MISSION STATEMENT

To ensure the protection, wise use and enhancement of the environment in Trinidad and Tobago, thereby contributing to an improved quality of life, through:

- *Active partnerships with all sectors of the community;*
- *Public awareness and education;*
- *Co-operation with public entities in respect of Environmental Management Programmes;*
- *Development and enforcement of environmental laws;*
- *Being proactive as well as responsive to environmental concerns.*

TRINIDAD AND TOBAGO

STATE OF THE ENVIRONMENT REPORT 2000

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CHAIRMAN'S MESSAGE

The year 2000 was a challenging year for the Environmental Management Authority (EMA). A new Board of Directors assumed office in August and the Organization focussed on the drafting of subsidiary legislation (Rules) in accordance with Sections 26 and 27 of the Environmental Management Act No. 3, 2000. The process required that the draft rules be submitted for public comment, be revised in keeping with the public comments, published in the Gazette and laid thereafter in Parliament subject to negative resolution. These rules when enacted as law will provide the Authority with the legislative framework that is essential for its enforcement and regulatory responsibilities.

While the 1997, 1998 and 1999 Reports analysed the status of our Biodiversity, Freshwater and the current situation with regard to environmental legislation and its enforcement, this Report provides an analysis and status of air pollution in Trinidad and Tobago because of the critical importance of air quality in the sustainable management of the environment and human health.

Trinidad and Tobago is the most industrialized country in the Commonwealth Caribbean region and suffers the attendant environmental problems associated with the production of oil, natural gas and petrochemicals in addition to rum, soap, paint and wood products. It is not surprising therefore to find a situation in which industrial pollution particularly from oil, gas and the downstream petrochemical industry is a critical environmental issue. Furthermore the fact that Trinidad & Tobago has the highest motorization (vehicles per capita) level in Latin America and the Caribbean results in the transportation sector having a significant impact on air quality. Trinidad and Tobago therefore needs to address the environmental implications of the energy and transport sectors.

Air that is free of fine particulates, gaseous pollutants and odours is essential for the protection of human health. Air pollution also adversely affects the natural and built environments through unsightly deposits on vegetation and the soiling of buildings. In Trinidad & Tobago air pollution is caused mostly by emissions from vehicles, power plants and energy based industries. Forest and bush fires, uncontrolled burning to prepare land for crops, the burning of sugarcane fields during the harvest and the use of bagasse as a fuel all create windblown smoke, soot, dust and chaff that pollute our atmosphere with particulate matter. In addition, during the dry season fires at our land fills pose a serious threat to the environment.

In seeking to regulate air pollution, the EMA has drafted Air Pollution Rules and Air Pollution Fees Regulations which are to be laid in Parliament subject to negative resolution. National ambient air quality standards and criteria are being established under the prescribed rules for Trinidad and Tobago.

These will serve as the air quality objectives for the setting of limits for pollutants that may be released into the ambient air by various sources. The national ambient air quality standards will provide a basis for protecting public health from the adverse effects of air pollution and for eliminating, or reducing to a minimum, those air pollutants that are known to be or are likely to be hazardous to human health and the environment.

In collaboration with the Bureau of Standards appropriate Vehicle Emissions Standards are being prepared by the Bureau and Regulations are being drafted by the EMA under the Motor Vehicles and Road Traffic Act. Both the draft Standards and the Regulations would be completed in 2001. The phasing out of lead in gasoline by the year 2002 in accordance with the United Nations Development Programme/World Bank Energy Sector Management Assistance Programme for the elimination of lead in gasoline in Latin America and the Caribbean, will also be given high priority.

Given the emerging picture of the serious risks posed by global environmental changes on small island developing states, perhaps one of the most serious environmental challenges facing Trinidad and Tobago, as a result of global warming and climate change is sea level rise; with associated coastal erosion and salt water intrusion into our estuaries and aquifers.

While we are a very minor contributor to green house gas emissions on a global scale, we are one of the major contributors among developing countries on a per capita basis. The most recent scientific estimates indicate that by the year 2100, the world will on average experience a temperature rise of 1 ° C to 3.5 °C, a sea level rise of 15 to 95 cm plus a rainfall deficit of about 15%. Our climate may therefore become hotter and drier, posing significant threats to our valuable marine and terrestrial ecosystems. The EMA will address these global environmental issues by implementing vulnerability assessment studies of our marine and terrestrial ecosystems that will be utilized to develop adaptation programmes.

The analyses and data presented in the Report on air pollution have demonstrated information gaps in basic ambient air quality that need to be closed for the implementation of effective air pollution control programmes. The EMA, however, recognizes the need to establish a firmer scientific basis from which to tackle the problems that are exacerbated by our country’s rapidly growing industrial and transportation sectors. The challenge is therefore to identify, in spite of scientific uncertainties, prudent, cost effective and adaptive management approaches that can be implemented with the full support of the private sector, NGOs, CBOs and civil society.

Finally, it is my honour to acknowledge the work of the past Board, management, and staff who piloted the EMA through this crucial period of its early development and who have provided a solid foundation for the exciting and challenging road ahead.

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ABBREVIATIONS

$C_2H_3Cl_3$	1,1,1-Trichloroethane
CBO	Community based organisation
CFC	Chlorofluorocarbons
CH_4	Methane
Cl_2	Chlorine
CNG	Compressed natural gas
CO	Carbon monoxide
COHb	Carboxyhaemoglobin
EMA	Environmental Management Authority
ESMAP	Energy Sector Management Assistance Programme
F_2	Fluorine
Gg	Gigagram
GHG	Greenhouse gas
GORTT	Government of the Republic of Trinidad and Tobago
Hb	Haemoglobin
HC	Hydrocarbons
HNO_3	Nitric acid
IQ	Intelligence quotient
ISP	Institutional Strengthening Programme
km	Kilometre
LPG	Liquified petroleum gas
m^3	Cubic metre
mg	Milligram
MWH	Mega watt hours
N_2O	Nitrous oxide
NGO	Non-governmental organisation
NH_3	Ammonia
NMVOC	Non-methane volatile organic compounds
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_3	Nitrate
NO_x	Oxides of nitrogen
O_3	Ozone
PAH	Polycyclic aromatic hydrocarbons
PAHO	Pan American Health Organisation
PAN	Peroxyacetyl nitrates
Pb	Lead
PM_{10}	Particulate matter of aerodynamic diameter maximum 10 m
$PM_{2.5}$	Particulate matter of aerodynamic diameter maximum 2.5 m
SO_2	Sulphur dioxide

SO_4	Sulphate
SO_x	Oxides of sulphur
SPM	Suspended particulate matter
SVOCs	Semi-volatile organic compounds
TCPD	Town and Country Planning Division
TSP	Total suspended particulates
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
UV-B	Ultraviolet B
UWI	University of the West Indies
VOCs	Volatile organic compounds
WHO	World Health Organisation
m	Micrometer

GLOSSARY

Acid deposition. Acid deposition consists of delivery of acidic substances, mainly sulphur and nitrogen oxides, acids and salts, through the atmosphere to the earth's surface. These compounds (principally the oxides) are introduced into the atmosphere as by-products of combustion and industrial activity

Acidification. The decrease of acid neutralizing capacity in water or base saturation in soil caused by natural or anthropogenic processes.

