Short Communication

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Environmental Pollution: A Short Communication

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The term pollution is used to describe the introduction of harmful substances into the environment as a result of domestic, agricultural or industrial activities. Substances which pollute the air include gases like oxides of carbon, sulphur and nitrogen and the hydrocarbons emitted by thermal plants, motor vehicles and chemical industries. The increase in the level of carbon dioxide produces greenhouse effect, while nitrogen and sulphur oxides come down as acid rain causing destruction of vegetation and aquatic life. Water is normally polluted by effluents from industries, pesticides and fertilizers washed down from agricultural fields and city sewage. The greatest release of hazardous waste to the environment is from industries. Toxic chemicals flowing into rivers often kill fish. People who eat the contaminated fish have been known to develop health related problems, at times even fatal. Oil spills are also a major cause of water pollution which, if happens near the shore may seriously affect coastal flora and fauna. The increasing level of noise is also another cause of pollution which affects the environment. Pollution in any form is harmful to human life, and unless checked in time may threaten our very survival. Environmental pollution caused by the use of solvents, reagents and products will be dealt herewith.

The solvents that are mostly employed include volatile organic solvents (VOCs) like methylene chloride, chloroform, perchloroethylene and carbon tetrachloride. Some VOCs like, isopropyl alcohols, xylenes toluenes and ethylenes have been used as cleaning fluids because of their ability to dissolve oils, waxes and greases. Also, they readily evaporate from the items that they are being used to clean (VOCs readily evaporate or vaporise at room temperature). When VOCs come in contact with sun light and nitrogen oxides (by-products from the combustion of fossil fuels), these are transformed into ozone, nitric acid and partially oxidised organic compounds (Baird, 1999).

$$\text{VOCs} + \text{NO} \xrightarrow{\text{Sunlight}} \underset{\text{(Partially Oxidised)}}{O_3 + HNO_3 + \text{Organic Compounds}}$$

This product mixture is formed at the ground level and is commonly called smog. Continued exposure to smog may result in aggravating asthma and may induce respiratory problems[1] and can also cause lung cancer. This phenomenon leads to elevated levels of tropospheric ozone (one of the components of smog) and may cause damage to crops, discolour fabrics and harden rubber.

The use of chlorofluorocarbons (CFCs) and hydro chlorofluorocarbons (HCFCs) as solvents creates environmental problems. When CFCs are released into the atmosphere, these being inert, rise through the troposphere into the stratosphere (The CFCs are also released to the atmosphere from refrigeration industries), where they are photochemically decomposed by high-energy ultraviolet radiation from the sun. In fact the ozone layer present in the stratosphere prevents the harmful ultraviolet radiations from reaching the earth. On photochemical decomposition, the CFCs result in the formation of atomic chlorine (chlorine radical), which destroys the ozone by abstracting an oxygen atom from an ozone molecule and converting it into oxygen. The ClO radical formed, can react with an oxygen atom to form an oxygen molecule and regenerate chlorine radical.

$$CF_2Cl_2 \xrightarrow{UV} CF_2Cl^{\cdot} + Cl^{\cdot}$$

$$O_3 + Cl^{\cdot} \longrightarrow O_2 + ClO^{\cdot}$$

$$ClO^{\cdot} + O \longrightarrow Cl^{\cdot} + O_2$$

The overall reaction is the conversion of ozone into oxygen.

$$O_3 + O \longrightarrow 2O_2$$

This results in depletion of ozone layer and so the harmful ultraviolet radiations reach the surface of the earth. These ultraviolet radiations are responsible for causing skin cancer and cataract among humans.

Due to above reasons, the governments around the world have forbidden the use of CFCs. The Montreal Protocol, signed in Canada in 1987 and 1989, and subsequently in London in 1990 decided to speed up the phasing out of CFCs. Liquid and supercritical carbon dioxide has replaced CFCs which were also used as blowing agents for polystyrene.[3] Subsequently in place of CFCs, aliphatic hydrocarbons (e.g., pentane) were used as blowing agents for polystyrene. Though aliphatic hydrocarbons are not ozone depleting, they can lead to the formation of ground level smog if their emissions are not captured. A harmless blowing agent viz. carbon dioxide has been developed. The advantage of carbon dioxide is that it does not deplete the ozone layer, does not form smog, is economical, handling is easier and is non-flammable. However carbon dioxide is greenhouse gas. It is commonly known that in the atmosphere, carbon dioxide allows UV and visible radiations to reach the earth's surface but reflects the IR radiations coming from the earth's surface and directing it back to the earth. Thus, excess levels of carbon dioxide in the atmosphere can significantly raise the temperature of the earth's atmosphere, which is responsible for global warming (Drath and Frost, 1994). Nitrous oxide (N_2O), commonly known as laughing gas is also known to cause environmental pollution. Nitrous oxide is obtained as a by-product during the manufactured adipic acid as follows:

Benzene (C_6H6) combines with hydrogen (H_2) in the presence of catalyst Ni or Pt to form cyclohexane (C_6H_{12}) which combines with oxygen (O_2) to form cyclohexanone ($C_6H_{10}O$) and cyclohexanol ($C_6H_{11}OH$). Cyclohexanol combines with nitric acid (HNO_3) or ammonium nitrate (NH_4NO_3) and yields adipic acid ($HOOC - (CH_2)_4 - COOH$) and nitrous oxide (N_2O).

The production of nitrous oxide as a by-product can cause 10% annual increase of Nitrous oxide.[4] The nitrous oxide is obtained as a by-product in a number of reactions involving oxidation with nitric acid. The nitrous oxide rises into the stratosphere and plays a role in the destruction of the ozone layer. The first step in this process is the reaction of nitrous oxide with atmospheric oxygen to produce $NO^{\cdot}$, which acts as a catalyst to deplete ozone. Nitric oxide abstracts an oxygen atom from an ozone molecule, giving O_2 and $NO^{\cdot}{}_2$. The resulting $NO^{\cdot}{}_2$ then reacts with an additional oxygen atom regenerating $NO^{\cdot}$ and forming another molecule of O_2. The regenerated $NO^{\cdot}$ can react again resulting in significant loss of ozone for every molecule of N_2O.

$$N_2O + O^{\cdot} \longrightarrow 2NO^{\cdot}$$
$$NO^{\cdot} + O_3 \longrightarrow NO^{\cdot}{}_2 + O_2$$
$$NO^{\cdot}{}_2 + O^{\cdot} \longrightarrow NO^{\cdot} + O_2$$

The overall reaction is

$$O_3 + O^{\cdot} \longrightarrow 2O_2$$

Nitrous oxide acts as a greenhouse gas and cause global warming (as in the case of carbon dioxide). Also, air pollution is a result of exhaust emission particularly carbon dioxide and nitrogen oxides. The nitrogen oxide part of the exhaust mixes with moisture in the atmosphere and then comes down in the form of acid rain. During lightning and thunder storm, the nitrogen in the atmosphere combines with oxygen to give nitric oxide, which combines with oxygen to give nitrogen dioxide which dissolves in water to give nitrous acid and nitric acid, which finally come to earth in the form of acid rain.

$$N + O \xrightarrow{\text{Electric discharge}} NO$$
$$NO + O \longrightarrow NO_2$$
$$2NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$$

Acid rain is detrimental to plants and aquatic life. In some extreme cases, when the pH falls below 4.5, acid rain is responsible for making lakes devoid of aquatic life (Buella and Girard, 1994).

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