and transportation.

INDUSTRIAL WASTE

Water pollution has many sources. The most polluting of them are the city sewage and industrial waste discharged into the rivers. Industrial waste is defined as waste generated by manufacturing or industrial processes.

The types of industrial waste generated include cafeteria garbage, dirt and gravel, masonry and concrete, scrap metals, trash, oil, solvents, chemicals, weed grass and trees, wood and scrap lumber, and similar wastes. Industrial solid waste - which may be solid, liquid or gases held in containers - is divided into *hazardous* and *non-hazardous* waste.

Hazardous waste may result from manufacturing or other industrial processes. Certain commercial products such as cleaning fluids, paints or pesticides discarded by commercial establishments or individuals can also be defined as hazardous waste.

Non-hazardous industrial wastes are those that do not meet the EPA's definition of hazardous waste - and are not municipal waste.

Industrial waste has been a problem since the industrial revolution. Industrial waste may be toxic, ignitable, corrosive or reactive. If improperly managed, this waste can pose dangerous health and environmental consequences. The introduction of many new products for the home and office - computers, drugs, textiles, paints and dyes, plastics - also introduced hazardous waste, including toxic chemicals, into the environment.

Waste water from manufacturing or chemical processes in industries contributes to water pollution. Industrial waste water usually contains specific and readily identifiable chemical compounds. Water pollution is concentrated within a few subsectors, mainly in the form of toxic wastes and organic pollutants. Out of this a large portion can be traced to the processing of industrial chemicals and to the food products industry. Most major industries have treatment facilities for industrial effluents but this is not the case with small-scale industries, which cannot afford enormous investments in pollution control equipment as their profit margin is very slender.

The effects of water pollution are not only devastating to people but also to animals, fish, and birds. Polluted water is unsuitable for drinking, recreation, agriculture, and industry. It diminishes the aesthetic quality of lakes and rivers. More seriously, contaminated water destroys aquatic life and reduces its reproductive ability. Eventually, it is a hazard to human health.

What Can Be Done and What is Being Done?

There are many ways to reduce waste in an industrial setting. Waste minimization includes any source reduction and/or recycling activity undertaken by a waste generator (i.e. any business that produces waste through their operations). These activities result in a reduction of waste produced and/or a reduction in the toxicity of the waste. Some examples of waste minimization techniques are listed below.

Waste reduction techniques:

- Change the composition of the product to reduce the amount of waste resulting from the product's use.
- Reduce or eliminate hazardous materials that enter the production process.
- Use technology (including measuring and cutting) to make changes to the production process; equipment, layout or piping; or operating conditions.
- Purchase what you need to avoid waste from unwanted materials.
- Good operating practices such as waste minimization programs, management and personnel practices, loss prevention, and waste segregation help to reduce waste at their source.

Recycling Techniques:

- Return waste material to original process.
- Use the waste material as a raw material substitute for another process.
- Process waste material for resource recovery.
- Process waste material as a by-product.
- Investigate contractors to recycle waste material.
- Advertise waste material.
- Use packaging waste again (cardboard, bubble wrap or polystyrene).

ENERGY FROM MUNICIPAL WASTE

Municipal Solid Waste (MSW) contains organic as well as inorganic matter. The latent energy present in its organic fraction can be recovered for gainful utilisation through adoption of suitable Waste Processing and Treatment technologies. The recovery of energy from wastes also offers a few additional *benefits* as follows:

- The total quantity of waste gets reduced by nearly 60% to over 90%, depending upon the waste composition and the adopted technology;
- Demand for land, which is already scarce in cities, for land filling is reduced;
- The cost of transportation of waste to far-away landfill sites also gets reduced proportionately; and
- Net reduction in environmental pollution.

Basic Technology of Energy recovery

Energy can be recovered from the organic fraction of waste (biodegradable as well as non-biodegradable) basically through two methods as follows:

(i) **Thermo-chemical conversion** : This process entails thermal de-composition of organic matter to produce either heat energy or fuel oil or gas; and

(ii) **Bio-chemical conversion:** This process is based on enzymatic decomposition of organic matter by microbial action to produce methane gas or alcohol.

The Thermo-chemical conversion processes are useful for wastes containing high percentage of organic non-biodegradable matter and low moisture content.

The main technological options under this category include Incineration and Pyrolysis/ Gasification. The bio-chemical conversion processes, on the other hand, are preferred for wastes having high percentage of organic bio-degradable (putrescible) matter and high level of moisture/ water content, which aids microbial activity. The main technological options under this category is Anaerobic Digestion, also referred to as Biomethanation.

