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Distance Learning Programme (DLP)

ENVIRONMENT & DISASTER MANAGEMENT

(UPSC MAINS)

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ENVIRONMENT & DISASTER MANAGEMENT

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Pollution

Chapter 1

"Environmental problems are really social problems. They begin with people as the cause, and end with people as victims. They are usually born of ignorance and apathy. It is people who create a bad environment and a bad environment brings out the worst in people. Man and nature need each other, and by hurting one we wound the other…"

– Edmund Hillary "ECOLOGY 2000"

Pollution can be defined as the introduction of contaminants into the natural environment that causes adverse changes. As per Environment Protection Act (EPA), 1986 "Environmental Pollution" is the presence of pollutant, defined as any solid, liquid or gaseous substance present in such a concentration as may be or may tend to be injurious to the environment.

The agents, which cause environmental pollution, are called pollutants. Pollutants are physical, chemical or biological substance intentionally or unintentionally released into the environment which is directly or indirectly harmful to humans and other living organisms.

Air Pollution

Air pollution occurs when harmful or excessive quantities of substances, including gases, particulates, and biological molecules are introduced into Earth's atmosphere. It may cause diseases, allergies and also the death of humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. Air pollution is defined as the presence of any solid, liquid or gaseous substance, including noise and radioactive radiation in the atmosphere in such concentration that may be directly and indirectly injurious to humans or other living organisms, plants, property or interferes with the normal environmental processes. Air pollutants can be classified into the following three types:

Natural Pollutants: The pollutants which come out from natural sources such as forest fires started by lightening, dispersal of pollen, soil erosion, volcanic eruptions, volatile organic compounds from leaves and trees, decomposition of organic matter and natural radioactivity, etc. are natural pollutants.

Primary Pollutants: A primary pollutant is a harmful substance that directly enters the air as a result of human activities. For example, when coal, oil, natural gas or wood is burnt, carbon dioxide and carbon monoxide are formed, automobiles contributing a large share of carbon monoxide. All these gases enter the atmosphere.

Another important pollutant is sulphur dioxide (SO_2) which is added to the atmosphere by burning of coal and oil containing sulphur as an impurity in electric power plants. Other primary pollutants are oxides of nitrogen, hydrocarbons and suspended particulate matter.

Secondary Pollutants: Secondary pollutants result from harmful chemical reaction between two or more air components. For example, sulphur dioxide, the primary pollutant reacts with oxygen in the atmosphere to form the secondary pollutant, sulphur trioxide (SO_3) ($2SO_2 + O_2 = 2S0_3$). The sulphur trioxide can then react with water vapour in the air to form droplets of sulphuric acid (H_2SO_4), another secondary pollutant. Troposphere Ozone (O_3) is another secondary pollutant.

Sources of Air Pollution

The sources of Air Pollution can be classified into three types:

- **Point Sources:** It includes pollutants coming from industries, power plants, waste burning, etc.
- **Areal Sources:** It includes heating and cooling activities, burning of crop residues, forest fires, etc.
- **Line Sources:** It includes pollutants generated by movement of traffic, air planes, etc.

Pollutants Types Based on State

- Gaseous Pollutants like carbon dioxide (CO_2), NOx (N_2O, NO_2) etc.
- Suspended Particulate Matter (SPM)

Gaseous Pollutants

Gaseous Pollutants and Their Sources

Pollutants	Sources of Pollutants
Carbon Compounds (CO and CO_2)	Automobile exhaust, burning of wood and coal, indoor heating system, smoking.
Sulphur Compounds (SO_2 and H_2S)	Burning of fossil fuels, Power plants and refineries, smelting of metallic ores like iron, copper, zinc, lead, rotting of weeds.
Nitrogen Compounds (NO and N_2O)	Motor vehicle exhaust, electric power plants, soil microbes.
Hydrocarbons (benzene, ethylene)	Automobiles, cigarettes, refineries, paints and solvents, fossil fuels.
Aldehydes (Acrolein and formaldehyde)	Incomplete combustion of fossil fuels, formation of smog.

Particulate Pollutants

Particulate matter suspended in air – dust, liquids and soot, is called Suspended Particulate Matter (SPM). It can be divided into dust, fume, mist, smoke and aerosols based on the size. Major source of SPM (suspended particulate matter) are vehicles, power plants, construction activities, oil refinery, railway yard, market place, industries, etc. Their size ranges from 0.001 to 500 micrometers in diameter. The size and weight, in particular, determine their suspension from a few seconds to months in the atmosphere. Particles less than 10 µm (for example PM10 and PM2.5) are called Respirable Suspended Particulate Matter (RSPM). They float and move freely with the air current. Particles which are more than 10 µm in diameter settle down.