Aerodynamic equivalent diameter. The settling rate of suspended particles and their penetration into the respiratory tract is in accordance with the particle AED, an expression that accounts for the inertial and aerodynamic drag properties of particles. The AED is dependent upon the particle density, shape, and size. The particle AED is defined as the diameter of a smooth, unit density [= 1 gram per cubic centimetre (g/cm^3)] sphere having the same terminal settling velocity as the actual particle. The use of the AED enables one to standardise particles of different shapes, smoothness, and densities for direct comparative purposes

Aerosol. A colloid in which solid particles or liquid droplets are suspended in a gas. Smoke is an example of a solid aerosol; fog is an example of a liquid aerosol.

Air inversion. A meteorological condition in the earth's atmosphere in which the temperature of the air some distance above the earth's surface is higher than the air temperature of the surface. Normally, air temperatures decrease progressively as altitude increases. Such a condition traps air and released gases and vapours near the earth's surface, thus impeding their dispersion.

Air pollutant. Any substance in air which could, if in high enough concentration, harm man, other animals, vegetation, or material. Pollutants may include almost any natural or artificial composition of matter capable of being airborne. They may be in the form of solid particles, liquid droplets, gases, or in combinations of these forms. Generally, they fall into two main groups: (1) those emitted directly from identifiable sources; and (2) those produced in the air by interaction between two or more primary pollutants, or by reaction with normal atmospheric constituents, with or without photoactivation.

Air pollution. The contamination of the atmosphere by any toxic or radioactive gases and particulate matter as a result of human activity.

Airway resistance. Pressure drop across airway per unit flow.

Alcohol. An organic compound with a carbon bound to a hydroxyl group. Examples are methanol, CH_3OH; ethanol, CH_3CH_2OH; propanol, $CH_3CH_2CH_2OH$.

Aldehyde. Organic compounds with a carbon bound to a -(C=O)-H group. Examples are formaldehyde (HCHO), acetaldehyde, CH_3CHO, and benzaldehyde, C_6H_6CHO.

Algal bloom. Sudden spurts of algal growth, which can affect water quality adversely and indicate potentially hazardous changes in local water chemistry.

Alkanes. A series of organic compounds with general formula C_nH_{2n+2}. Alkane names end with -ane. Examples are propane (with n=3) and octane (with n=8).

Alkene. A compound that consists of only carbon and hydrogen, that contains at least one carbon-carbon double bond. Alkene names end with -ene. Examples are ethylene (CH_2=CH_2); 1-propene (CH_2=CH_2CH_3), and 2-octane (CH_3CH_2=$CH_2(CH_2)_4CH_3$).

Alkyl-lead compounds. Man-made compounds in which a carbon atom of one or more organic to a lead atom.

Anaerobic. A biological process which occurs in the absence of oxygen.

Anoxic. Conditions where concentration of oxygen is very low (less than 0.1 ml/litre of water).

Anthropogenic. Refers to something originating from humans and the impact of human activities on nature.

Area sources. Sources of air pollutants that are generally small operations, such as gas stations and dry cleaners, which by themselves may not emit very much pollution, but when many area sources are located close together their combined emissions may be of concern.

Aromatics. A type of hydrocarbon, such as benzene or toluene, with a specific type of ring structure. Aromatics are sometimes added to gasoline in order to increase octane. Some aromatics are toxic.

Asthma. A disease characterized by recurrent attacks of dyspnea, wheezing, and perhaps coughing caused by spasmodic contraction of the main airways in the lungs.

Atmosphere. The sum total of all the gases surrounding the Earth, extending several hundred kilometres above the surface in a mechanical mixture of various gases in fluid-like motion. The permanent constituents are molecular nitrogen; 78.1%, molecular oxygen; 20.9%, argon; 0.934%, and approximately 0.036% carbon dioxide. Various other components exist in trace amounts. Not to be under emphasised, these trace components are where the interesting atmospheric chemistry occurs. The atmosphere can also be artificially divided into layers. Example: the troposphere (the layer closest to the earth) and the stratosphere (the layer above the troposphere).

Bioaccumulation. A process where chemicals are retained in fatty body tissue and increase in concentration over time.

Biodiversity. The number and variety of different organisms in the ecological complexes in which they naturally occur. Organisms are organised at many levels, ranging from complete ecosystems to the biochemical structures that are the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, and genes that must be present for a healthy environment. A large number of species must characterise the food chain, representing multiple predator-prey relationships.

Biosphere. A volume including the lower part of the troposphere (as high as living organisms can fly or be lofted) and the surface of the earth including the oceans. This region, by definition, encompasses all the living matter of the earth. Some very important atmospheric chemicals are produced in this region and pass into the atmosphere. This region exchanges chemicals and particulate matter with the atmosphere and soils and waters of the earth.

Bronchi. The hollow branches of the pulmonary tree which connect the trachea to the alveoli.

Bronchitis. Inflammation of the larger air passages of the lungs. Disease or physical or chemical irritants may cause it. Symptoms are generally that of a chest cold and may include in addition chest pain and coughing.

Calcium carbonate ($CaCO_3$). A chemical compound found in nature as calcite (in limestone, marble, and chalk) and aragonite (in pearls) and in plant ashes, bones, and many shells.

Carbon monoxide (CO). A toxic, odourless, colourless gas produced during fossil fuel or biomass burning. Compound consisting of one carbon and one oxygen. Except for carbon dioxide, it is one of the longest lived naturally occurring atmospheric carbon compounds (this wording is meant to exclude chlorofluorocarbons). The recent change in tropospheric CO content may portend a change in the balance between oxidants and reductants in the atmosphere.

Carboxyhaemoglobin. Haemoglobin in which the iron is bound to carbon monoxide instead of oxygen.

Carcinogenic-. Capable of causing cancer. A suspected carcinogen is a substance that may cause cancer in humans or animals but for which the evidence is not conclusive

Cardiovascular. A term indicating the heart and blood vessels.

Code of good environmental practice. A document to provide guidance to owners and operators of facilities as to the likely environmental impacts associated with the industry and the acceptable methods of control.