NOISE POLLUTION AND ITS CONTROL

The human ear is constantly being assailed by man-made sounds from all sides, and there remain few places in populous areas where relative quiet prevails.

What do aero planes, trains, cars and radio and television sets have in common? They all produce *noise*, the most dangerous pollutant of man's environment. Noise has become a permanent part of our lives these days because of the development of machinery, industry and technology. Noise harms the body and mind. Noise not only causes irritation or annoyance but it constricts your arteries, increases the flow of adrenaline and forces your heart to work faster.

The word noise (Latin nausea) is usually defined as unwanted or unpleasant sound that causes discomfort. Noise is also defined as "wrong sound, in the wrong place at the wrong time". Noise pollution means "the unwanted sound dumped into the atmosphere leading to health hazards".

Formerly noise was limited only to the industry. This too was not much as there were only few industries. These days there has been rapid industrial growth. Moreover, there has been population explosion, due to which there is heavy traffic, urban crowd and electric equipment (luxury items and entertainment). All these have added to the noise nuisance in environment. In our country, besides these the two other factors are the religious and social functions which increase the gravity of situation. You can not sleep whole might if there is a *Bbagwati Jagran or DJ sound* in nearby.

Sources of Noise

The main contributors to noise are factories and industries, transportation (air, rail and road) and community and religious activities. There should not be an exaggeration to say that we Indians are a noisy people and every occasion is manifested in a noisy manner-be it a religious occasion, elections or a family celebration.

The chief man-made sources in urban areas are automobiles, factories, industries, trains, airplanes. Noise makers are horns, sirens, lawn mover, musical instruments, TV, radio, transistor, telephone, dogs, loudspeakers, washing machines, vacuum cleaner, food mixers, pressure cookers, fans, air conditioners, coolers. Ever since the industrial revolution, there has been doubling every 10 years of environmental noise.

Properties

There are two basic properties of sound, (i) loudness and (ii) frequency.

Loudness: It is the strength of sensation of sound perceived by the individual. It is measured in terms of *decibels*. Just audible sound is about 10 dB, a whisper about 20 dB, library place, 30 dB, normal conversation 35-60 dB, heavy street traffic 6080 dB, boiler factories 120 dB, jet planes (take oft) about 150 dB, rocket engine, about 180 dB. The loudest sound a person can stand without much discomfort is about 80 dB. *Sounds beyond 80 dB can be safely regarded as pollutant as it harms hearing system.* The WHO has fixed 45 dB as the

safe noise level for a city. For international standards a noise level upto 65 dB is considered tolerate however, for hospital zones. Mumbai, New Delhi, Kolkata and Chennai usually register more than 90 dB.

Loudness is also expressed in sones. One sone equals the loudness of 40 dB sound pressure at 1000 hz,

Frequency: It is defined as the number of vibrations per second. It is denoted as Hertz (hz). One Hz equals to one vibration per second. People can hear sound from 16 (infra-audibile) to 20,000 (ultrasonic) Hz.

Effects of noise pollution

The different effects are categorized as (i) auditory effects (affecting hearing faculty) and (ii) non-auditory effects (other than auditory ones).

Auditory effects. These include auditory fatigue, and deafness. Auditory fatigue appears in the 90 dB and may be associated with side effects as whistling and buzzing in ears. Deafness can be caused due to continuous noise exposure. Temporary deafness occurs at 4000-6000 Hz. Permanent loss of hearing occurs at 100 dB. Mumbai and Kolkata are the nosiest cities in the world. Many persons have risk of deafness. .

Non-auditory effects. These are

- **Interference with speech communication**. A noise of 50-60 dB commonly interferes with speech; sound of warning (signal) may be misunderstood.
- **Annoyance**. Balanced persons express great annoyance at even low-level of noise as crowd, highway, radio etc. The effects are ill temper, brickering etc.
- **Loss in working efficiency**. There develop tiredness and those doing mental work may put to deterioration in their efficiency or even complete loss of ability to work.
- **Physiological disorders**. There develop a number of physiological disorders due to imbalance in functioning of the body. These are neurosis, anxiety, insomnia, hypertension, hepatic diseases, behavioral and emotional stress, increase in sweating, giddiness, nausea, fatigue etc. Noise also causes visual disturbance, and reduces depth and quality of sleep thus affecting overall mental and physical health. Other effects are undesirable changes in respiration, circulation of blood in skin and gastrointestinal activity. Noise pollution also causes incidence of peptic ulcers.