Aerosols: Aerosols are minute particles suspended in the atmosphere. They are of a size less than 1 micron. Particles of size less than 0.02 µm form persistent aerosols. The aerosols remain constantly under the influence of the gravitational force of the earth. The aerosols in the atmosphere are of two kinds: one is the natural, such as fog, bacteria, plant spores, pollen etc. These usually do not cause any atmospheric pollution. The second type of aerosols, such as cement powder, flue dust from coal dust combustion, quartz and asbestos powder, oil smokes, tobacco smokes and radioactive aerosols are air pollutants due mainly to man's activities and cause constant damage and threat to the atmosphere.

Indian Monsoon and Aerosols

According to a study conducted by a team of Indian Institute of Tropical Meteorology, Pune, aerosols from vehicular exhaust, half-burnt crop residue, and dust and chemical effluents may be weakening the Indian monsoon. Earlier in 2015, it was reported in a journal 'Climate Dynamics' that a mix of GHGs, aerosols and changes in forest and agricultural cover was disturbing the strength of the monsoon. Aerosols are microscopic organic and inorganic particles that are constantly being released into the atmosphere from dust, volcanic ash and vapours emitted by plants, or human-made, such as vehicular exhaust, emissions from mines and soot from thermal power plants. Dust clouds shield the earth from the sun's rays, affecting land and sea temperatures. The monsoon, which is produced by the difference in temperature between the two, is thus weakened. Additionally, greater the number of aerosols, the larger is the number of cloud droplets. But more cloud droplets do not necessarily mean higher precipitation. As cloud water gets distributed among too many aerosols, they result in a large number of smaller droplets, which are slower to combine into bigger droplets that can fall as precipitation.

Black Carbon (BC), or Carbon Black, or Elemental Carbon (EC): It is often called soot, composed of pure carbon clusters and skeleton balls, and is one of the most important light absorbing aerosols in the atmosphere. BC from fossil fuels, as estimated by the IPCC in the Fourth Assessment Report, contribute to global mean radiative forcing.

According to a recent assessment by Wadia Institute of Himalayan Geology (WIHG, Dehradun) black carbon travelling from Mediterranean countries during the western disturbances and wind trajectories may be one of the contributing factors leading to pollution and the receding snowline in the Himalayas. When deposited on ice and snow, black carbon and coemitted particles reduce surface albedo, the ability to reflect sunlight, and heat the surface. The Arctic and glaciated regions such as the Himalayas are particularly vulnerable to melting as a result.

Hydrocarbons: Hydrocarbons are compounds made up of carbon and hydrogen. Some hydrocarbons have a direct effect on human beings and are carcinogenic in nature. They are produced during the production of coke and smouldering of refuse piles near coal mines or during improper burning of coal.

Fly Ash: Fly ash is ejected mostly by thermal power plants as by-products of coal burning operations. Fly ash pollutes air and water and may cause heavy metal pollution in water bodies. It contains silica, iron oxides and other heavy metals. Fly ash affects vegetation as a result of its direct deposition on leaf surfaces or indirectly through its deposition on soil. Fly ash is now being used for making bricks and as a landfill material.

Use of Fly Ash
Fly ash possesses good pozzolinic properties due to the presence of active and finely divided silica, alumina and calcium oxide, which provide it with cement like qualities in combination with lime rich material. Thus fly ash emitted by thermal power plants can be used for manufacturing bricks, blocks, aggregates and cement production. The Fly Ash Utilisation Policy makes it mandatory to use only fly ash/fly ash based products in the construction of buildings, roads and reclamation/compaction of land within a radius of 100 km from a coal or lignite based thermal power plant, thus displacing the cement use. It also mandates utilisation of Fly Ash for backfilling or stowing of the mines.

Trace Air Pollutants: These are heavy metals found only in trace amounts. It causes extensive damage to ecosystem and human beings.

Causes of Air Pollution

- Industrial exhaust
- Burning of fossil fuels in Industries and automobiles, transport sector
- Particulates from road dust, crop burning, construction and demolition waste
- Emission from solid and liquid waste
- Mining operations
- Power plants

Effects of Air Pollution

Breathing polluted air puts humans at a higher risk for asthma and other respiratory diseases. When exposed to ground ozone for about 6 to 7 hours, the lung function decreases it causes respiratory inflammation. Air pollutants are mostly carcinogens and living in a polluted area can put people at risk of Cancer. Coughing and wheezing are common symptoms observed in metro cities. Air pollution also damages the immune system, endocrine and reproductive systems. High levels of particle pollution have been associated with higher incidents of heart problems.