Command and control. Specific requirements prescribing how to comply with specific standards defining acceptable levels of pollution.

Compressed natural gas. An alternative fuel for motor vehicles; considered one of the cleanest because of low hydrocarbon emissions and its vapours are relatively non-ozone producing. However, vehicles fuelled with CNG do emit a significant quantity of nitrogen oxides.

Defoliate. Removal of foliage from plants, often by chewing insects.

Dioxins. Family of 75 different toxic chlorinated hydrocarbons formed as by-products in chemical reactions involving chlorine and hydrocarbons, usually at high temperatures.

Dry deposition. Dry deposition is the direct transfer to and absorption of gases and particles by natural surfaces such as vegetation, soil, water or snow.

Economic instrument. A way of influencing the actions of individuals and corporations using methods such as tax credits for certain types of investment or subsidies for certain products.

Ecosystem. The interacting synergism of all living organisms in a particular environment. Every plant, insect, aquatic animal, bird, or land species that forms a complex web of interdependency. An action taken at any level in the food chain, use of a pesticide for example, has a potential domino effect on every other occupant of that system.

Emphysema. An irreversibly diseased lung condition in which the alveolar walls have lost their resiliency, resulting in an excessive reduction in the lungs' capacity.

Environment. The sum of all external conditions affecting the life, development and survival of an organism.

Furans. Organic compounds composed of oxygen and 4 carbons in a ring.

Greenhouse effect. The phenomenon in which outgoing infrared radiation that would normally exit from a planet's atmosphere but instead, is trapped or reflected because of the presence of the atmosphere and its components (see below) is called the greenhouse effect. It has been calculated that this effect is necessary to maintain the earth's climate and surface temperature and, more importantly, the liquid state of water in the majority of the earth's biosphere; however, the best scientific estimates to date suggest that increasing amounts of greenhouse gases are resulting in higher temperatures world-wide. This could result in melting of icecaps that would raise the sea level and cause devastating floods in coastal areas, more extremes in rainfall and intensity, and the distribution of species in the biosphere.

Greenhouse gas. Atmospheric components that absorb strongly in the infrared region of the spectrum. Infrared radiation is reflected and emitted by the earth's surface as heat and causes a fairly large warming effect when trapped by these gases in the atmosphere. In order of abundance and importance as greenhouse gases are water vapour, carbon dioxide, ozone, nitrous oxide, methane, and chlorofluorocarbons (CFCs). Absorption by water vapour, the most common greenhouse gas, explains why many humid or cloudy days feel much hotter than dry, clear days of the same air temperature. Because of these gases, only about 5% of the radiation escapes from the atmosphere while more than 90% is radiated back to the surface of the earth.

Haemoglobin. Protein used by all vertebrates and some invertebrates for oxygen transport because the two substances combine reversibly. In vertebrates it occurs in red blood cells (erythrocytes), giving them their colour.

Halocarbons. Compounds that contain carbon and halogen atoms and (sometimes) hydrogen. The simplest are compounds such as tetrachloromethane (CCl_4), tetrabromomethane (CBr_4).

Halons. Bromine containing compounds with long atmospheric life- times whose breakdown in the stratosphere cause depletion of ozone. Halons are used in fire fighting.

Hydrocarbons. Chemicals containing only carbon and hydrogen. These are of prime economic importance because they encompass the constituents of the major fossil fuels, petroleum and natural gas, as well as plastics, waxes, and oils. In urban pollution, these components--along with NO_x and sunlight--contribute to the formation of tropospheric ozone.

Hydrogen peroxide (H_2O_2). A colourless, rather unstable oxidant with a bitter taste and caustic to the skin. Hydrogen peroxide will decompose, liberating oxygen. Pure hydrogen peroxide is stable, but the slightest impurity will enhance decomposition, often violently. Concentrated solutions of hydrogen peroxide are highly corrosive and toxic. H_2O_2 is used as bleach, deodoriser, and in the manufacturing of rocket fuel. The hydrogen peroxide in your bathroom is approximately 3 percent in water. In the atmosphere this is probably one of the oxidisers for sulphur dioxide in cloud water droplets that produces sulphuric acid, a major component in acid rain.

Incomplete combustion. Part of the carbon is not completely oxidised producing soot or carbon monoxide (CO). Incomplete combustion uses fuel inefficiently and the carbon monoxide produced is a health hazard.

Infrared radiation. Energy that is emitted in the form of electromagnetic waves at a wavelength greater than about 750 up to approximately 30,000 nanometres. Although the earth absorbs almost all the IR, UV, and visible radiation the hits it, the surface of the earth emits only the longest wavelength radiation of these three, IR, in any significant amounts. It is this re-emission of IR towards space--and its subsequent absorbance, re-emission and scattering--that contributes to the process that heats the atmosphere. This re-emission and subsequent heating is a part of the greenhouse effect.

Inhalable particles. All dust capable of entering the human respiratory tract.

Ketones. A molecule that contains a carbonyl carbon covalently bonded to two different carbons.

Lead (Pb). A heavy metal that is hazardous to health if breathed or swallowed. Its use in gasoline, paints, and plumbing compounds has been sharply restricted or eliminated by regulations and US federal laws.

Lesion. An abnormal change, injury, or damage to tissue or to an organ.

Liquefied petroleum gas (LPG). A liquid petroleum fuel. LPG is a mixture of butane and propane, which is gaseous at normal temperature and atmospheric pressure.

Magnesium carbonate ($MgCO_3$). A carbonate produced in paper by the action of atmospheric carbon dioxide on magnesium hydroxide.

Methane (CH_4). A colourless, odourless, flammable, greenhouse gas. It is the simplest of all hydrocarbons with a formula of CH_4. Methane is released naturally into the air from anaerobic environments such as marshes, swamps, and rice fields, and from symbiotic microbes in the guts of ruminant animals (such as cattle, sheep, and camels), and sewage sludge. Methane is released from methane producing bacteria (methanogens) that live in these anaerobic places.

Mobile sources. Moving objects that release regulated air pollutants, e.g. cars, trucks, buses, planes, trains, motorcycles, and gas-powered lawn mowers.

Morbidity. Rate of incidence of disease.

Mortality. Death rate.

Mucous membrane. The mucous-secreting membrane lining the hollow organs of the body; i.e., nose, mouth, stomach, intestine, bronchial tubes, and urinary tract.

Nitrate. A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and which can have harmful effects on humans and animals.

