UNIT-I
POLLUTION CONTROL
AND
CONTROLE TECHNOLOGY

Classification of pollution-

1.Air Pollution

2.Water pollution

3.Soil Pollution

4.Noise Pollution

Air Pollution

- Air pollution occurs due to the presence of undesirable solid or gaseous particles in the air in quantities that are harmful to human health and the environment.
- On the basis of origin of pollutants they can be classified as primary or secondary pollutants.

Air Pollutants

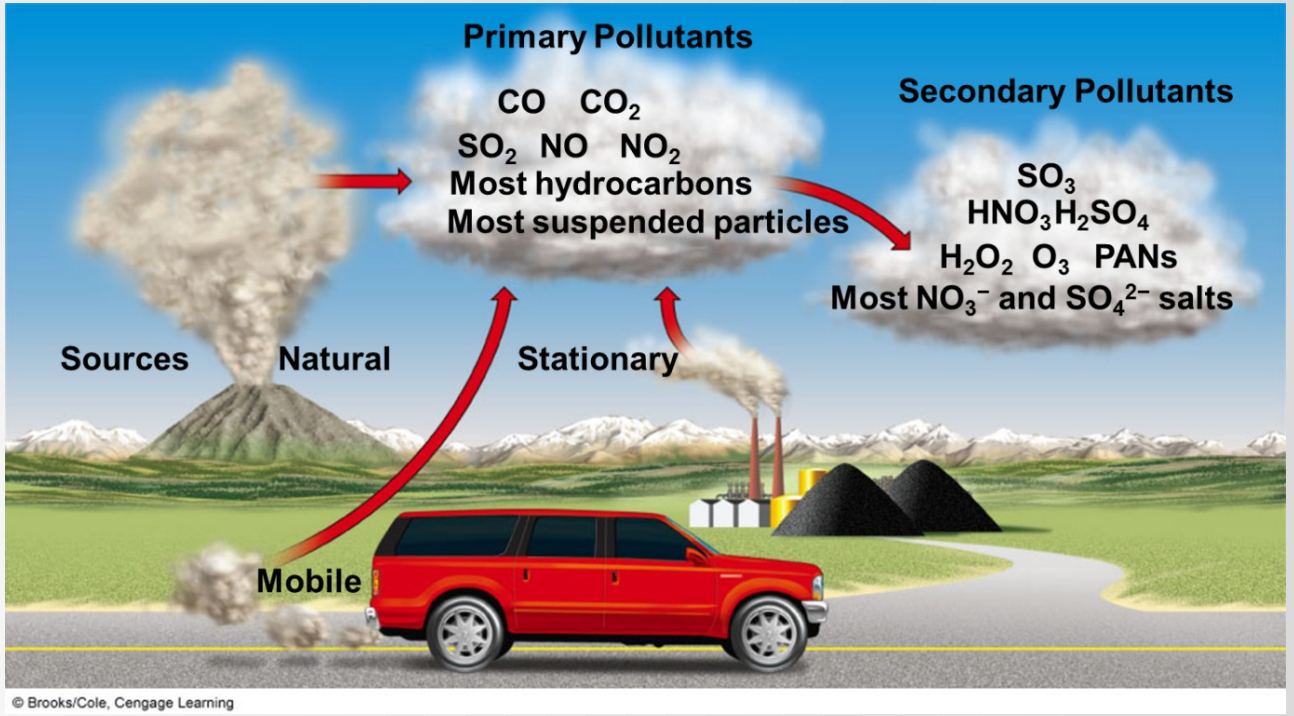
Primary Pollutants

- Natural events (e.g., volcanic eruptions)
- Human activities (emission from vehicles, industries, etc.).
- Five primary pollutants that together contribute about 90% of the global air pollution.
  - Carbon oxides (CO and CO_2),
  - Nitrogen oxides,
  - Sulphur oxides,
  - Volatile organic compounds (mostly hydrocarbons)
  - Suspended particulate matter(SPM).

Secondary Pollutants

- Formed by interaction of primary pollutant(s) with other primary pollutant(s).
- e.g. sulphuric acid, nitric acid, ozone (O_3), peroxyacetyl nitrate (PAN), etc.

Classification of Air Pollutants



Suspended Particulate Material (SPM)

- Thousands of different solid or liquid particles suspended in air
  - Includes: soil particles, soot, lead, asbestos, sea salt, and sulfuric acid droplets
- Dangerous for 2 reasons
  - May contain materials with toxic or carcinogenic effects
  - Extremely small particles can become lodged in lungs

Air Pollution-Causes

- The causes of air pollution are natural and man-made (anthropogenic).

Natural Causes

- Volcanic eruptions, forest fires, wind blown terrestrial dust, biological decay, photochemical oxidation of terpenes (a class of lipids gives forests their odour) etc.

Man Made

- Thermal power plants, industrial units, vehicular emissions, fossil fuel burning, agricultural activities etc.
- Automobiles are the first rate of polluters with emission of gases such as carbon monoxide (about 77%), oxides of nitrogen (about 8%) and hydrocarbons (about 14%). Industries occupy second position.

Indoor air pollution

- Many houses in India use fuels like coal, dung-cakes, wood and kerosene in their kitchens.
- Incomplete combustion produces the toxic gases such as CO, SO_2, soot and many others like formaldehyde, benzo-(a) pyrene (BAP) that are toxic and harmful for health.
- A housewife using wood as fuel for cooking inhales BAP equivalent to 20 packets of cigarette a day.

Air Pollution-Effects

Effects on human health

- Years of exposure to air pollutants (including cigarette smoke) adversely affects the natural defences of body and can result in lung cancer, asthma, chronic bronchitis and emphysema (damage to air sacs leading to loss of lung elasticity and acute shortness of breath).
- Carbon monoxide (CO) reaches lungs and combines with haemoglobin of blood with an affinity of 210 times more than oxygen. This causes suffocation and long exposure to CO may cause unconsciousness and even death.
- Many other air pollutants like benzene, formaldehyde, polychlorinated biphenyls (PCBs) and dioxins (from burning of polythene) can cause mutations, reproductive problems or even cancer.

Effects on plants

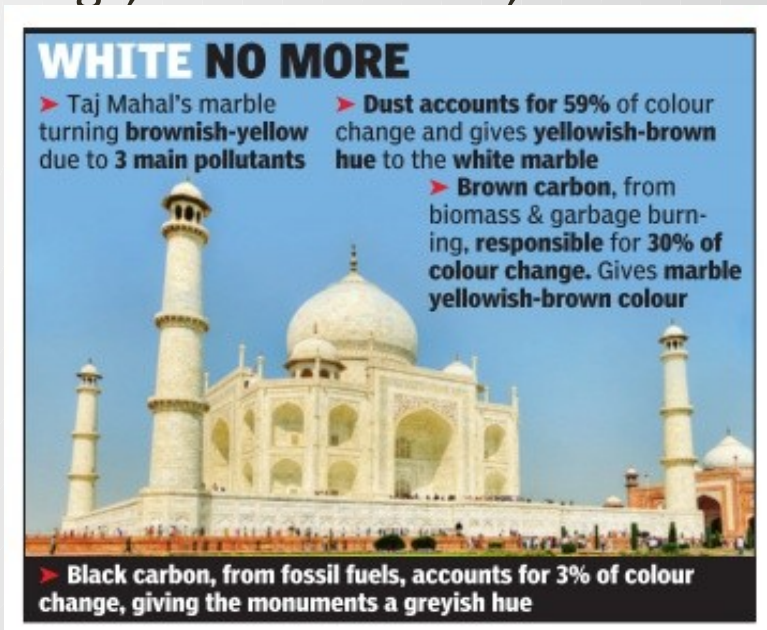
- Air pollutants affect plants by entering through stomata (leaf pores through which gases diffuse), destroy chlorophyll and affect photosynthesis.
- Exposure of the leaves to air pollutants can break down the waxy coating that helps prevent excessive water loss and leads to damage from diseases, pests, drought and frost.

Effects on aquatic life

- Air pollutants mixing up with rain can cause high acidity (lower pH) in fresh water lakes. Some of the fresh water lakes have experienced total fish death.

Effects on materials

- Presence of SO_2 and moisture can accelerate corrosion of metallic surfaces due to formation of sulphuric acid which cause damage worth billions of rupees.
- Ozone in the atmosphere can cause cracking of rubber.
- All around the world air pollutants have discoloured irreplaceable monuments, historic buildings, marble statues, etc.



