

OUR ENVIRONMENT - UNDERSTANDING POLLUTION

Pollution and the contributors towards it, as well as the fight against pollution need to be fully understood. This document serves to give a generic overview of what pollution is and what contributes to the various aspects of pollution in a developing country such as South Africa.

1. Introduction

The effect of pollution can be described as a measurable or perceivable detrimental change resulting from an air pollutant. The pollutant may affect humans, plants, animals, microbes – in fact any living matter. It may also affect non-living materials such as paints, metals, fabrics etc. The living and non-living matter that receive pollution are called “receptors”.

The evidence upon which air pollution guidelines are based is gathered from:

- Case studies
- Laboratory research
- General field studies
- Other sources, such as practical experience.

Although scientists try to establish casual relationships, i.e. evidence which proves that exposure to a specific pollutant causes an identifiable adverse effect, such precise evidence is virtually impossible to obtain. At best, scientific and statistical methods can be used to reduce the uncertainty about the observed relationship between a specific pollution situation and an identifiable effect.

2. The science of pollution

Two basic physical forms of pollution exist:

2.1 Particles

- Small, discrete masses of solid or liquid matter eg: dust, smoke, mist and fly ash
- Float in air or settle very slowly

2.2 Gases

- Widely separated molecules in rapid motion
- Lack definite shape and volume e.g.: carbon monoxide, sulphur dioxide and hydro-carbon vapours

2.3 Pollutants can also be classified as primary or secondary pollutants:

2.3.1 Primary Pollutants

- Emitted into atmosphere, directly from identifiable sources.
- Found in the atmosphere in the same chemical form as when emitted from source.

2.3.2 Secondary Pollutants

- Formed as a result of chemical reactions involving primary pollutants in the atmosphere.

3. Criteria pollutants

Criteria pollutants are widespread, common pollutants which have been shown to be harmful to human health and welfare. In order to protect human health and wellbeing, and prevent undesirable impacts on the environment, National Ambient Air Quality Guidelines have been set for these pollutants.

POLLUTANT	SYMBOL	FORM	TYPE
Carbon Monoxide (CO)	CO	Gaseous	Primary
Sulphur oxides	SO _x	Gaseous	Primary
Nitrogen dioxide	NO ₂	Gaseous	Primary & Secondary
Hydrocarbons	HC	Gaseous	Primary
Ozone	O ₃	Gaseous	Secondary
Particulate matter	TSP (Total Suspended Particulates)	Particulate	Primary & Secondary
Lead	Pb	Particulate	Primary

4. Definitions: -

4.1 Carbon Monoxide (CO):

- Colourless
- Odourless
- Tasteless
- Man-made sources are motor vehicles and industrial/domestic combustion
- Natural sources are the sea, rivers and swamps

Transportation accounts for about 80% of man-made emissions in Gauteng. The most severe CO problems are found in cities where vehicle emissions are concentrated between rows of tall buildings. The ambient concentration of carbon monoxide on a particular day depends on the number of vehicles and the weather.

Carbon monoxide reduces the supply of oxygen to the human body. Oxygen transporting cells usually replace carbon dioxide with oxygen. However, in the presence of carbon monoxide, they will replace the oxygen and carbon dioxide with carbon monoxide.

Carbon monoxide at the levels found in some major metropolitan areas can lead to heart and circulatory system related diseases.

Smokers inhale a significant amount of CO!

4.2 Sulphur Oxides (SO_x)

4.2.1 Sulphur Dioxide (SO₂):

- Colourless
- Irritating odour
- Man-made sources are industrial processes and combustion
- Natural sources include erupting volcanoes and biogenic sea spray

Coal and oil combustion in boiler furnaces and stoves contributes to about 30% of emissions in the world, iron and copper ore smelting furnaces about 5%, and combustion in motor vehicle engines and domestic combustion a further 15%.

Natural sources account for approximately 50% of emissions in the world.

In the combustion of coal, the sulphur combines with oxygen and forms Sulphur dioxide (SO₂). Therefore, the higher the sulphur content in the coal, the higher the SO₂ emissions would be. This is also referred to as the "pass through pollutant".

4.2.2 Nitrogen Oxides (NO_x):

- Include several gases
- Composed of nitrogen and oxygen
- Man-made sources are primarily the combustion of fossil fuels and motor car emissions.
- Natural sources are erupting volcanoes, forest and veld fires, swamps, rivers and lightning.

Nitrogen dioxide (NO₂) is relatively more harmful than other criteria pollutants. Nitric oxide (NO), the most commonly emitted of all NO_x, is relatively less harmful. It is, however, rapidly converted into nitrogen dioxide, which is toxic.