Nitric acid (HNO_3). A corrosive, non-volatile, and inorganic acid. It is a strong acid (dissociates completely in aqueous solution) and is also an oxidiser. In the atmosphere it is formed by the conversion of nitrogen monoxide into nitrogen dioxide, and ultimately into nitric acid. Nitric acid is highly water-soluble. This solubility with water allows easy removal of nitric acid from the troposphere by atmospheric precipitation. Commonly, this is referred to as acid rain or snow. Nitric acid has a relatively low concentration in the atmosphere but provides an important role in the production of sulphuric acid. It acts as a catalyst in the conversion of sulphur dioxide to sulphuric acid.

Nitrogen dioxide (NO_2). The lesser of the two emitted NO_x gases from high temperature combustion in air. It is an important species in the atmosphere. Since it absorbs in the visible wavelength region--creating the Brown Cloud see over Denver, LA, Mexico City, Beijing, etc.--and can be photolyzed and yield oxygen atoms that can react with molecular oxygen to create ozone, NO_2 and the NO/NO_2 ratio is important in tropospheric chemistry.

Nitrous oxide (N_2O). A by-product of biological activity of a symbiotic bacteria living in leguminous plant roots. It is a principal greenhouse gas that absorbs in the infrared wavelength region and unfortunately falls in an IR "window" between IR absorbing features of water and carbon dioxide (a characteristic of all the "trace" greenhouse gases with significant radiative forcing). It is also laughing gas used in medicine as a gentle general anaesthetic.

Organic compounds. Substances that contain the element carbon, with the exception of carbon dioxide and various carbonates.

Oxides of nitrogen (NO_x). Include NO and NO_2 . Mainly produced by microbes in the soil in response to agriculture, but also produced in the ocean, from burning of timber, from fertilisers and from combustion of fossil fuels.

Oxygenates. Compounds containing oxygen in a chain of carbon and hydrogen atoms. They are blended into gasoline in two forms: alcohols or ethers.

Ozone depleting substances. Chemicals that have the potential to deplete the ozone layer, e.g. chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs).

Ozone- (O_3). A molecule that consists of three oxygen atoms bonded together. The ozone layer in the stratosphere absorbs UV radiation and creates a warm layer of air in the stratosphere and is therefore responsible for the thermal structure of the stratosphere. Ozone that is present in the troposphere is mostly a result of anthropogenic pollution and therefore higher concentrations are found in urban areas. Ozone is involved with NO_x in the photochemical production of many of the constituents of pollution environments (see nitrogen oxides and hydroxyl radicals.)

Peroxyacetyl nitrates (PAN). A class of chemical substances found as a pollutant in the troposphere, formed by photolysis from natural and manufactured organic chemicals. These chemicals act as irritants and mutagens in mammals and are toxic to many plants.

pH. The negative logarithm of the hydrogen ion concentration of a solution. It is the quantitative expression of the acidity and alkalinity of a solution and has a scale that ranges from about 0 to 14. pH 7 is neutral; <7 is acidic; and >7 is alkaline.

Photochemical oxidants. Air pollutants formed by the action of sunlight on oxides of nitrogen and hydrocarbons.

Photochemical smog. Natural and artificially emitted hydrocarbons in the presence of oxides of nitrogen undergo photochemical reactions that produce a cloud of toxic chemicals including ozone and a variety of caustic agents. This process is powered by sunlight and some of the products, such as ozone, reach a peak soon after photon flux from the sun reaches a maximum, around midday. The thermal inversions often associated with some cities can lead to a dangerous build-up of smog in urban areas. Human deaths have been attributed to photochemical smog since the Industrial Revolution in cities such as London and New York.

Photosynthesis. Photosynthesis is a biological process that plays a vital role in cycling the atmosphere's carbon dioxide, while simultaneously producing oxygen and other complex substances. Green plants, with chlorophyll, utilise the sun's energy to convert carbon dioxide and water into the plant biomass while oxygen that is released into the atmosphere.

PM_{10}. An air pollutant that consists of particulate matter in ambient air exceeding 10 microns in diameter.

Pneumonia. Inflammatory lung disease caused by microorganisms, virus, and chemical or physical irritants.

Point sources. Stationary locations or fixed facilities such as an industry or municipality that discharge pollutants into air or surface water through pipes, ditches, lagoons, wells, or stacks; a single identifiable source such as a ship or a mine.

Polycyclic aromatic hydrocarbons. A class of very stable organic molecules made up of only carbon and hydrogen. These molecules are flat, with each carbon having three neighbouring atoms. These compounds are known or suspected carcinogens.

Primary air pollutant. A harmful chemical that enters directly into the atmosphere either from human activities or natural processes (such as volcanic eruptions).

Radicals. Highly reactive molecules or atoms with an unpaired electron. The species is often represented by a formula with a single dot as the unpaired electron.

Refrigerant. The compound (working fluid) used in air conditioners, heat pumps, and refrigerators to transfer heat into or out of an interior space. This fluid boils at a very low temperature enabling it to evaporate and absorb heat.

Remediation. Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a Superfund site; 2. for the Asbestos Hazard Emergency Response program, abatement methods including evaluation, repair, enclosure, encapsulation, or removal of greater than 3 linear feet or square feet of asbestos-containing materials from a building.

Respirable particles. Are those that penetrate into and are deposited in the nonciliated portion of the lung. Particles greater than 10 micrometers aerodynamic diameter are not respirable.

Sahara Dust. Dust from the Sahara Desert in Africa. The dust turns skies around the northeastern Caribbean Sea hazy, reducing visibility and causing poor air quality. Saharan dust blows across the Atlantic a few times most summers, sometimes reaching southern Florida. Dust storms and rising warm air can lift the fine Saharan sand 15,000 feet or so above the African deserts. Winds carry the dust westward. Larger particles fall out as the dust crosses the Atlantic. But the smaller particles can cause problems an ocean away.

Secondary air pollutant. A harmful chemical that forms in the atmosphere when a primary air pollutant reacts chemically with other air pollutants or natural components of the atmosphere.

Stationary sources. Pollution location that is fixed rather than moving. One point of pollution rather than widespread.

Stratosphere. The thermal atmospheric region of the atmosphere between the troposphere and the mesosphere. The lower boundary of the stratospheric region is marked by the tropopause and begins at approximately 13 kilometres; however, this altitude of the troposphere depends on latitude. The upper limit of the stratosphere is marked by the stratopause at approximately 50 kilometres. The stratosphere is characterised by relatively stable temperatures (between -80 and -50 degrees Celsius) in the lower regions, and begins warming near 20 kilometres, reaching its maximum temperature of approximately 0 degree Celsius at the stratopause. Stratospheric chemistry is of particular interest to scientists because ozone, the principal substance that shields the earth from incoming solar ultraviolet radiation, is found in the stratosphere. It should also be noted that wind currents in the stratosphere are primarily horizontal in nature.