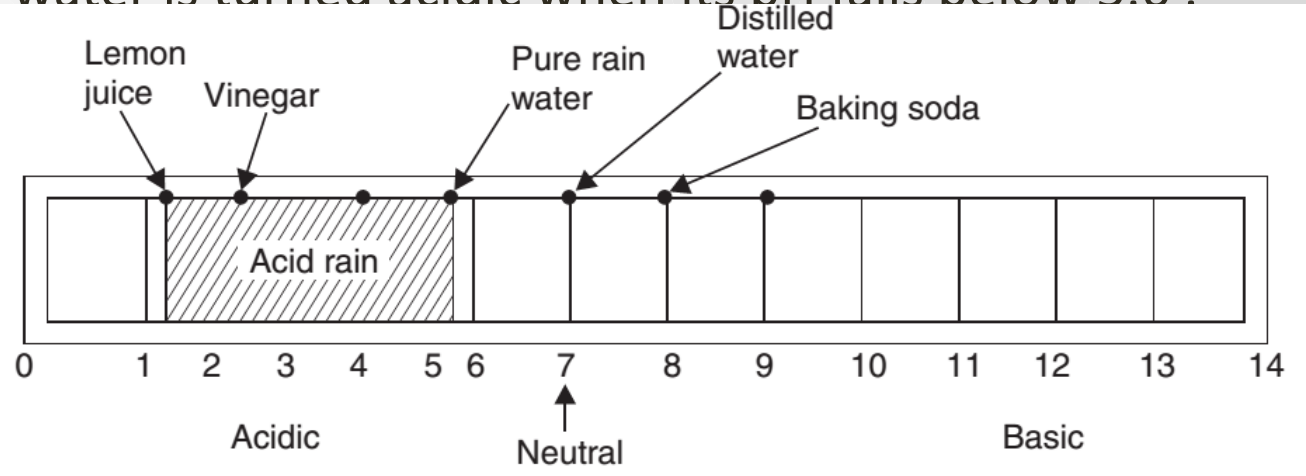
Air Pollution-Control Measures

- Effective means of controlling air pollution is to have proper equipment which includes devices for removal of pollutants form fuel gases through scrubbers, closed fuel collection recovery systems, filters, etc.
- Using unleaded petrol for vehicles is another way of control.
- Catalytic incineration offers a very economical means of controlling organic pollutants in emissions from industrial processes.
- Remove sulphur from coal and Burn low-sulphur coal.
- Minimize/modify activities which cause pollution e.g. using mass transport system, bicycles etc.
- Shifting to less polluting (clean) fuels (hydrogen gas) and non-conventional sources of energy.
- Planting more trees.
- Putting a greater emphasis on pollution prevention rather than control.

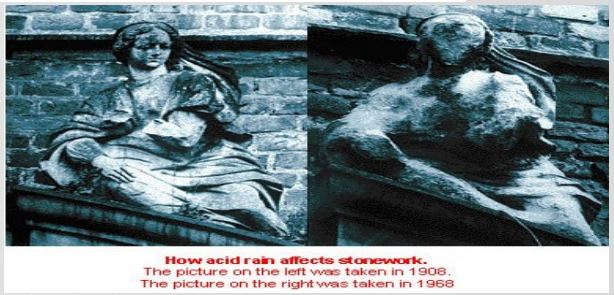



Acid Rains

- Toxic gases like SO_x and NO_x dissolve in rain water to form sulphuric acid and nitric acid and come down as acid rain.
- Rain water is turned acidic when its pH falls below 5.6 .



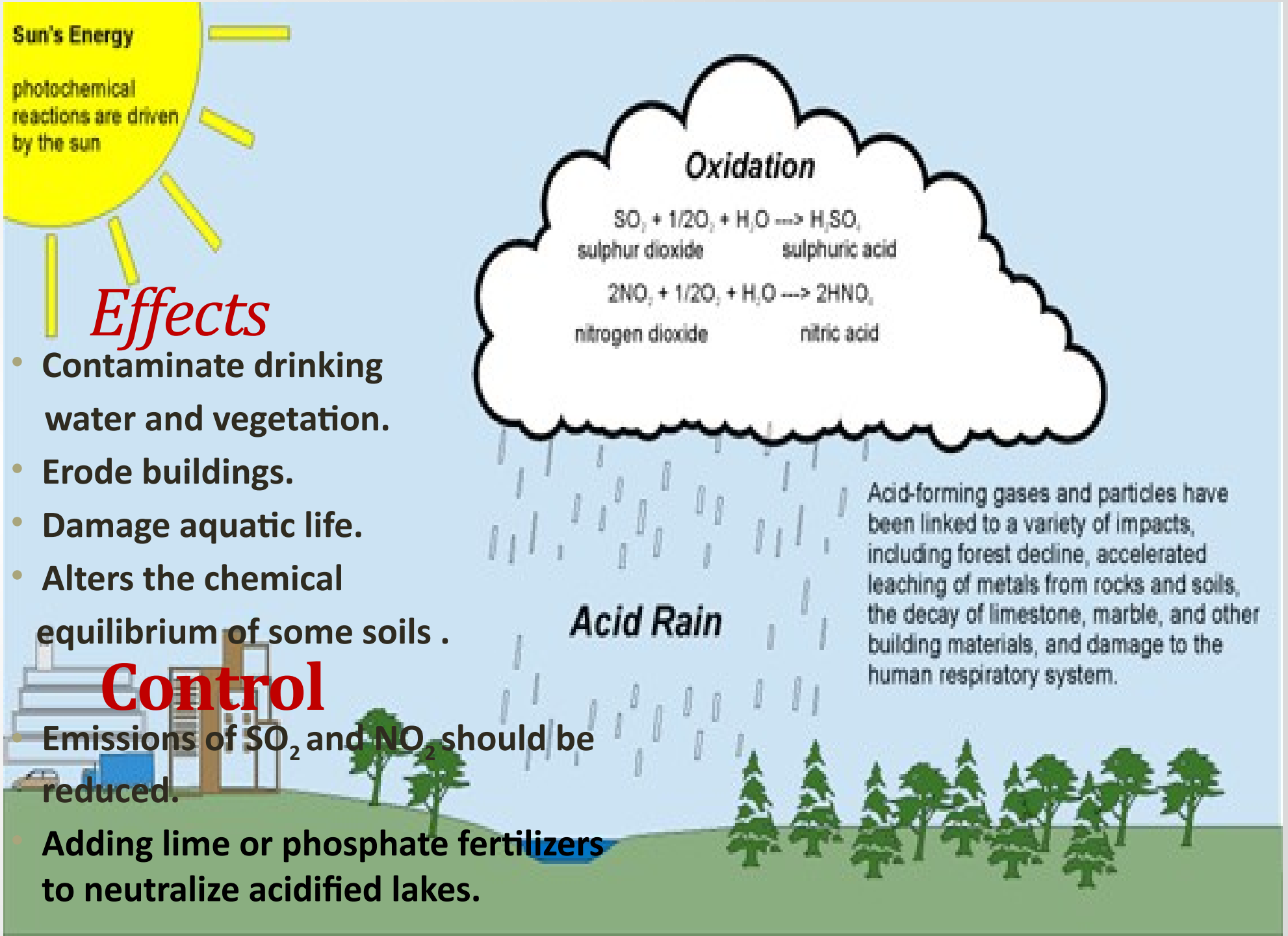
- Generally sulphuric acid forms a major fraction of acid rain, followed by nitric acid and a very small fraction of other acids.
- Motor vehicle exhaust fumes are the main source of nitrogen oxides.


How acid rain affects stonework.
The picture on the left was taken in 1908.
The picture on the right was taken in 1968

- White marble consists of $CaCO_3$, which is generally present in monuments (TajMahal). These monuments are attacked by acid rains forming grey stains due to the following reaction

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O$$

(Marble) (Acid Rain)



Effects

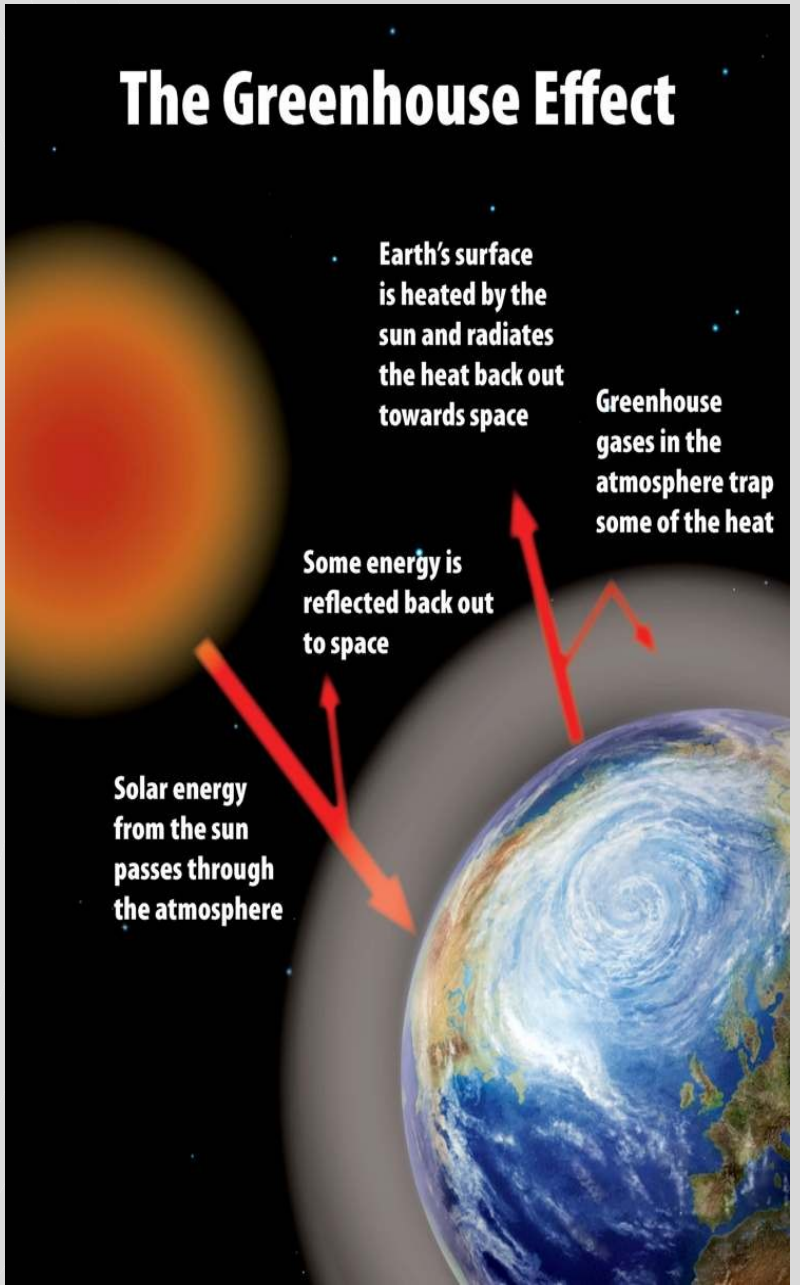
- Contaminate drinking water and vegetation.
- Erode buildings.
- Damage aquatic life.
- Alters the chemical equilibrium of some soils .