  Continuous noise causes an increase in cholesterol level resulting in the constriction of blood vessels making you prone to heart attack and strokes. There may be still births and usually low weight children born to mothers living near airports.

  Supersonic air planes create a shock wave called sonic boon, which produces a startle effect that can be more harmful than a continuous noise. The sonic boon may spread in an area of 10 to 80 miles and

when it hits the ground it damages window pans and building structures. This may also fasten the human fetus heart beat rate. Some of the important health hazards of noise are as follows:

Noise intensity (dB)	Health hazards
80	Annoyance
90	Hearing damage
130-135	Nausea, vomiting, dizziness,
140	Pain in ear
150	Burning of skin
180	Permanent damage

Indian scene

We are a noisy people, and every sentiment, be religious, social, family activity, is manifested in a noisy way. Loudspeakers and amplifiers are used without regard to inconvenience or annoyance it may cause to a neighbours. "*Dussehra*" festival is approaching and many neighbourhoods will suffer ten days of restless and disturbed nights. The "*Ramlilas*" are staged with loudspeakers at the highest pitch and the show goes on late into the night. Another regular feature is the "*Jagrans*" in the name of devis, a disease that is spreading like plague in many areas of cities. In temples there may be heard bells and recordings of devotional songs over the loudspeakers. One wonders if God listens only through loudspeakers. This is at the cost of health and peace of many. There is lot of noise nuisance during a marriage. The processions stop from place to place for dancing and drinking and what not. This is the way to manifest one's joy at cost of others. Election time and your peace and calm flyaway. Campaign commences in mid-night. Imagine the effects of these on sick, child, old, and those preparing for examinations and even on healthy man.

Many countries as U.K., U.S.A. have laws to control noise menace. We have also now included noise under air pollution to control it by law.

Control

There are following ways to control and reduce the noise menace.

At source control. This can be done by (i) designing and fabricating silencing devices in air-craft engines, automobiles industrial machines and home appliances and (ii) by segregating the noisy machines. There could be developed gadgets to control noise at source.

Transmission control. This can be achieved by covering the room walls with sound absorbers as acoustic tiles and construction of enclosures around industrial machinery.

To protect exposed person. The workers exposed to noise can be provided with wearing. devices as ear plugs and ear muffs.

To create vegetation cover. Plants absorb and dissipate sound energy and thus act as buffer zone. Trees should be planted along high ways, streets and other places. Ashok, Neem, Tamarind etc. are good for this purpose.

Noise pollution through law. Silence zones must be created near schools, hospitals and indiscriminate use of loudspeakers at public places may be done by laws: Adequate restrictions must be put on unnecessary use of horns and vehicles plying without silencers. There are already laws in some countries as U.K. and U.S.A. In India, we have Motor Vehicles Act which provides restriction on trucks using double sirens while passing through some localities. But this is not enough. In Delhi and Mumbai, there are flights round-the-clock at airport.

There is Indian Penal Code that has some provisions to which resort can be made on the ground of nuisance. These are Sections 268 and 290. Fortunately, noise has now been included under Air Pollution in the Air Pollution Control Act.

Education. Public must be made aware and educated about noise nuisance through adequate news media, lectures and other programmes. The movement against noise pollution is very weak in India. The main reason being that most of us do not consider noise as a pollution but as a part of routine life.

SOCIAL AND ECONOMIC EFFECTS OF ENVIRONMENTAL DEGRADATION

- On social front man tries to possess material resources and an account of this harmful by products originate.
- Pollutants presents in environment harmfully effect human health. Ammonia, a pollutant whose major source is the urea plant, causes adverse health effect.
- Arsenic emitted by purification plant in the manufacture of urea causes black foot disease. Similarly dust reduces visibility and is caused through various process plants. All these provide and make society having human being unhealthy possessing shorter span of life.
- Through working out environmental benefits quantitatively is a difficult task yet conflict between quality or environment and economic growth have been experienced. A cost benefit analysis theory states the benefit received on economic fronts are less as anticipated.

CLEAN TECHNOLOGY

Clean technology is one which is having characteristics of eco friendship. This technology is also called environmentally sound and appropriate technology. Under this technology renewable in place of non renewable resources are used. Examples in the energy field are biogas plants or biomass conversion systems.