Sulphate. An aerosol that has origins in the gas-to-aerosol conversion of sulphur dioxide; of primary interest are sulphuric acid and ammonium sulphate.

Sulphur dioxide. A colourless gas consisting of a single sulphur atom and two oxygen atoms. Sulphur dioxide is a major primary pollutant in the atmosphere originating mostly from coal fired power plants and other fossil fuels combustion. In the atmosphere, sulphur dioxide is usually oxidised by ozone and hydrogen peroxide to form sulphur trioxide, a secondary pollutant. Sulphur trioxide, similar to sulphur dioxide, is extremely soluble in water. If these sulphur oxides are present in the atmosphere when condensation occurs, droplets of sulphuric acid (acid rain) are formed. Volcanic eruptions provide a natural source of sulphur dioxide in the atmosphere. However the real problem associated with the production of sulphuric acid in the atmosphere is not with the sulphur dioxide expelled by volcanoes. Anthropogenic production of sulphur dioxide, caused by the burning of fossil fuels, is largely responsible for damage caused by acid rain.

Sulphuric acid. In the atmosphere sulphur oxides (see sulphur dioxide) are converted to sulphuric acid, a strong, non-volatile acid. Oxides of sulphur and nitrogen combine with atmospheric moisture to produce acid rain.

Suspended particulate matter. Particles floating in the air with a diameter below 10 μm.

Synergistic effect. Interaction of two or more biotic or abiotic substances or processes with the net effect being greater than the sum of the independent effects of each substance or process.

Tetrachloromethane. A colourless, dense, highly toxic, volatile, non-flammable liquid.

Total suspended particulates. Total particulate matter in a sample of ambient air.

Toxic effects. The physiologic, physical, or laboratory manifestations or derangement's that can be attributed to the presence of a substance within the body.

Trachea. The tube that connects your mouth and nose to your lungs. You can also call it the windpipe. It is in the front of your neck.

1,1,1-Trichloroethane. A colourless man-made chemical which does not occur naturally. In the environment, it can be found as a liquid, as a vapour, or dissolved in water and other chemicals.

Troposphere. The lowest layer of the Earth's atmosphere, ranging from the ground to the base of the stratosphere with a altitude of 10-15 kilometres depending on the latitude. This is where all weather occurs. The word troposphere is derived from the Greek words tropos--turning and spharia--sphere.

Ultraviolet radiation. Energy that is emitted in the form of electromagnetic waves with a wavelength of 1-380nm, which is composed of UV-A, UV-B, and UV-C light; UV-A light being the longest wavelength and having the smallest energy and UV-C light being the shortest wavelength and having the highest energy. All UV-C light and most UV-B light are filtered out of the atmosphere via the ozone layer. However, UV-A light travels to the surface of the earth.

Volatile organic compounds. Any organic compound which evaporates readily to the atmosphere. VOCs contribute significantly to photochemical smog production and certain health problems.

Wet deposition. Wet deposition is the transfer of a substance from the atmosphere to the surface of the earth within or on the surface of a hydrometeor (snow, hail or rain).

STATE OF THE ENVIRONMENT REPORT 2000

EXECUTIVE SUMMARY

Over the last few years a growing concern has been expressed in the quality of the air that we breathe. Our atmosphere is all pervasive, and contaminated air affects everyone's health, as well as that of the plants, animals and non-living components of our environment. In this report, the quality of our air, the pollutant emissions to it and the existing policy and institutional mechanisms to control air pollution are examined.

A wide range of pollutants has been identified as the cause of our diminished air quality. These include: particulate matter, sulphur dioxide, oxides of nitrogen, carbon monoxide, ozone, lead, volatile organic compounds, asbestos, ozone depleting substances and greenhouse gases (carbon dioxide, methane, nitrous oxide). Most of these compounds affect human health and many target the respiratory tract. Other affected organs/systems include the oxygen-carrying capacity of the blood, the nervous system, kidneys, cardiovascular and reproductive systems and the numerous other toxic effects produced by the volatile organic compounds. On the other hand, ozone depleting substances and greenhouse gases, are not directly toxic to human beings, but affect the atmospheric processes that are required for life on earth. Ozone depleting substances impair the formation of ozone, decreasing stratospheric ozone levels. This results in an increase in the transmittance of ultraviolet radiation and an increase in skin cancers and cataracts in people. Greenhouse gases contribute to global warming, and so may affect life on earth through climate change and sea level rise.

The sources of air pollutants are varied. Combustion of fossil fuels and incineration of waste material are major sources for a number of ambient air pollutants, including particulate matter, sulphur dioxide, carbon monoxide, carbon dioxide and lead (from leaded gasoline combustion). Volatile organic compounds enter the atmosphere through evaporation of solvents as well as incomplete combustion. Ozone depleting substances are emitted from leaks in refrigeration units, as well as through their use as aerosol propellants and fire-fighting equipment. Asbestos is emitted mainly from friction pads in vehicles, construction materials and insulation. However, not all major sources of air pollution are anthropogenic (man-made).

Measurements of the concentration of some air pollutants show that our air quality compares favourably with international standards. However, estimates of pollution loading by industry and other sectors of the economy give a different picture: namely a general lack of air pollution control technologies and uncontrolled emissions of air pollutants into our environment. Perhaps the main lesson learned from these few studies is that data on ambient air quality and air pollutant emissions are in short supply, and desperately needed. The

establishment of a national ambient air quality monitoring network is a major step towards filling the air quality data gap in Trinidad and Tobago. Another important step is the development of an air pollutant inventory, which would provide data on the emission rates of various air pollutants. Long-term, accurate data collection on a number of criteria air pollutants would provide a sound scientific basis for policy and strategy development, as well as compliance measurement and enforcement action.

There is little legislation that directly addresses air pollution from industrial sources, and enforcement is minimal to non-existent. One exception to this state of affairs is the enforcement against vehicle emissions. The advent of the Environmental Police Unit has increased, by more than a factor of five, the number of enforcement proceedings for visible emissions from motor vehicles.

The issue of air pollution control in Trinidad and Tobago is complex, because of the multitude of air pollution sources — from micro business to heavy industry. The 2000 report concludes with a number of priorities for action to improve the quality of our air. These include the establishment of ambient air quality standards, an ambient air monitoring network, and a regular air pollutant inventory to fill the need for accurate air pollutant emission data. Also required is the development and implementation of legislation and standards to control air emissions from all sectors of the economy, from heavy industry to micro business and finally, the development and support of on-going public education programmes, which are vital to achieving success in any air pollution control strategy. It is only through such educational projects that the public can be sensitised to the problems associated with contaminated air, and the ways in which we can prevent further deterioration of our atmosphere.