Control

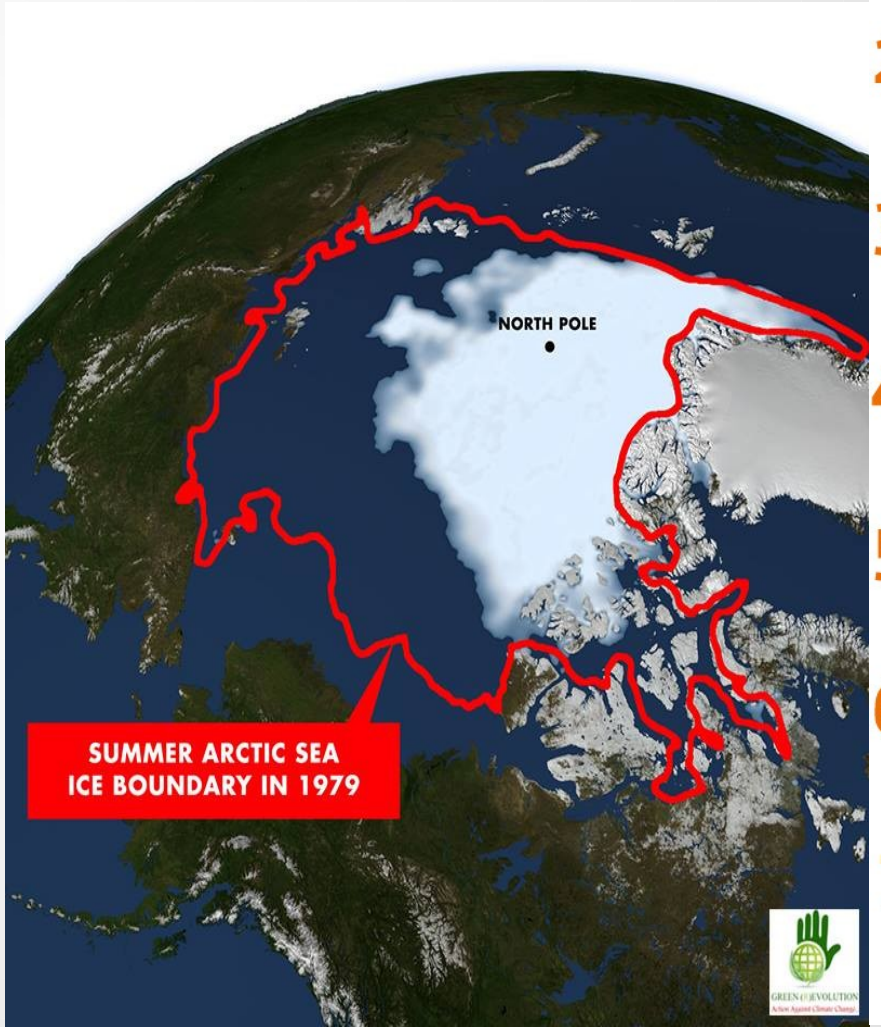
- Emissions of SO_2 and NO_2 should be reduced.
- Adding lime or phosphate fertilizers to neutralize acidified lakes.

Green House Effect-Global Warming

- Greenhouse gases (i.e. CO_2, water vapour, Nitrous oxide etc.) keep heat close to the earth's surface like a blanket making it livable for humans and animals, which is known as "Green House Effect".
- The average temperature on the Earth is 15°C now. If there was no greenhouse effect, the average temperature would be -18°C .
- But, Global warming is a phenomenon which is caused due to the increase in concentration of green house gases that trap heat in the form of infra-red radiation near the earth's surface.
- The major greenhouse gases are carbon dioxide, ozone, methane, nitrous oxide, chlorofluorocarbons (CFCs) and water vapours.



An outstanding Evidence for Global Warming



Reality Check

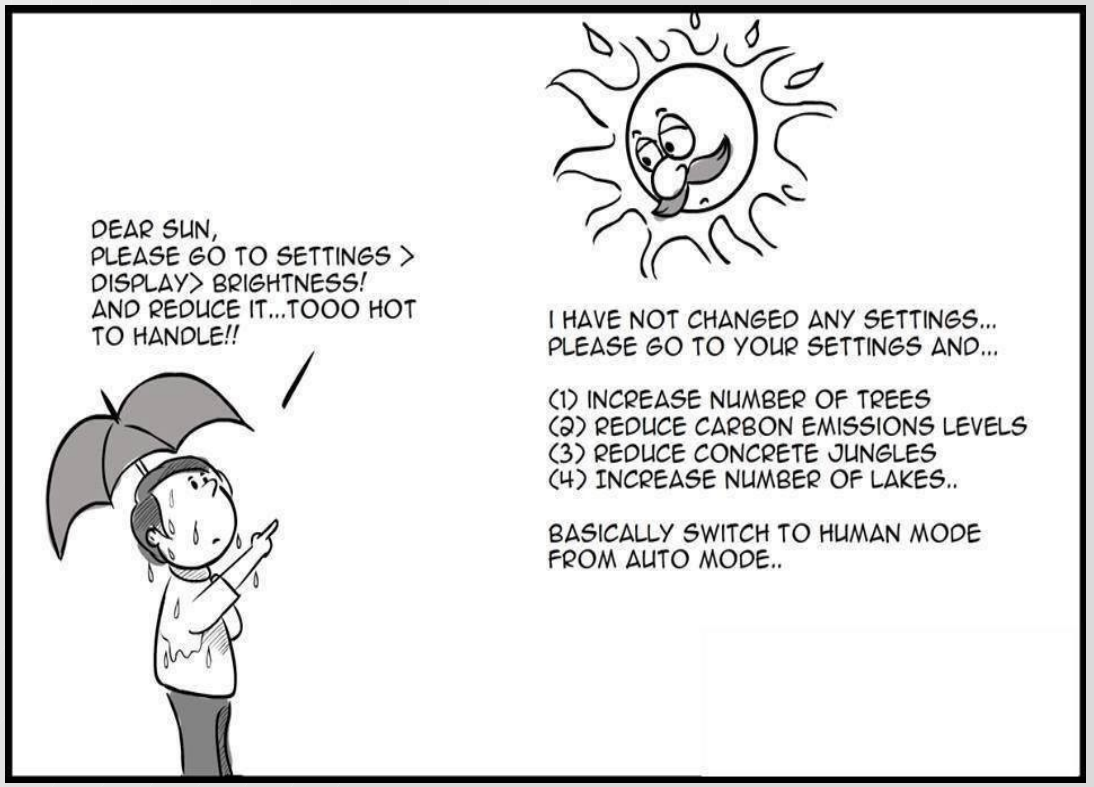
1. **Carbon dioxide** concentration is 40% higher than in pre-industrial times.
2. **Human activity** caused most of the warming between 1951 and 2010.
3. Earth's surface **warmed 0.85°C** over the period 1880 to 2012.
4. **Heatwaves and heavy rains** have become more frequent since the 1950s.
5. Arctic sea **ice has declined** on average 3.8% per decade since 1979.
6. Global **sea level is expected to rise** between 26 and 82 cm by 2100.
7. Only an **aggressive mitigation scenario** can keep temperature rise below 2°C.

Source: IPCC Working Group I - Fifth Assessment Report

Measures to check Global warming

To slow down enhanced global warming the following steps will be important:

- Cut down the current rate of use of CFCs and fossil fuel.
- Use energy more efficiently.
- Shift to renewable energy resources.
- Increase nuclear power plants for electricity production.
- Shift from coal to natural gas.
- Adopt sustainable agriculture.
- Stabilize population growth.
- Efficiently remove CO_2
- Plant more trees.
- Remove atmospheric CO_2 by utilizing photosynthetic algae.