Nitrogen in fuel is oxidised to form nitric oxide and small amounts of nitrogen dioxide. Nitrogen in the air within a combustion chamber is also converted to nitrogen oxides, mostly nitric oxide. Oxidation of nitrogen from air in a combustion chamber is much slower than oxidation of nitrogen in fuel.

Nitric oxides emitted to the air are converted to nitrogen dioxide by photochemical reactions promoted by sunlight.

4.2.3 Hydrocarbons (HC):

- HC's are composed of only hydrogen and carbon, and many are in gaseous form at normal atmospheric conditions.
- VOC - Volatile Organic Compounds - include most volatile hydrocarbons, and are in gaseous form at normal atmospheric conditions.
- VOC's are composed of hydrogen and carbon, and may contain elements such as oxygen, nitrogen, sulphur, chlorine and fluorine.
- VOC's include only those compounds which take part in atmospheric photochemical processes.
- Man-made sources are spray painting and domestic paints, petrochemical plants, dry cleaning services, vehicle emissions, and solvents in many products.

Combustion factors affecting VOC emissions include time in the combustion chamber, fuel and air mix, turbulence in chamber, temperature and pressure design of chamber.

VOC's must be controlled as they take part in the photochemical production of ozone and other photochemical oxidants.

4.2.4 Ozone (O₃):

- Gaseous
- Nitric oxides (NO) and Hydrocarbons (HC) form Nitrogen dioxide (NO₂). $NO_2 + VOC = \text{ozone}$.
- Formed in our atmosphere
- The main constituent of photochemical smog
- Both natural and manmade volatile organic compounds can produce ozone, but naturally occurring volatile organics seldom produce enough ozone to cause substantial adverse effects.

In the stratosphere a protective layer of ozone is found, while pollutant ozone occurs in the troposphere.

Factors affecting ozone concentration include:

- Primary pollutant concentration (HC, NO_x)
- Reaction time and ratios
- Intensity of sunlight
- Temperature
- Wind speed and direction
- Rainfall
- Occasionally special weather conditions draw ozone-rich air from the upper atmosphere down to the earth along leading edges of cold fronts.

5. Suspended Particulate Matter

- Measured as Total Suspended Particulates (TSP)
- Mostly primary pollutants, but includes some secondary pollutants
- Very small pieces of liquid or solid matter
- Natural sources are the sea and beach, deserts, volcanic eruptions and forests.
- Man-made sources are open cast mining operations, steel manufacturing industries and power stations. Agricultural processes contributing to TSP are ploughed fields, pollen from plants and dry maize fields, milling plants and aerial crop spraying.
- TSP emissions are distributed through wind and natural atmospheric currents.

6. Other pollutants

In addition to the pollution problems caused by the suspended particles themselves, these particles combine with other pollutants to form secondary - and sometimes more harmful - pollutants.

6.1 Lead (Pb):

- Grey metal
- Fairly abundant
- Derived from ore-bearing minerals
- Can be easily formed, moulded, and worked
- Withstands weathering and chemical erosion.

Because of its physical properties, lead has been used for, amongst others, cookware, stained glass, water piping and in some paints and petrol.

Lead is largely emitted into the atmosphere in a gaseous state through emissions from vehicles using fuel that contains lead. However, it can also be released as waste into the ground and water sources.

7. Hazardous Pollutants

- May cause or contribute to an increase in mortality or an increase in irreversible or incapacitating reversible illnesses
- Usually cause localised problems
- Controlled with emission guidelines rather than by limitations on the concentrations allowable in the ambient air.

Examples: Asbestos, Benzene, Vinyl Chloride, Mercury, Arsenic

7.1 Sources of Asbestos

- Mining, milling, and spraying of asbestos
- Manufacturing of asbestos-cement products, paper, plastics, gaskets, packings, roofing felts and insulation.

In Eskom plant, such as power stations, asbestos is not used for insulation purposes.

7.2 Sources of Benzene

- Petrochemical Industries
- Petrol stations
- Dry cleaning services
- Spray painting operations

7.3 Sources of Mercury

- Mercury-ore processing plants
- Hydrochloric acid manufacturing plants
- Plants which dispose of sewage treatment sludge by drying or burning.

7.4 Sources of Vinyl Chloride

- Production of polyvinyl chloride
- General public exposure may result from use in:
 - Aerosol containers
 - Food wrapping and containers
 - Plumbing pipes
 - Other plastic products

8. Other Hazardous Air Pollutants

- Manganese
- Vinylidene chloride
- Nickel
- Polycyclic organic matter (coke oven emissions)
- Ethylene dichloride
- Formaldehyde
- Cadmium
- Epichlorohydrin
- Ethylene oxide
- Acrylonitrile.

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