Clean technology includes recycling, renewable energy (wind power, solar power, biomass, hydropower, biofuels, etc.), information technology, green transportation, electric motors, green chemistry, lighting, Greywater, and many other appliances that are now more energy efficient. It is a means to create electricity and fuels, with a smaller environmental footprint and minimise pollution.

While there is no standard definition of "clean technology," it has been described by Clean Edge, a clean technology research firm, as "a diverse range of products, services, and processes that harness renewable

materials and energy sources, dramatically reduce the use of natural resources, and cut or eliminate emissions and wastes."

ROLE OF ENGINEER IN ENVIRONMENTAL PROTECTION

An engineer can help in the selection of industrial site which is comparatively pollution free and where the chances of atmosphere pollution are comparatively less and the location has capacity to absorb without much difficulty the pollutants which will come with the smoke of the factory or as dust with smokes or in the from of poisonous gases.

An engineer can also help in the final lay out plan of an industrial plant in such a way that atmosphere does not remain very much polluted and that pollution effects the minimum number of people.

An engineer while selecting site ensures that for the purpose waste disposal space in the vicinity is available.

One of the methods for controlling atmospheric pollution is that the distance between the point of origin of the pollutant and that of its final destination e.g. natural waters should be minimum. An engineer can make real contribution in this respect.

An engineer can suggest necessary measures for protection of monuments from the pollutants. Then one of the preventions which he can taken is that he can localize the pollution.

These days maximum stress is being laid on cost benefit analysis. An engineer while finalizing his proposals can ensure that the proposal for installing or a factory or while undertaking a new project is such that it is financially viable. An engineer can also help in reducing noise pollution.

COMPRESSED NATURAL GAS (CNG)

Compressed natural gas (CNG) is a fossil fuel substitute for gasoline (petrol), diesel, or propane/LPG. Although its combustion does produce greenhouse gases, it is a more environmentally clean alternative to those fuels, and it is much safer than other fuels in the event of a spill (natural gas is lighter than air, and disperses quickly when released). CNG may also be mixed with biogas, produced from landfills or wastewater, which doesn't increase the concentration of carbon in the atmosphere.

CNG is made by compressing natural gas (which is mainly composed of methane, to less than 1% of the volume it occupies at standard atmospheric pressure. It is stored and distributed in hard containers at a pressure of 200–248 bar, usually in cylindrical or spherical shapes.

CNG cars are bi-fuel vehicles burning one fuel at a time. Their engine is a standard gasoline internal combustion engine (ICE). This means that they can indifferently run on either gasoline from a gasoline tank or CNG from a separate cylinder in the trunk. The driver can select what fuel to burn by simply flipping a switch on the dashboard. Several manufacturers (Fiat, Opel (General Motors), Peugeot, Volkswagen, Toyota, Honda and others) sell bi-fuel cars.

Any existing gasoline vehicle can be converted to a bi-fuel (gasoline/CNG) vehicle. Authorized shops can do the retrofitting, this involves installing a CNG cylinder in the trunk, installing the plumbing, installing a CNG injection system and the electronics.

Advantages

- Due to the absence of any lead or benzene content in CNG, the lead fouling of spark plugs is eliminated.
- CNG-powered vehicles have lower maintenance costs when compared with other fuel-powered vehicles.
- CNG fuel systems are sealed, which prevents any spill or evaporation losses.
- Increased life of lubricating oils, as CNG does not contaminate and dilute the crankcase oil.
- CNG mixes easily and evenly in air being a gaseous fuel.
- CNG is less likely to auto-ignite on hot surfaces, since it has a high auto-ignition temperature (540°C) and a narrow range (5%-15%) of flammability.
- Less pollution and more efficiency

ELECTRONIC WASTE

Electronic waste, e-waste, e-scrap, or Waste Electrical and Electronic Equipment (WEEE) describes loosely discarded, surplus, obsolete, broken, electrical or electronic devices. The processing of electronic waste in developing countries causes serious health and pollution problems because electronic equipment contains some very serious contaminants such as lead, cadmium, beryllium and brominated flame retardants. Even in developed countries recycling and disposal of e-waste involves significant risk to workers and communities and great care must be taken to avoid unsafe exposure in recycling operations and leaching of material such as heavy metals from landfills and incinerator ashes.