1.0 INTRODUCTION

Blanketing the earth on which we live is a 480 km thick layer of gases, which forms the atmosphere of our planet and constitutes the transition between the planet's surface and the vacuum of space. This layer, which is casually referred to as air, is made up of nitrogen (78%), oxygen (21%), varying levels of water vapour, argon (0.9%), carbon dioxide (0.03%) and trace amounts of numerous other gases.

Some theorists argue that the atmosphere was formed by planetary degassing, a process in which gases like carbon dioxide, water vapour, sulphur dioxide and nitrogen were vented from the interior of the Earth, by volcanic and other activities. Life forms on Earth, most notably the photosynthesising organisms, have modified the composition of the atmosphere since their evolution. Life on earth has therefore adapted to and created these changes, closing a giant loop of cause and effect.

The composition of the earth's atmosphere has evolved over time and continues to display an inherent dynamism. This is in part due to the very nature of gas molecules and their pervasive ability to absorb energy and move in a random fashion - virtually free from close confining bonding that confines other states of matter. Air moves freely and mixes freely, allowing it to sustain life on our planet, recycle water and other chemicals, and work with the electrical and magnetic forces to produce a climate.

By far one of the most important functions of the atmosphere is its ability to act as an insulator, preventing the earth from experiencing extremes in temperature. The thickest part of this layer lies within 16 km of the earth's surface and has the ability to trap and retain long wave infrared radiation. Further up at the 25 km mark is the area of greatest accumulation of ozone, a molecular entity that has the ability to block the earth from much of the incoming ultra violet radiation from the sun. Thus the atmosphere protects us from the frigid vacuum of space and high-energy radiation.

We do not own nor can we control the air we breathe. We cannot see most of the particles and gas molecules in the air, and as long as it is odour free and colourless, we assume the air is safe. We are however in the process of polluting the air we breathe as a result of our activities. As societies become more developed and sophisticated, man's activities increasingly affect the composition of the atmosphere and thus the quality of the air we breathe.

The atmosphere is therefore a dynamic and fluid medium in the wider environment. It is a common place for deposition and storage of gaseous or particulate waste. It also has the ability to disperse or degrade such waste, and when the amount of waste entering the atmosphere in an area overwhelms this ability, problems result, namely air pollution. The physical components of our biosphere are all important in sustaining life. Water, land and air, together with the energy of the sun create varying environments on our planet to which life adapts, using the energy of the sun and the resources of the earth, air and water to proliferate, reproduce and evolve. In this report, we look specifically at air, delineating the ways in which we pollute it, outlining what we need to do and what has already been accomplished.

Many of the pollutants in the atmosphere have natural as well as human (anthropogenic) sources. The two major types of anthropogenic air pollution sources are stationary and mobile sources. Stationary sources are those that have a relatively fixed location (e.g. factories and industrial plants) while mobile sources are emitters that move from place to place while yielding emissions (e.g. cars). The stationary source category can be further subdivided into point and area sources. Point sources emit pollutants from one or more controllable sites, while area sources generate air pollutants from open areas exposed to the wind (e.g. construction sites, sugar cane burning) or a large number of smaller sources (e.g. dry cleaners and gas stations).

In the case of water and soil pollution there are expensive but feasible alternatives for remediating many types of contamination. Unfortunately once air becomes polluted there is no practical intervention we can make to clean it up. In the work place respirators are often used to filter polluted air. Some homes even have particulate filtering systems. However most of us are constantly exposed to many air pollutants that can harm us. This illustrates the overwhelming importance that must be placed on air pollution management and prevention.

The following chapters address the effects and common sources of air pollution, and the results of studies on air pollution in Trinidad and Tobago. In addition the legal and administrative framework and some strategies for managing air pollution are discussed.

2.0 MAJOR AIR POLLUTANTS AND THEIR ADVERSE EFFECT ON HUMAN HEALTH AND THE ENVIRONMENT

2.0 Definition of air pollutants and air pollution

An air pollutant is a substance whose presence in the atmosphere is determined to cause or likely to cause harm to human, plant or animal life; to damage man-made materials and structures; to bring about changes in weather or climate; or to interfere with the enjoyment of life or property. They can be produced from both natural and anthropogenic sources. Air pollutants can be classified as primary or secondary, depending on their origin. Primary air pollutants are those that are emitted directly to the atmosphere. Secondary air pollutants are those formed by chemical reactions between other, primary pollutants. Air pollution is brought about when the amount and/or concentration of the air pollutant in the atmosphere are enough to cause adverse effects to human health and the environment.

The amount of pollutants released to the atmosphere by anthropogenic sources is generally associated with the level of economic activity in the area. Meteorological and topographical conditions affect dispersion and transport of these pollutants, which can then result in ambient concentrations that may harm people, structures and the environment. In general, the effects of air pollution on people are most intense in urban centres with significant emission sources, unfavourable dispersion characteristics, and high population densities.

Table 2.1 summarises the major air pollutants, their significant sources and adverse health effects.

2.1 Suspended Particulate Matter - Total Suspended Particulates and PM_{10}

2.1.1 Description

Suspended particulate matter (SPM) is a complex mixture of organic [illegible] inorganic substances, present in the atmosphere as both liquids and solids. Particulate matter suspended in air includes total suspended particulates (TSP), PM_{10} and $PM_{2.5}$ - particulate matter of aerodynamic diameter of maximum 10 μm and of 2.5μm respectively. Some examples of these fine and ultrafine particles include diesel exhaust, fly-ash, mineral dusts, metal dusts and fumes, acid mists, pesticide mists, carbon black and oil smoke.

A wide range of terminology is applied to particulate matter, reflecting measuring methods (e.g. “total suspended particulates”, “black smoke”), site of deposition in humans (e.g. “inhalable”, “thoracic particles”), or physical characteristics (e.g. “PM_{10}” and “$PM_{2.5}$”). Total suspended particulates (TSP) consist of airborne particulate matter of diameter less than 100 μm (Stokes equivalent diameter), as determined by a standard method. Both PM_{10} and $PM_{2.5}$ are suspended inhalable and respirable particles.

Particulate matter may exist as either a primary or secondary air pollutant.