Ozone layer depletion(Ozone hole)

- For the last 450 million years the earth has had a natural sunscreen in the stratosphere called the ozone layer.
- This layer filters out harmful ultraviolet radiations from the sunlight and thus protects various life forms on the earth.
- Ozone is a form of oxygen. The molecule of ozone contains three (O_3) oxygen atoms.
- In the stratosphere ozone is continuously being created by the absorption of short wavelength ultraviolet (UV) radiations.

$$O_2 + h\nu \longrightarrow O + O$$

$$O + O_2 + M \longrightarrow O_3 + M$$

(M is a third body necessary to carry away the energy released in the reaction).

- Ozone thus formed distributes itself in the stratosphere and absorbs harmful ultraviolet radiations and is continuously being converted back to molecular oxygen.

$$O_3 + h\nu \longrightarrow O_2 + O$$

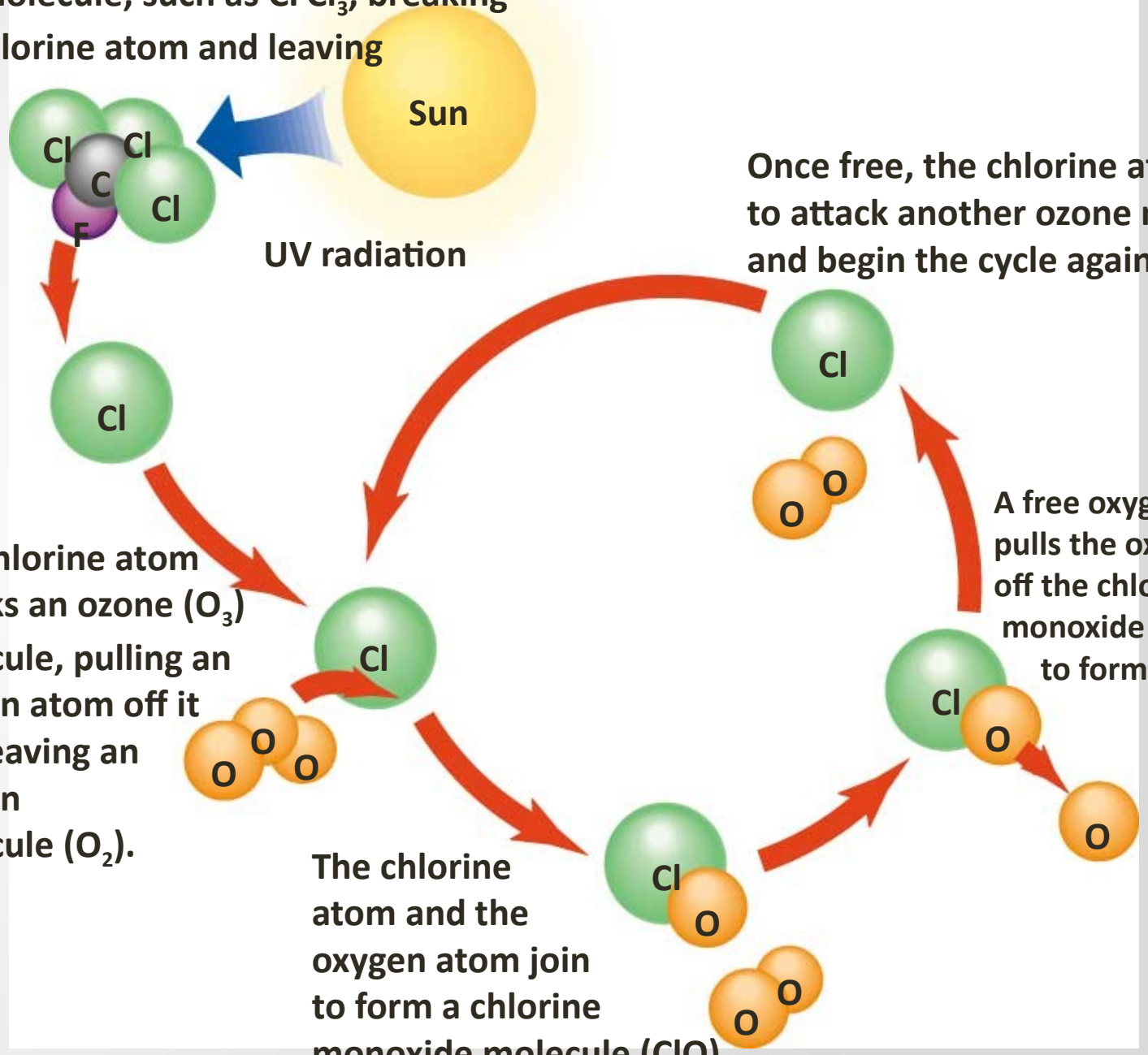
The Main Ozone-Depleting Substances

- Chlorofluorocarbons (CFCs)
- Halons
- Nitrogen oxides (i.e. NO_2)
- Methyl Chloroform
- Carbon Tetrachloride
- Hydrofluorocarbons (HCFCs)

Thinning of Ozone layer by CFCs

- Chlorofluorocarbons (CFCs) are mainly responsible for ozone depletion in the stratosphere, accounting for over 80% of total stratospheric ozone depletion.
- CFCs remain in the stratosphere for 65–110 years.
- CFCs are used as coolants in refrigerators and air conditioners, as propellants, cleaning solvents, sterilant and in styrofoam etc.
- This led to the adoption of the *Montreal Protocol* banning the use of CFC compounds, as well as other ozone depleting chemicals such as carbontetrachloride, trichloroethane and bromine compounds.

Ultraviolet light hits a chlorofluorocarbon (CFC) molecule, such as $CFCl_3$, breaking off a chlorine atom and leaving $CFCl_2$.



Harmful effects of Ozone layer depletion

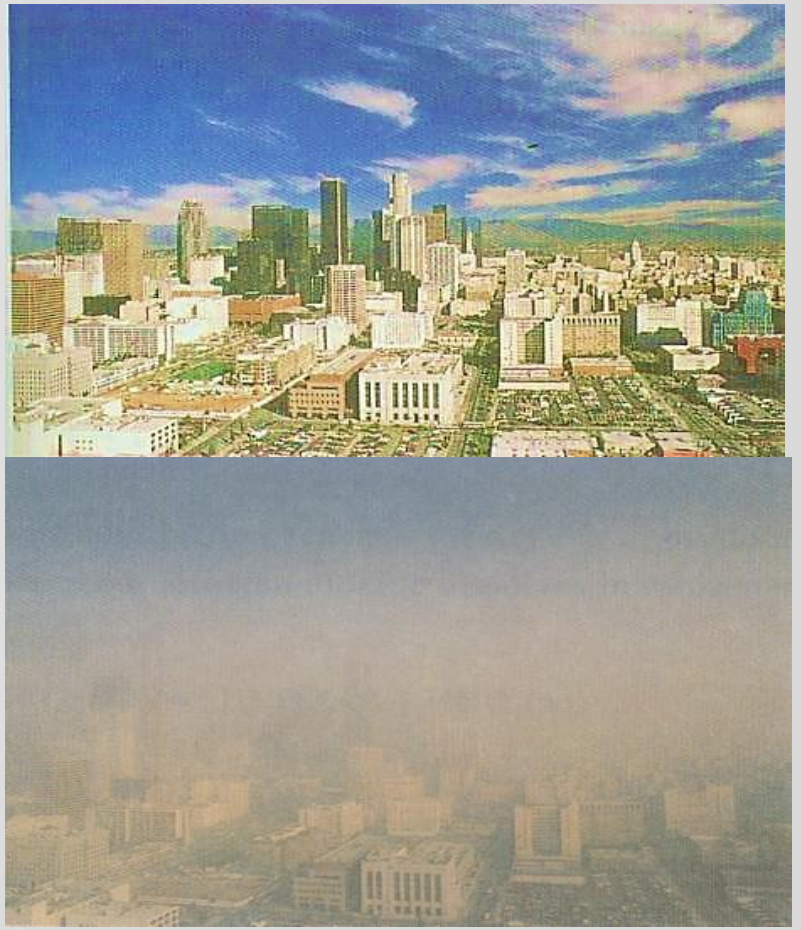
- Skin cancer (ultraviolet radiation can destroy acids in DNA)
- Cataracts and sun burning
- Suppression of immune systems
- Adverse impact on crops and animals
- Reduction in the growth of ocean phytoplankton
- Degradation of paints and plastic material