Photochemical smog has a deleterious effect on plants. In the presence of sunlight, various pollutants combine to form ozone and peroxyacetyl nitrate (PAN). Ozone is also extremely damaging to plants. It enters leaves through the stomata which are used for normal gas exchange, and alters the permeability of the membranes of the stomata, causing nutrient-and electrolyte-imbalances resulting in the death of the cells. In effect, ozone increases respiration of leaves, killing the plant by depleting its food. Chronic exposure to ozone may weaken plants and make them more susceptible to disease, or age them prematurely, reducing crop yields without signs of outward injury. PAN is phyto-toxic. It blocks the process of photosynthesis killing the plant by shutting down food production. Sulphur dioxide has a potential for serious damage to plants by contributing to acid rains. These rains leach nutrients from the soil and foliage, and affect soil organisms responsible for nitrogen fixation. Acids enhance the uptake by plants, of toxic heavy metals from soil. This has seriously affected the existing conifer forests in Europe and Western United States.

Monitoring of Air Pollutants

The monitoring of pollutants is carried out for 24 hours (4-hourly sampling for gaseous pollutants and 8-hourly sampling for particulate matter) with a frequency of twice a week,

to have one hundred and four (104) observations in a year. The monitoring is being carried out with the help of the Central Pollution Control Board; State Pollution Control Boards; Pollution Control Committees; National Environmental Engineering Research Institute (NEERI), Nagpur.

National Air Quality Monitoring Programme (NAMP)

The Central Pollution Control Board is executing a nationwide programme of ambient air quality monitoring known as National Air Quality Monitoring Programme (NAMP). The network consists of Six hundred and Eighty Three (683) operating stations covering Three Hundred (300) cities/towns in twenty nine (29) states and seven (7) Union Territories of the country. The objectives of the NAMP are to determine status and trends of ambient air quality; to ascertain whether the prescribed ambient air quality standards are violated; to identify non-attainment cities; to obtain the knowledge and und erstanding necessary for developing preventive and corrective measures and to understand the natural cleansing process undergoing in the environment through pollution dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated. Under NAMP, four air pollutants viz. Sulphur Dioxide (SO_2), Oxides of Nitrogen as NO_2, Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM/PM10) have been identified for regular monitoring at all the locations. The monitoring of meteorological parameters such as wind speed and wind direction, relative humidity (RH) and temperature was also integrated with the monitoring of air quality.

Central Pollution Control Board
The Central Pollution Control Board (CPCB), a statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment, Forest and Climate Change under the provisions of the Environment (Protection) Act, 1986. Principal Functions of the CPCB are to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and to improve the quality of air and to prevent, control or abate air pollution in the country.

National Air Quality Index (AQI)

The Minister of Environment, Forests & Climate Change launched the National Air Quality Index (AQI) in 2014 under the Swachh Bharat Abhiyan. It is outlined as 'One Number-One Colour-One Description' for the common man to judge the air quality within his vicinity. It is published every month by the Central Pollution Control Board (CPCB) along with a numerical value and a colour code which helps in comparing air pollution levels in cities. It is determined on the basis of concentration of 8 pollutants which includes Particulate Matter (PM 2.5, PM 10), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), ammonia (NH_3) and lead (Pb).

India is adopting a new system to measure air quality. India is tying up with the United States and Finland to develop a pollution-forecast system that will help anticipate particulate matter (PM) levels at least two days in advance and at a greater resolution than what is possible now. The Ministry of Earth Sciences (MoES) will be coordinating this exercise. Currently, the System of Air Quality and Weather Forecasting and Research (SAFAR) run by the Indian Institute of Tropical Meteorology (Pune) serves as the apex forecaster of pollution trends in Delhi, Mumbai, Pune and Ahmedabad. It generates a likely

air quality profile a day in advance for these cities. IITM is an organisation under the MoES. The new system, to be jointly developed with expertise from the Finnish Meteorological Institute and the U.S.' National Oceanic and Atmospheric Administration, will use a different modelling approach as well as computational techniques from that employed in the SAFAR model. Though SAFAR will continue to be the backbone for pollution forecast, but this new system will use a different method of analysis leading to better resolution and more accurate forecasts. The Union Environment Ministry has also released a draft of the National Clean Air Programme (NCAP) that aims to improve air quality monitoring in India by increasing the number of pollution monitoring stations and incorporating it into a pollution forecast system.

SAFAR
"System of Air Quality Forecasting and Research (SAFAR)" was inaugurated in 2010. It works under the aegis of the Ministry of Earth Sciences. This system has been developed indigenously by the Indian Institute of Tropical Meteorology (IITM), Pune. It encompasses 11 Air Quality Monitoring Stations, 34 Automatic weather stations in NCR along with GPS observations and Doppler Weather Radar.

Graded Response Plan by CPCB

It has been designed to give real-time information on air quality grade to prevent mass health distress and diseases. The graded response plan is one of the comprehensive and stringent strategies adopted globally during severe air pollution days. The plan will ensure the checks on most emission sources nearly throughout the year. The plan urges to kick-start necessary preparations so that the response plan is in place at least four weeks in advance of the "anticipated critical pollution days". A task force will be set up with members from CPCB, MoEFCC, Delhi Pollution Control Committee (DPCC) and pollution control boards from other NCR states, India Meteorological Department (IMD), health experts, among others. The task force will review the air quality status.