Recycling of e-waste

Today the electronic waste recycling business is in all areas of the developed world a large and rapidly consolidating business. Electronic waste processing systems have matured in recent years, following increased regulatory, public, and commercial scrutiny, and a commensurate increase in entrepreneurial interest. Part of this evolution has involved greater diversion of electronic waste from energy-intensive downcycling processes (e.g., conventional recycling), where equipment is reverted to a raw material form. This diversion is achieved through reuse and refurbishing. The environmental and social benefits of reuse include diminished demand for new products and virgin raw materials (with their own environmental issues); larger quantities of pure water and electricity for associated manufacturing; less packaging per unit; availability of technology to wider swaths of society due to greater affordability of products; and diminished use of landfills.

Audiovisual components, televisions, VCRs, stereo equipment, mobile phones, other handheld devices, and computer components contain valuable elements and substances suitable for reclamation, including lead, copper, and gold.

Processing Techniques

In developed countries, electronic waste processing usually first involves dismantling the equipment into various parts (metal frames, power supplies, circuit boards, plastics), often by hand. The advantages of this process are the human's ability to recognize and save working and repairable parts, including chips, transistors, RAM, etc. The disadvantage is that the labor is often cheapest in countries with the lowest health and safety standards.

In an alternative bulk system, a hopper conveys material for shredding into a sophisticated mechanical separator, with screening and granulating machines to separate constituent metal and plastic fractions, which are sold to smelters or plastics recyclers. Such recycling machinery is enclosed and employs a dust collection system. Most of the emissions are caught by scrubbers and screens. Magnets, eddy currents, and trommel screens are employed to separate glass, plastic, and ferrous and nonferrous metals, which can then be further separated at a smelter. Leaded glass from CRTs is reused in car batteries, ammunition, and lead wheel weights, or sold to foundries as a fluxing agent in processing raw lead ore. Copper, gold, palladium, silver, and tin are valuable metals sold to smelters for recycling. Hazardous smoke and gases are captured, contained, and treated to mitigate environmental threat.

An ideal electronic waste recycling plant combines dismantling for component recovery with increased cost-effective processing of bulk electronic waste.

Reuse is an option to recycling because it extends the lifespan of a device. Devices still need eventual recycling, but by allowing others to purchase used electronics, recycling can be postponed and value gained from device use.

WASTE HIERARCHY

The waste hierarchy is a process used to protect the environment and conserve resources through a priority approach. The waste hierarchy ranks waste management options according to what is best for the environment. It gives top priority to preventing waste in the first place. If waste is not produced then it has not to be disposed of. When waste is produced, it gives precedence to preparing it for reuse, then recycling, then recovery, and last of all disposal.

Stages

Prevention: The prevention of waste is the most vital point in the waste hierarchy. Prevention or reduction minimizes the generation of waste products in the first place. Prevention usually results in the least environmental and economic life cycle costs because it requires no collecting or processing of materials.

Prevention also typically produces significant benefits in terms of production efficiencies and the use of resources. It involves using less material in design and manufacture, trying to keep products for longer, and using less hazardous materials.

Reuse: The reuse of waste is the next most desirable option. It is any operation where products or materials that are not waste are used again for the same purpose for which they were intended. Reusing waste often requires collection but relatively little or no processing. It involves checking, cleaning, repairing, and/or refurbishing, entire items or spare parts.

Recycle: Recycling of waste is the next step in priority. It is any activity that includes the collection of used, reused, or unused items that would otherwise be considered waste. Recycling involves sorting and processing the recyclable products into raw material and then remanufacturing the recycled raw materials into new products.

Recovery: The recovery of waste is further separated into categories: the recovery of materials and the recovery of energy. Whichever of these two choices is better for the environment and human health is the preferred option. The recovery of materials is most often preferred and includes activities such as recycling and composting. These management activities generally require a collection system and a method of material processing and conversion into a new product. Recovery of energy, such as incineration, is usually the less preferred option. The conversion of non-recyclable waste materials into usable heat, electricity, or fuel is done through a variety of processes, including anaerobic digestion, gasification, and pyrolysis.

Disposal: The last resort is disposal and is only considered once all other possibilities have been explored. Disposal is any operation that involves the dumping and incineration of waste without energy recovery. Before final disposal, a considerable amount of pre-treatment may be necessary to change the characteristics of the waste in order to reduce the quantity or harmfulness of the waste and that may include physical, thermal, chemical, or biological processes. Landfills are the most common form of waste disposal and the final disposal option.

SOIL POLLUTION

With the rise of concrete buildings and roads, one part of the Earth that we rarely see is the soil. It has many different names, such as dirt, mud and ground. However, it is definitely very important to us. The plants that feed us grow in soil and keeping it healthy is essential to maintaining a beautiful planet. However, like all other forms of nature, soil also suffers from pollution. The pollution of soil is a common thing these days, and it happens due to the presence of man made elements.