Photochemical Smog

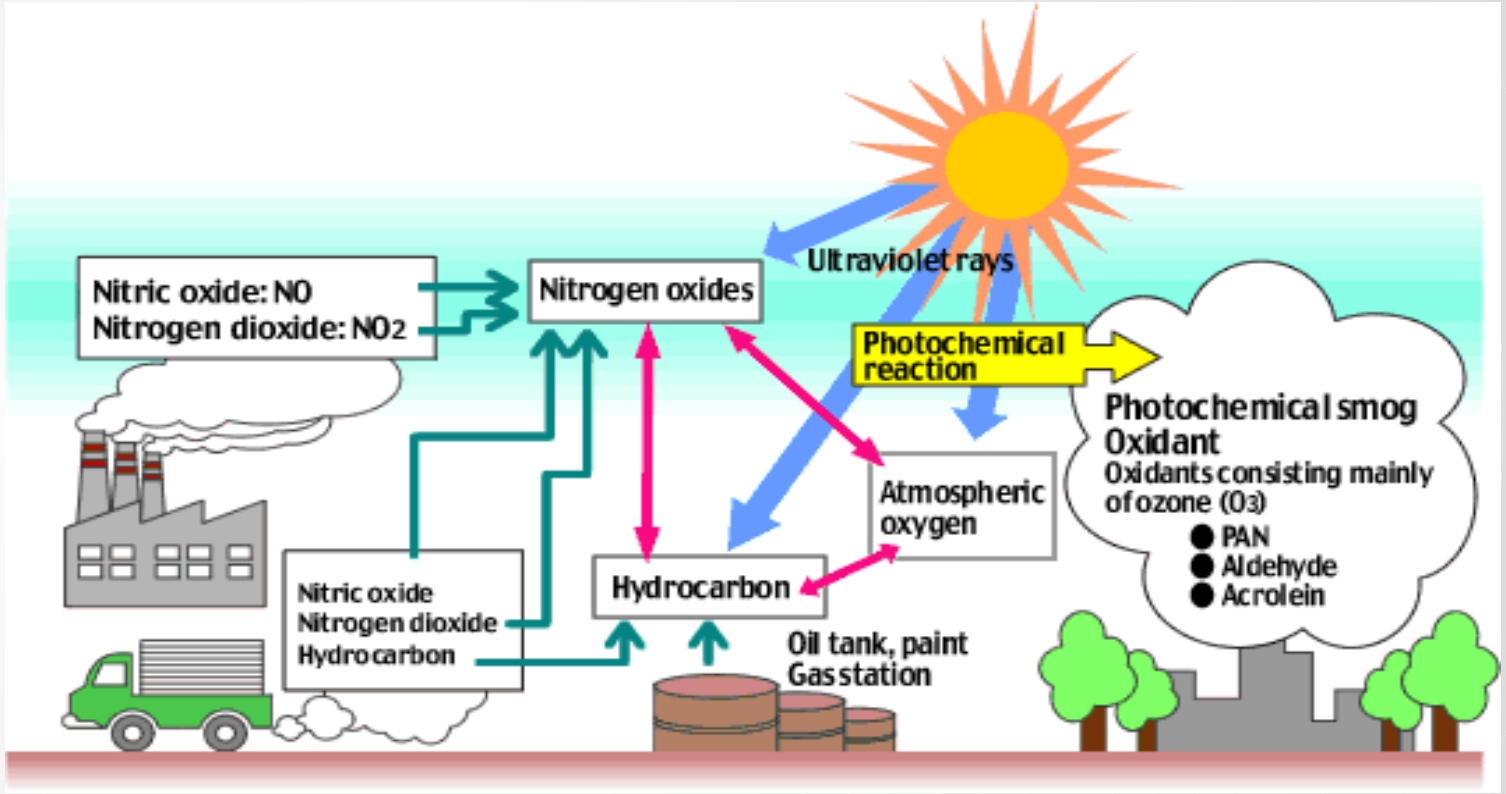
- The word smog is a combination of two words ‘smoke’ and ‘fog’.
- Toxic mixture of highly reactive and oxidizing air pollutants including:
  - Oxides of Nitrogen (NO_x)
  - Volatile organic compounds
  - Troposphere Ozone
  - Peroxyacyl Nitrates (PAN)

$$R\text{-}C(=O)\text{-}OONO_2$$

    - The photochemical smog is characterized by brown, hazy fumes which irritate the eyes and lungs.
    - Effects on human health
      - Headaches
      - Eyes, nose and throat irritations
      - Impaired lung function
      - Coughing and wheezing



General Mechanism of smog formation



PAN formation

RCHO

$HO^{\bullet}$ ↓

$RC^{\bullet}=O$ acyl radical

↓ O_2

$RC(=O)OO^{\bullet}$ Peroxyacyl radical

↓ NO_2

$RC(=O)OONO_2$

Peroxyacyl nitrate (PAN)

Water Pollution

Water Pollution:

"The Change in the chemical, physical, biological and radiological quality of water that is injurious to its existing, intent ended or potential uses are called Water Pollution".

Or

"The addition of any substance that has a negative effect on water or the living things that depend on water is called Water Pollution".

Water Pollutants:

"The substances that cause water pollution are called water pollutants".

Classification of Water Pollutants

- Infectious Agents
  - Bacteria, Viruses, Protozoa, Parasitic Worms
  - Source: Human and animal waste
- Oxygen-Demanding Waste
  - Organic debris & waste + aerobic bacteria
  - Source: Sewage, feedlots, paper-mills, food processing
- Inorganic Chemicals
  - Acids, Metals, Salts
  - Sources: Surface runoff, Industrial effluent, household cleansers
- Radioactive Materials
  - Iodine, radon, uranium, cesium, thorium
  - Source: Coal & Nuclear Power plants, mining, weapons production,
- Plant Nutrients
  - Nitrates, Phosphates,
  - Source: Sewage, manure, agricultural and landscaping runoff
- Organic Chemicals
  - Oil, Gasoline, Plastics, Pesticides, Solvents, detergents
  - Sources: Industrial effluent, Household cleansers, runoff from farms and yards
- Eroded Sediment
  - Soil, Silt
  - Heat/Thermal Pollution
  - Source: Power plants, Industrial

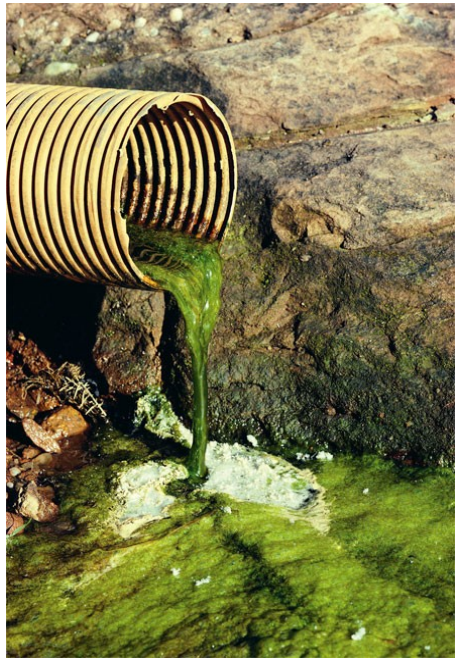
Sources of Water Pollution

Point Source pollution

It is a specific source of pollution that can be identified.

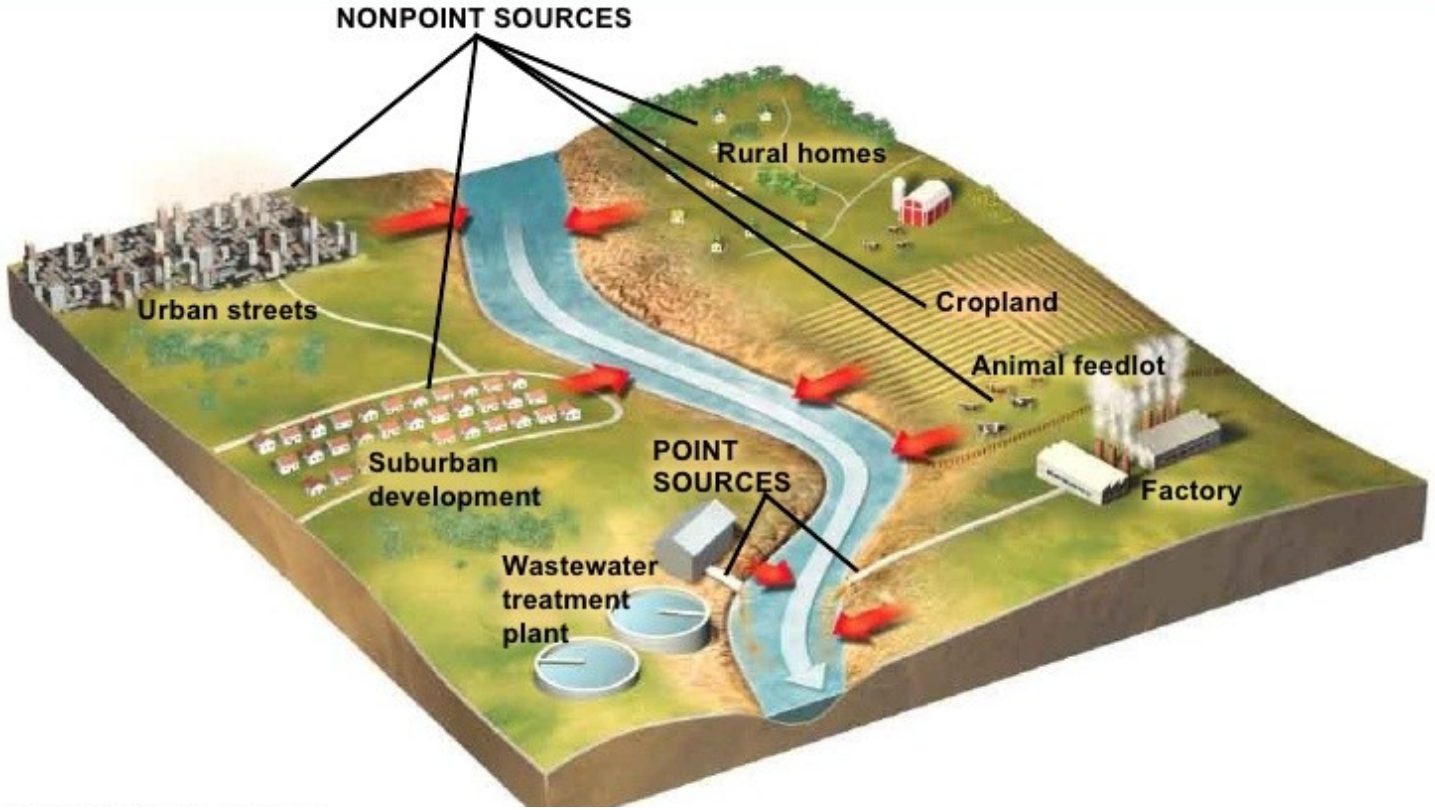
- Factories
- Power Plants
- Sewage Treatment Plants
- Oil Wells