TABLE 2.1

MAJOR AIR POLLUTANTS AND THEIR ADVERSE HEALTH EFFECTS

AIR POLLUTANT	MAJOR ANTHROPOGENIC SOURCES	ADVERSE HEALTH EFFECTS
Suspended Particulate Matter: Total suspended particulates (TSP); Particulate matter of aerodynamic diameter of maximum 10 μm (PM_{10})	Combustion of fossil fuels, including fuel in motor vehicle engines; Industrial activities - stone crushing, mining, metallurgical processes, cement manufacturing; Agro-industrial processes; Road traffic.	Respiratory system effects such as coughing, runny nose, sore throat; Associated with respiratory diseases such as pneumonia, asthma, bronchitis. Unable to define a threshold below which no health effects occur.
Sulphur dioxide (SO_2)	Combustion of fuels containing sulphur; Smelting non-ferrous ores; Incineration of refuse	Associated with reduced lung function – changes in lung function of asthmatics at 1000 $\mu g/m^3$, exacerbation of respiratory systems in sensitive individuals from 100 to 250 $\mu g/m^3$ increased incidence of respiratory symptoms and diseases and premature mortality.
Nitrogen dioxide (NO_2)	Combustion of fossil fuels from stationary sources (heating, power generation) and transport (motor vehicles) sources; Incineration; Industrial processes - welding, nitric acid manufacture	Slight changes in lung function in asthmatics at 365 to 565 $\mu g/m^3$; Increased susceptibility to respiratory infection, and decreased pulmonary function
Carbon monoxide (CO)	Incomplete combustion of carbonaceous fuels (in industrial processes and motor vehicles)	Forms carboxyhaemoglobin (COHb) which lowers O_2 in blood – critical level of COHb approx, 2.5% . Health effects related to COHb levels. Impaired learning ability, manual dexterity and mental judgement; Coma and convulsions, death.
Ozone (O_3)	Secondary pollutant. O_3 precursors are VOCs and oxides of nitrogen	Respiratory function responses – eye and nose irritant.
Lead (Pb)	Lead in gasoline; Processing of lead and lead containing ores; Lead-acid batteries; Incineration.	Critical level of Pb in blood is 25 μg Pb /L; affects nervous system, blood forming system, kidneys, cardiovascular and reproductive systems; in children, lowers IQ, hyperactivity
Volatile Organic Compounds (VOCs) Includes some hydrocarbons (HC)	Evaporation of gasoline and other fuels; Incomplete combustion of fuels; Evaporation of solvents.	Health effects are compound-specific. Some VOCs are proven or potential carcinogens.

2.1.2 Major sources

Particulate matter is emitted from a wide range of natural and anthropogenic sources. Natural sources include: Sahara dust incursions (usually in the months of April to November), volcanic or other geothermal eruptions, forest and bush fires, sea salt, windblown soil and dust, and pollen. Particulate matter from natural sources tends to be coarse.

Major anthropogenic sources of primary particulate matter include: fossil fuel-based thermal power plants, metallurgical processes, cement manufacturing, mining, stone crushing, flour milling, burning of fossil fuels including fuel combustion in automotive engines (exhaust emissions), heating and household cooking, agricultural field burning, incineration and other burning of wastes, and vehicular traffic. Particulate matter generated from combustion tends to be fine, while agro-industrial processes and road traffic (i.e. grinding of concrete, asphalt and tyres) contribute mostly coarse particulate emissions.

Secondary particulate matter can also be formed by the transformation of gaseous emissions. Reactions between substances such as oxides of sulphur, oxides of nitrogen, and volatile organic compounds (VOCs) including hydrocarbons (HC) can produce particulate matter.

2.1.3 Human health effects

Health effects of suspended particulate matter in humans depend on particle size and concentration, and can fluctuate with daily fluctuations in PM_{10} or $PM_{2.5}$ levels. In nasal breathing, particulate matter greater than 10 μm is deposited and removed in our noses and throats (extrathoracic part of the respiratory tract) with very few particles getting into the trachea or bronchi. Particles in the size 5 to 10 μm are mostly removed in the trachea and bronchi and do not get into the lungs. Particles smaller than 3.5 to 2.5 μm present a larger health concern because these particles can evade the human body's respiratory defence system and reach the lung tissue, where it can remain imbedded for years, or in the case of soluble particles, be absorbed into the blood stream.

Particulate matter and sulphur dioxide often occur together in ambient air and may have synergistic effects with other pollutants.

Short-term health effects of exposure to combined sulphur dioxide, black smoke and particulate matter include: increased mortality, morbidity and deficits in pulmonary function. Some of the "lowest-observed effect" levels for short term exposure to particulate matter are: excess mortality – 500 $\mu g/m^3$ (smoke), increased acute respiratory morbidity in adults – 250 $\mu g/m^3$ (smoke); decline in lung function in children –180 $\mu g/m^3$ (total suspended particulates), and 110 $\mu g/m^3$ (thoracic particles).

The adverse health effects are associated with coughing and respiratory diseases such as pneumonia, asthma, and bronchitis.

The World Health Organisation (WHO) has reported that current epidemiological studies on the health effects of particulate matter are unable to define a threshold below which no effects occur; even at low levels of particulate matter (less than 100 $\mu g/m^3$), short term exposure is associated with health effects. Hence, no guideline value for short-term average concentrations in ambient air has been recommended by WHO (WHO 1999).

With respect to long term effects of particulate matter on health, some studies have suggested that long term exposure is associated with reduced survival, and a reduction of life expectancy in the order of 2 to 3 years. Other recent studies have shown that the prevalence of bronchitis symptoms in children, and of reduced lung function in both children and adults are associated with particulate matter exposure. For this reason, no guideline value for long term average concentrations in ambient air has been recommended by WHO (WHO 1999).

It should be noted that exposure to air pollutants and especially particulate matter, may give rise to feelings of discomfort, which may cause annoyance.

Table 2.2 summarises the WHO guidelines for a number of ambient air contaminants, including suspended particulate matter.

2.1.4 Other environmental effects

Large-size particulate matter falls out of the atmosphere based on its settling characteristics and atmospheric conditions (especially wind). Particulate matter that settles out of the air adversely affects people’s welfare by accumulating virtually anywhere - on buildings, windows, cars, laundry, even inside houses - leaving dirty deposits, requiring frequent cleaning, and damaging some materials.

Particulate matter that remains suspended in the air is of a small size that can reduce visibility. Other environmental effects of particulate matter include potential modification of climate and contribution to acid deposition.

2.2 Sulphur Dioxide

2.2.1 Description

Sulphur dioxide (SO_2) is a colourless gas and is the predominant form of oxides of sulphur (i.e. compounds of sulphur and oxygen molecules) found in the lower atmosphere. When present in the atmosphere at concentrations in the range of in the range of 1000 to 3000 $\mu g/m^3$, it can be detected by taste and smell. At concentrations of 10 000 $\mu g/m^3$, it has a pungent, unpleasant odour.