Control of Air Pollution

We can study the control of air pollution under following two heads:

Control of Industrial Pollution

To control industrial pollution, especially particulate matters, installing devices such as filters, electrostatic precipitators, inertial collectors, scrubbers, gravel bed filters or dry scrubbers can be used. Filters remove particulate matter from the gas stream. In Electrostatic Precipitators (ESP), the emanating dust is charged with ions and the ionized particulate matter is collected on an oppositely charged surface. The particles are removed from the collection surface by occasional shaking or by rapping the surface. ESPs are used in boilers, furnaces, and many other units of thermal power plants, cement factories, steel plants, etc. Inertial Collectors works on the principle that the inertia of SPM in a gas is higher than its solvent and as inertia is a function of the mass of the particulate matter, this device collects heavier particles more efficiently. 'Cyclone' is a common inertial collector used in gas cleaning plants. Scrubbers are wet collectors. They remove aerosols from a stream of gas either by collecting wet particles on a surface followed by their removal, or else the particles are wetted by a scrubbing liquid. The particles get trapped as they travel from supporting gaseous medium across the interface to the liquid scrubbing medium. Gaseous pollutants can be removed by absorption in a liquid using a wet scrubber and depends on the type of the gas to be removed, for e.g., removal of sulphur dioxide alkaline

solution is needed as it dissolves sulphur dioxide. Gaseous pollutants may be absorbed on an activated solid surface like silica gel, alumina, carbon, etc. Silica gel can remove water vapour. Condensation allows the recovery of many by products in coal and petroleum processing industries from their liquid effluents.

Control of Vehicular Pollution

Use of quality fuel can be greatly helpful in controlling the menace of vehicular pollution. BS-IV has been adopted across the country in 2017 and the government has taken the decision to implement BS-VI norms by 2020 directly, skipping BS-V as vehicles complying with BS VI norms emit less exhaust and are less polluting. To deal with the critical pollution situation in the national capital, the Ministry of Petroleum, recently, brought forward the date for the rollout of Bharat Stage (BS)-VI fuel for Delhi to April 1, 2018 instead of the original deadline of April 1, 2020. The main difference between BS-IV and BS-VI (which is comparable to Euro 6) is in the amount of sulphur in the fuel. BS-VI fuel is estimated to bring around an 80% reduction in sulphur content–from 50 parts per million (ppm) to 10 ppm.

Bharat Stage emission norms are the Indian equivalent of European emission standards. First introduced in 2000, the BS emission standards are instituted and implemented by the Central Pollution Control Board under the Ministry of Environment, Forest and Climate Change. However, there are several challenges to the implementation of the recent decision. Some of them are: First, it took as many as seven years for the entire country to shift to BS-IV. The attempt, this time is to leapfrog one stage–BS-V– altogether, and that makes the switch to BS-VI that much more difficult for both the oil companies and automobile makers. Second, the introduction of higher grade fuel will be beneficial only if it is done in tandem with the rollout of BS-VI compliant vehicles. Using BS-VI fuel in the current BS-IV engines or, conversely, running BS-VI engines on the current-grade fuel, may be ineffective in curbing vehicular pollution, and may damage the engine in the long run. Third, even if automakers were to bring forward their manufacturing schedules, it doesn't make practical sense for them to build BS-VI compliant vehicles for just one city. Thus, while the move to BS-VI fuel in Delhi could reduce the particulate emissions from the existing fleet of vehicles, there are more steps the government can take, such as stringently enforcing the order banning BS II and earlier vintage vehicles from plying in the NCR region.

Some other measures to control vehicular pollution are greater promotion and use of alternative fuels such as CNG/LPG and electric vehicles/Hybrid and battery based E-Rickshaw and buses. Zero emission vehicles (non motorised transport) like cycle rickshaw, cycle and walking should be promoted. Public Transport System including Mass Transit System (MTS) should be promoted. Metro, bus rapid transit, urban rail should be adopted in big cities since it reduces dependence on private vehicles. Urban roads and flyover projects should be introduced which help to reduce congestion and hence emissions from the vehicles. Special emphasis should be given to increasing tree cover or green cover as plants reduce carbon dioxide and other pollutants.

Recent Issues

Delhi Air Pollution

Recently, Delhi's Air Quality Index (AQI), which measures the concentration of poisonous particulate matter in the air, hit the "severe" level. The AQI breached the maximum reading of 500 at some monitoring stations. The Supreme Court has also intervened and sought the response of the Centre and the governments of Punjab, Delhi and Haryana on measures taken to counter the smog and pollution choking the national capital and surrounding areas.