Example:
A pipe gushing colored water into a river



Non-Point Source Pollution

- No specific point to identify.
- These are scattered or diffused.
- Expensive to clean up.



Causes

- Marine dumping
- Industrial Waste
- Sewage
- Household usage
- Radioactive waste
- Oil Pollution
- Underground storage leaks
- Global warming
- Atmosphere deposition

Effects

- Biological Oxygen Demand Effects
- Biomagnification
- Eutrophication
- Health Effects
- Ground Water Pollution

Water Pollution – Control Technologies

- ECO-REMIDIATION TECHNOLOGY
- AQUATIC VEGETATION RESTORATION TECHNOLOGY
- BIO-MANIPULATION TECHNOLOGY
- FLOATING AQUATIC-PLANT BED SYSTEMS
- WETLANDS REHABILITATION TECHNOLOGY
- BIOLOGICAL TECHNOLOGIES
- ADVANCED OXIDATION PROCESS
- ADSORPTION TECHNOLOGIES
- COAGULATION TECHNOLOGY

Prevention of Water Pollution

- Conserve water by turning off the tap.
- Don’t throw paints and oils in water channels.
- Use environment friendly household products.
- Take great care not to overuse pesticides and fertilizers.
- Don’t throw litter into rivers, lakes or oceans.
- Suspended, solid particles and inorganic material can be removed by the use of filters.
- Use of biological filters and processes can naturally degrade the organic waste material.

Soil Pollution

- It is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents, which have adverse effects on plant growth and animal health.

Causes of Soil Pollution

- Domestic Sewage
- Discharge of industrial waste into the soil
- Acid rain damages the soil fertility by decreasing the pH of the soil
- Rupture of underground storage tanks
- Excess application of pesticides, herbicides or fertilizer
- Hospital wastes with pathogens
- Deforestation and Soil erosion
- Disposal of Plastics and polyethene wastes.
- Mining activities

Effects of Soil Pollution

- Reduce soil fertility
- Reduce nitrogen fixation
- Larger loss of soil and nutrients
- Reduce crop yield
- Contamination of underground and surface drinking water
- Ecological imbalance.
- Release of pollutant gases.
- Reduce vegetation.

Soil Erosion

- Soil erosion is one form of soil degradation and it is considered as a global environmental problem.
- Soil is naturally removed by the action of water or wind at roughly the same rate it formed. But, human activities increased that rate by 10-50 times.
- While soils can be eroded over a period of years or decades, their regeneration may require hundreds or even thousands of years.

Solid Waste Management

Objective of the Solid Waste Management:

The objective of solid wastes management is to control, collect, process, dispose of solid wastes in an economical way consistent with the public health protection

1. Bio degradable waste

2. Recyclable Waste

3. Inert Waste

4. Hazardous Waste

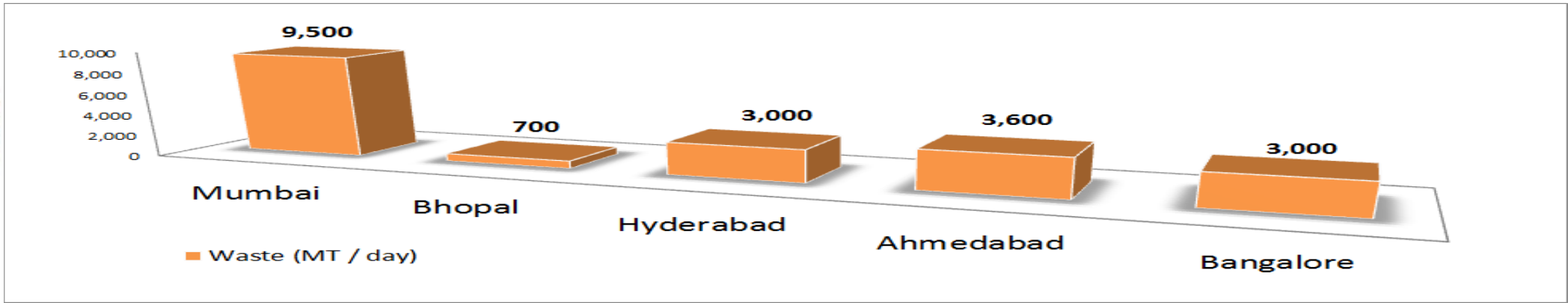
5. Medical Waste

6. Electronic Waste

Why to manage waste?

How much waste does the world produce each day on average?

10 billion pounds



Effects of solid waste

A: Health hazard

- If solid waste are not collected and allowed to accumulate , they may create unsanitary conditions.
- This may lead to epidemic outbreaks .
- Many diseases like cholera. Diarrhea, dysentery, plague, jaundice, or gastro-intestinal diseases may spread and cause loss of human lives
- In addition improper handling of the solid wastes ,a health hazard for the workers who come in direct contact with the waste.

B: Environmental impact

- If the solid wastes are not treated properly, decomposition and may generate intolerable odour.
- Industrial solid wastes spread on land and can affect the productivity of soils.
- Toxic substances may leach or percolate to contaminate the ground water.

Waste Disposal

1. Land filling: ‘Burying’ of waste.

PROBLEMS:

Wind-blown litter.

Generation of liquid leachate.

Harmful Gas.

2. Incineration: ‘Burning’ of Waste

PROBLEMS:

Emission of dangerous fumes.

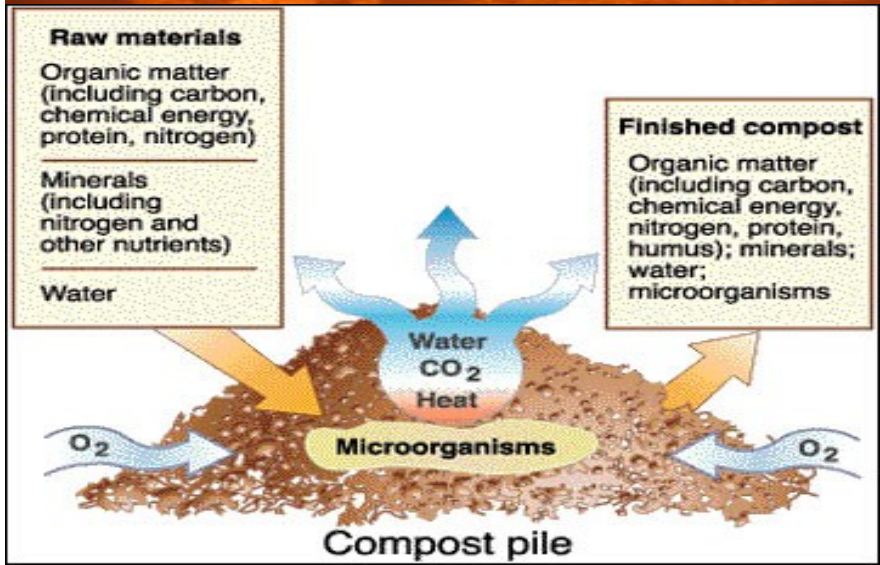
Require a source of energy to start.

3. Vermicomposting

’Composting’ using various ‘Worms.’

Manages Bio-Degradable waste.

Highly economical.



Control Measures

1. Reduce. 2. Reuse. 3. Recycle

Reduction

- By reducing, consumer and industry can save natural resources and reduce waste management costs.

Reuse

- Large production companies such as Electronic, appliances and gadgets, should establish the collection centre, where damaged items can be repaired and reuse.

Recycling

- Recycling turns materials that would otherwise become waste into valuable resources

Modern Agriculture

- More than 90% of farmers today work using the most innovative practices and growing techniques to produce enough food, fuel and fiber for a growing world, while minimizing their environmental footprint at the same time.