The main reason why the soil becomes contaminated is due to the presence of man made waste. The waste produced from nature itself such as dead plants, carcasses of animals and rotten fruits and vegetables only adds to the fertility of the soil. However, our waste products are full of chemicals that are not originally found in nature and lead to soil pollution.

Main Causes of Soil Pollution

- **Industrial Activity**: Industrial activity has been the biggest contributor to the problem in the last century, especially since the amount of mining and manufacturing has increased. Most industries are dependent on extracting minerals from the Earth. Whether it is iron ore or coal, the by products are contaminated and they are not disposed off in a manner that can be considered safe. As a result, the industrial waste lingers in the soil surface for a long time and makes it unsuitable for use.
- **Agricultural Activities**: Chemical utilization has gone up tremendously since technology provided us with modern pesticides and fertilizers. They are full of chemicals that are not produced in nature and cannot be broken down by it. As a result, they seep into the ground after they mix with water and slowly reduce the fertility of the soil. Other chemicals damage the composition of the soil and make it easier to erode by water and air. Plants absorb many of these pesticides and when they decompose, they cause soil pollution since they become a part of the land.
- **Waste Disposal**: Finally, a growing cause for concern is how we dispose of our waste. While industrial waste is sure to cause contamination, there is another way in which we are adding to the pollution. Every human produces a certain amount of personal waste products by way or urine and feces. While much of it moves into the sewer the system, there is also a large amount that is dumped directly into landfills in the form of diapers. Even the sewer system ends at the landfill, where the biological waste pollutes the soil and water. This is because our bodies are full of toxins and chemicals which are now seeping into the land and causing pollution of soil.
- **Accidental Oil Spills**: Oil leaks can happen during storage and transport of chemicals. This can be seen at most of the fuel stations. The chemicals present in the fuel deteriorates the quality of soil and make them unsuitable for cultivation. These chemicals can enter into the groundwater through soil and make the water undrinkable.
- **Acid Rain**: Acid rain is caused when pollutants present in the air mixes up with the rain and fall back on the ground. The polluted water could dissolve away some of the important nutrients found in soil and change the structure of the soil.

Effects of Soil Pollution

- **Effect on Health of Humans**: Considering how soil is the reason we are able to sustain ourselves, the contamination of it has major consequences on our health. Crops and plants grown on polluted soil absorb much of the pollution and then pass these on to us. This could explain the sudden surge in small and terminal illnesses. Long term exposure to such soil can affect the genetic make-up of the body, causing congenital illnesses and chronic health problems that cannot be cured easily. In fact, it can sicken the livestock to a considerable extent and cause food poisoning over a long period of time. The soil pollution can even lead to widespread famines if the plants are unable to grow in it.

- **Effect on Growth of Plants**: The ecological balance of any system gets affected due to the widespread contamination of the soil. Most plants are unable to adapt when the chemistry of the soil changes so radically in a short period of time. Fungi and bacteria found in the soil that bind it together begin to decline, which creates an additional problem of soil erosion. The fertility slowly diminishes, making land unsuitable for agriculture and any local vegetation to survive. The soil pollution causes large tracts of land to become hazardous to health. Unlike deserts, which are suitable for its native vegetation, such land cannot support most forms of life.
- **Decreased Soil Fertility**: The toxic chemicals present in the soil can decrease soil fertility and therefore decrease in the soil yield. The contaminated soil is then used to produce fruits and vegetables which lacks quality nutrients and may contain some poisonous substance to cause serious health problems in people consuming them.
- **Toxic Dust**: The emission of toxic and foul gases from landfills pollutes the environment and causes serious effects on health of some people. The unpleasant smell causes inconvenience to other people.
- **Changes in Soil Structure**: The death of many soil organisms (e.g. earthworms) in the soil can lead to alteration in soil structure. Apart from that, it could also force other predators to move to other places in search of food.

Controlling Soil Pollution

A number of ways have been suggested to curb the current rate of pollution. Such attempts at cleaning up the environment require plenty of time and resources to be pitched in. Industries have been given regulations for the disposal of hazardous waste, which aims at minimizing the area that becomes polluted. Organic methods of farming are being supported, which do not use chemical laden pesticides and fertilizers. Use of plants that can remove the pollutants from the soil is being encouraged. However, the road ahead is quite long and the prevention of soil pollution will take many more years.