- The term "modern agriculture" depicts their commitment to innovation, stewardship and meeting the global food challenge all at once – there is nothing conventional about that

Modern Agriculture Supposed to be Sustainable Agriculture

Modern agricultural practices enable farmers to meet ALL three goals of sustainability: conserve and protect natural resources; meet the food and fuel needs of a growing population; and be financially viable for both growers and consumers.

Organic Farming:

- Non-chemical fertilizers & pesticides in agriculture
- crop rotation
- animal and green manure
- Biological control of pests

Principle Involved:

- Natural model of farming
- Soil as a living system

Methods:

- Bio-dynamic
- Bio-intensive
- Perm culture
- LEISA
- Composting
- Vermiculture

Biofertilizers

Biofertilizers are defined as preparations containing efficient strains of microorganisms that improve the soil fertility by natural means and also helps the crop plants to take up nutrients in the soil.

Advantages of Biofertilizers

- cost effective
- Harmless
- Made from natural substances

Limitations of Bio-fertilizers

- Not synthesized in large quantities
- not available for all types of crops.

Effects of Modern Agriculture over Environment

1. deforestation for opening up new agriculture farms, causing
   - loss of biodiversity
   - makes climate change worse
   - increase in soil erosion
   - increase CO_2 emission
   - loss of soil fertility
   - change in rainfall pattern

2) oil and water pollution by excessive use of agrochemicals (e.g., fertilizers and pesticides)

3) emissions of greenhouse gases such as CO_2 (from fossil fuels), CH_4 (methane from flooded soils like rice fields and livestock like cattle and sheep), NO_2 (nitrous oxide from N-based fertilizers)

4) increase in soil erosion due to increased soil disturbance such as plougging or farming activities on hill slopes

5) replacing biodiversity with mono species

Problems using fertilizers

1. Micronutrient imbalance: Ex: Excessive use of fertilizers in Punjab and Haryana caused deficiency of micronutrient Zinc thereby affecting productivity of soil.
2. Nitrate pollution: Excess Nitrogenous fertilizers applied in fields leach deep into the soil contaminating the groundwater. It causes "Blue Baby Syndrome“
3. Eutrophication: The application of excess fertilizers in fields leads to wash off of the nutrient loaded water into nearby lakes causing over-nourishment. This is called "Eutrophication". Eutrophication causes the lakes to be attacked by "algal blooms". Algal blooms use nutrients rapidly and grow fast. Their life is short, they die and pollute water thereby affecting aquatic life in the lake.

Problems in using Pesticides

1. **Death of non-target organisms:** Several insecticides kill not only the target species but also several beneficial not target organisms.
2. **Pesticide resistance**: Some pests that survive the pesticide generate highly resistant generations that are immune to all kinds of pesticides. These pests are called "super pests"
3. **Bio-magnification**: Most pesticides are non-biodegradable and accumulate in the food chain. This is called bio-accumulation or bio-magnification.
4. **Risk of cancer**: Pesticide enhances the risk of cancer in two ways (i) It acts as a carcinogen and (ii) It indirectly suppresses the immune system.

Noise Pollution

WHAT IS NOISE POLLUTION?

- Sound that is unwanted or disrupts one's quality of life is called as noise. When there is lot of noise in the environment, it is termed as noise pollution.

- Sound becomes undesirable when it disturbs the normal activities such as working, sleeping, and during conversations.

- It is an underrated environmental problem because of the fact that we can't see, smell, or taste it.

- World Health Organization stated that "Noise must be recognized as a major threat to human well-being"

Health Effects

- According to the USEPA, there are direct links between noise and health. Also, noise pollution adversely affects the lives of millions of people.
- Noise pollution can damage physiological and psychological health.
- High blood pressure, stress related illness, sleep disruption, hearing loss, and productivity loss are the problems related to noise pollution.
- It can also cause memory loss, severe depression, and panic attacks.

Sources of Noise Pollution

- Transportation systems are the main source of noise pollution in urban areas.
- Construction of buildings, highways, and streets cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers.
- Industrial noise also adds to the already unfavorable state of noise pollution.

- Loud speakers, plumbing, boilers, generators, air conditioners, fans, and vacuum cleaners add to the existing noise pollution.

Solutions for Noise Pollution

- Planting bushes and trees in and around sound generating sources is an effective solution for noise pollution.
- Regular servicing and tuning of automobiles can effectively reduce the noise pollution.
- Buildings can be designed with suitable noise absorbing material for the walls, windows, and ceilings.
- Workers should be provided with equipments such as ear plugs and earmuffs for hearing protection.

Solutions for Noise Pollution

- Similar to automobiles, lubrication of the machinery and servicing should be done to minimize noise generation.
- Soundproof doors and windows can be installed to block unwanted noise from outside.
- Regulations should be imposed to restrict the usage of play loudspeakers in crowded areas and public places.
- Factories and industries should be located far from the residential areas.

Solutions for Noise Pollution

- Community development or urban management should be done with long-term planning, along with an aim to reduce noise pollution.

- Social awareness programs should be taken up to educate the public about the causes and effects of noise pollution.

e-Waste

What is E-waste?

Electronic Waste (e-Waste) comprises of waste electronic/electrical goods which are not fit for their originally intended use. These include items such as computers, cellular phones, stereos, refrigerators, air conditioners, other consumer durables, etc.

Is e-Waste Hazardous?

E-waste is not hazardous waste per-se. However, the hazardous constituents present in the e-waste render it hazardous when such wastes are dismantled and processed, since it is only at this stage that they pose hazard to health and environment.

Salient points of proposed e-waste Rules

- Responsibility of each element in the e-waste Value Chain:
  - Producers – Extended/Individual Producer Responsibility
  - Dealers
  - Collection agencies/ collection Centres
  - Dismantler
  - Recycler
  - Consumer and bulk consumers
- Procedure for Authorization of producers, collection agencies, dismantlers, recyclers and enforcement agencies
- Procedure for registration/renewal of registration of recyclers
- Regulations for import of e-waste
- Liability of producers, collection agencies, transporter, dismantlers and recyclers
- Information & Tracking
- Elimination of hazardous substances used in e-equipments
- Setting up of Designated Authority to ensure transparency, audit and inspect facilities, examine authorization/ registration etc.

Toxic constituents in e-waste

COMPONENTS	CONSTITUENTS
➢ Printed circuit boards	Lead & cadmium
➢ Cathode ray tubes (CRTs)	Lead oxide & Cadmium
➢ Switches & flat screen monitors	Mercury
➢ Computer batteries	Cadmium
➢ Capacitors and transformers	Poly Chlorinated Bi-phenyls (PCB)
➢ Printed circuit boards, plastic	Brominated Flame Retardant casings cable
➢ Cable insulation/coating	Poly Vinyl Chloride (PVC)

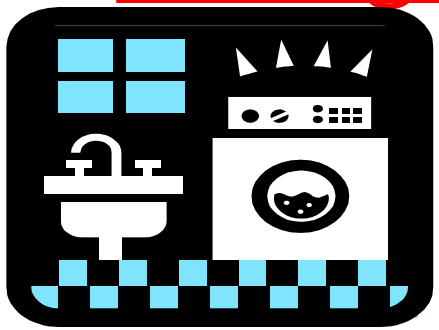
Recycling scenario in India

- E-waste recycling is presently concentrated in the informal (unorganized) sector
  - No organized collection system prevails
  - Operations are mostly illegal
  - Processes are highly polluting
  - Recycling operations engage in:
    - dismantling
    - sale of dismantled parts
    - valuable resource recovery
    - export of processed waste for precious metal recovery

…expected to rapidly change with formal recyclers setting operations

Pollution control technologies

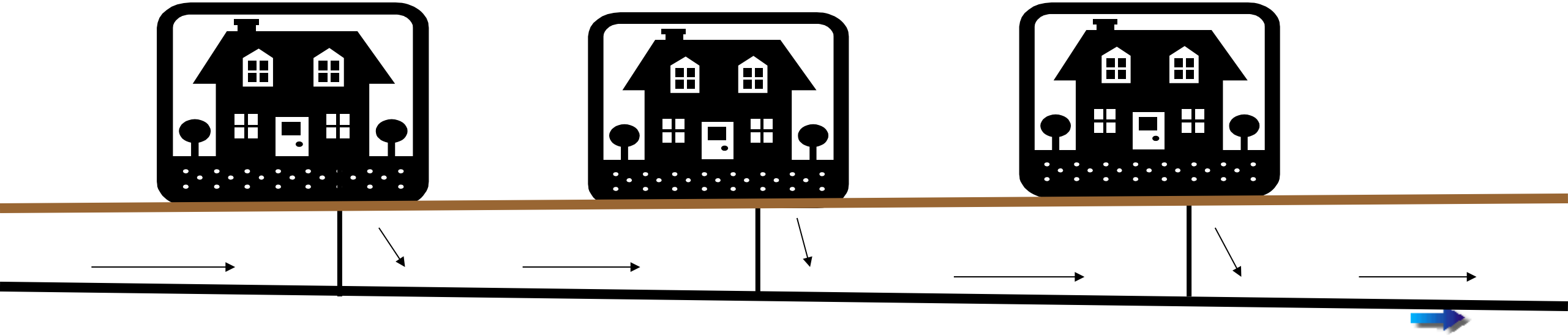
Sewage water Treatment



Where does the water from the washer go?

When you flush the toilet where does the contents go?

By gravity flow, the waste is on its way to your local wastewater treatment plant!



Why treat wastewater?

- Causes a demand for dissolved oxygen (lower DO levels of streams)
- Adds nutrients (nitrate and phosphate) to cause excessive growth
- Increases suspended solids or sediments in streams (turbidity increase)

Levels of Treatment

Primary

- removal by physical separation of grit and large objects (material to landfill for disposal)

Secondary

- aerobic microbiological process (sludge)

Mostly dead microbes

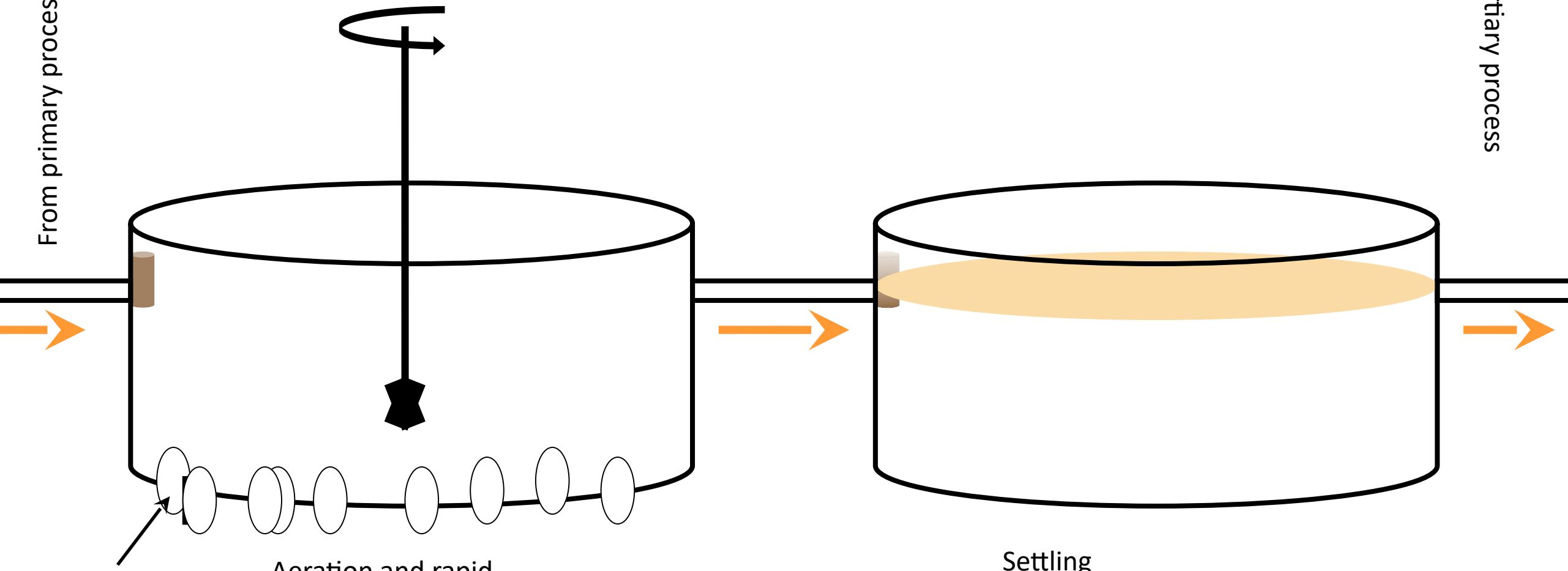
$$\text{organic matter} + O_2 \rightarrow CO_2 + NH_3 + H_2O$$

$$NH_3 \rightarrow NO_3^-$$

- lowers suspended solids content (into sludge)

aquatic nutrient

Secondary process



Levels of Treatment continued

Tertiary (advanced)

- anaerobic microbiological process with a different microbe where O_2 is toxic (more sludge)

$$NO_3^- \rightarrow N_2 \text{ (escapes to atmosphere)}$$

- PO_4^{-3} if not removed in sludge in secondary process

$$PO_4^{-3} + Al^{+3} \rightarrow AlPO_4 \text{ (s)} \quad \text{(into sludge)}$$

- aeration to strip N_2 and re-oxygenate (add DO)

Levels of Treatment continued

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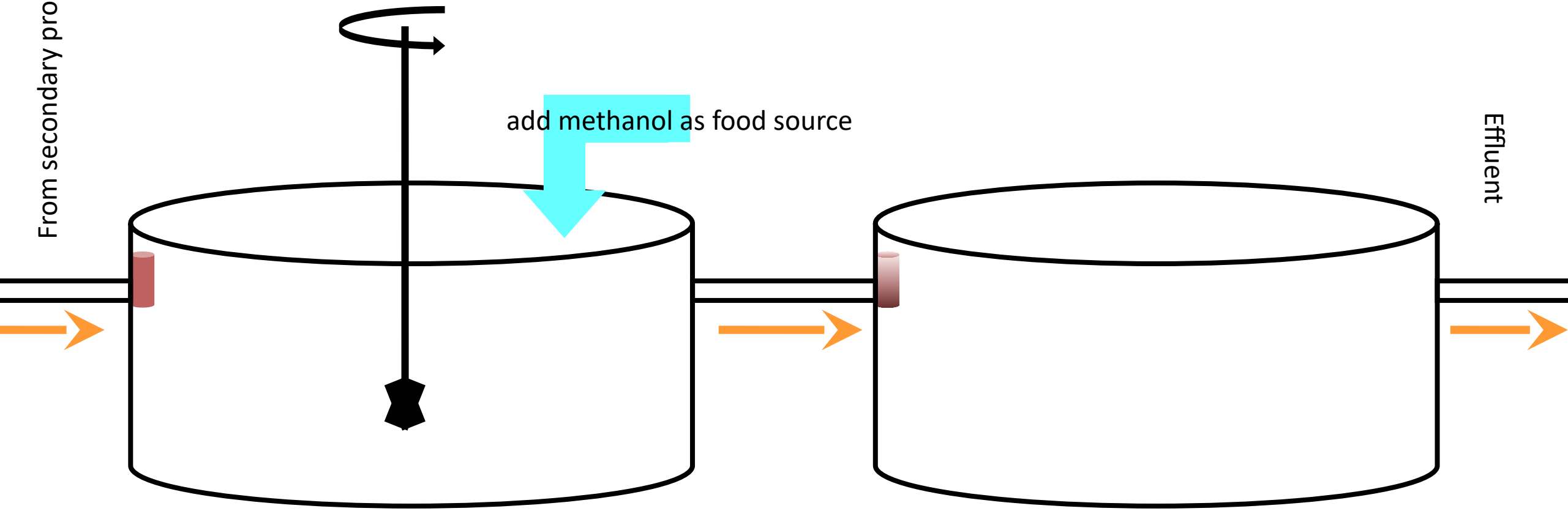
Tertiary process



Kyoto protocol,

The Kyoto Protocol is a agreement under which industrialized countries will reduce their collective emissions of greenhouse gases by 5.2% compared to the year 1990

Compared to the emissions levels that would be expected by 2010 without the Protocol, this target represents a 29% cut.

The goal is to lower overall emissions from six greenhouse gases - carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, HFCs, and PFCs - calculated as an average over the five-year period of 2008-12.

National targets range from 8% reductions for the European Union and some others to 7% for the US, 6% for Japan, 0% for Russia, and permitted increases of 8% for Australia and 10% for Iceland.“

Sinks can be used to offset emission and emission credits can be traded.

IPPC analyses used in assessments of sources and sinks

Montréal Protocol.

International policy

- 1970s - studies linking increased UV to cancer
- **1977** UNEP World Plan of Action for the Ozone Layer meeting
- 1979 Margaret Thatcher Elected
- 1980 Ronald Reagan Elected
- 1985 - Discovery of the Ozone Hole
- **1985** Vienna Convention, not binding and no protocol for reducing CFC emissions. "Umbrella Treaty".
  - US, Canada, Sweden, Norway, and Finland on one side (proposing 80% reduction, complete production ban); EEC countries on the other (30% cut, production cap).
- **1986**. Negotiations on a protocol to the Vienna Convention for controlling CFCs resumed.
- **1987**. Montreal Protocol on Substances That Deplete the Ozone Layer achieved in a 9-month period. Production ban, phase-out, Multilateral fund.
- Subsequent amendments: 1990 and onward

Montreal Protocol as a model for GHG

Similarities

- Science frames the debate
- Global problem
- Public concern
- Existing regime framework
- Multiple hazards
- Industry resistance to change

Differences

- Disconnect between science and policy.
- Uncertain future projections.
- Climate responses to GHG have longer timescales.
- No equivalent “Dread Factor”
- No viable energy substitute
- Incomplete international participation
- Kyoto vs. Montreal regime frameworks
- No accepted plan for developing world
- No equivalent to Farman et al. 1985 paper - observation of catastrophic change.
- CO_2 problem is much bigger in every way: Impacts, mitigation.