SO_2 dissolves readily in water present in the atmosphere to form ultimately, sulphuric acid. This is generally present as an acid aerosol, often associated with other pollutants in droplets or solid particles of a wide range of sizes. The sulphuric acid is finally removed from the atmosphere by either wet or dry deposition.

2.2.2 Major sources

The most significant natural source of SO_2 is volcanic eruptions.

The major anthropogenic sources of SO_2 are the burning of fuels containing sulphur, petroleum refining, smelting non-ferrous ores (mainly copper, lead, nickel and zinc), manufacture of sulphuric acid, conversion of wood pulp to paper, incineration of refuse, and production of elemental sulphur.

2.2.3 Human health effects

In general, exposure to sulphur dioxide in the ambient air has been associated with reduced lung function, increased incidence of respiratory symptoms and diseases, irritation of the eyes, nose and throat, and premature mortality. Children, the elderly, and those already suffering from respiratory ailments, such as asthmatics, are especially at risk. Epidemiological studies indicate the following effects after short-term SO_2 exposures: possible small reversible declines in children's lung function (250 to 450 $\mu g/m^3$); aggravation of bronchitis (about 500 $\mu g/m^3$); increased mortality (500 to 1000 $\mu g/m^3$).

Sulphuric acid and other sulphates also have human health effects. Respiratory effects have been reported for concentrations of sulphuric acid ranging from 350 to 500 $\mu g/m^3$. The lowest-demonstrated-effect level is 100 $\mu g/m^3$ for exercising adolescent asthmatics. High concentrations of SO_2 (greater than 1000 $\mu g/m^3$) together with suspended particles are believed to have been responsible for high mortality levels during the London smog event of 1958.

The WHO health based guidelines for SO_2 are presented in Table 2.2.

2.2.4 Other environmental effects

Sulphur oxide emissions cause adverse impacts to vegetation, including forests and agricultural crops. Some studies in the United States and elsewhere have shown that plants exposed to high ambient concentrations of sulphur dioxide may lose their foliage, become less productive, or die prematurely (World Bank 1998). Trees and other plants exposed to wet and dry sulphuric acid depositions at some distance from the source of emissions may also be damaged. Impacts on forest ecosystems vary greatly according to soil type, plant species, atmospheric conditions, insect populations, and other factors that are not well understood.

Acid depositions can damage freshwater lake and stream ecosystems by lowering the pH of the water. Acidification also decreases the species variety and abundance of other animal and plant life.

Sulphate aerosols, converted from sulphur dioxide in the atmosphere, can reduce visibility by scattering light. In combination with warm temperatures, abundant sunlight, high humidity, and reduced vertical mixing, such aerosols can contribute to haziness extending over large areas.

Sulphur dioxide emissions may affect building stone, and ferrous (iron and steel) and non-ferrous metals, such as zinc and copper. Acids in the form of gases, aerosols, or precipitation may chemically erode building materials such as marble, limestone and dolomite. Of particular concern is the chemical erosion of historical monuments and works of art.

2.3 Nitrogen Dioxide

2.3.1 Description

Nitrogen dioxide (NO_2) is a reddish brown gas with a pungent odour; it is a strong oxidant and soluble in water. It is the most predominant form of the oxides of nitrogen (NO_x) existing in ambient air; the other oxides of nitrogen include nitric oxide (NO), nitrous oxide (N_2O) (which is classified as a greenhouse gas). Most anthropogenic NO_2 derives from emissions of NO. NO is readily converted to the much more harmful nitrogen dioxide by chemical reaction with ozone present in the atmosphere. Because this transformation occurs quite rapidly, NO_2 is generally regarded as being more important from the point of view of human health.

In the atmosphere, NO_2 may be involved in a series of reactions (in the presence of ultraviolet radiation) that produce photochemical smog, reducing visibility. It may also react with moisture in air to form nitric acid (HNO_3) aerosols. Most HNO_3 is then removed from the atmosphere by wet deposition, and to a lesser extent, by dry deposition.

In the lower atmosphere (troposphere) NO_2 forms ozone by reacting with hydrocarbons.

2.3.2 Major sources

On a global scale, natural emissions of nitrogen oxides far outweigh anthropogenic emissions. These natural emissions result primarily from lightning, volcanic eruptions and bacterial action in soil. These give rise to low level background atmospheric emissions.

Anthropogenic emissions are mainly due to fossil fuel combustion from both stationary sources (heating, power generation) and transport (internal combustion engines – exhaust emissions), and from incinerators. Other atmospheric contributions come from non-combustion processes such as: nitric acid manufacture, welding processes and the use of explosives. According to one study by Godish (1991) quoted in a World Bank report (World Bank 1998), only about 10% of all NO_x emissions come from anthropogenic sources.

2.3.3 Human health effects

NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. Generally, exposure to NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics, and decreased pulmonary function. Short-term exposure to NO_2 has been associated with a wide range of lower respiratory illnesses in children (cough, runny nose, and sore throat are among the most common), as well as increased sensitivity to urban dust and pollen.
A variety of respiratory system effects have been reported to be associated with exposure to short- and long- term NO_2 concentrations of less than 3.8 mg/m^3 in humans and animals.

These include: altered lung function and increased prevalence of acute respiratory illness and symptoms observed in controlled human exposure studies and community epidemiological studies; and lung tissue damage, development of emphysema-like lesions in the lung, and increased susceptibility to infection observed in animal toxicology studies.

Adverse effects to human pulmonary function due to single, short-term exposure (less than 3 hours duration) to NO_2 have been unambiguously demonstrated, but only for concentrations greater than 1.9 mg/m3. This value is well in excess of ambient exposure levels typically encountered by the public.

2.3.4 Other environmental effects

Strong evidence suggests that NO_x can harm the environment through nitrate formation and acidification of surface waters, damaging freshwater lake and stream ecosystems. Acid depositions can lower the pH of the water, with potentially serious consequences for fish, other animal, and plant life. Lakes in areas with soils containing only small amounts of calcium or magnesium carbonates that could help neutralise acidified rain are especially at risk. Few fish species can survive the sudden shifts in pH (and the effects of soluble substances) resulting from atmospheric depositions and runoff of contaminated waters; affected lakes may become completely devoid of fish life. Acidification also decreases the species variety and abundance of other animal and plant life.

The atmospheric deposition of nitrogen oxides is a substantial source of nutrients that damage estuaries by causing algal blooms and anoxic conditions.

Emissions of nitrogen oxides are a precursor of ground-level ozone, which is potentially a more serious problem. Elevated ozone concentrations in the troposphere (lower atmosphere) can contribute to reductions in crop yields.

Nitrogen oxides can also combine with photochemical oxidants to form smog, which reduces visibility.

2.4 Carbon Monoxide

2.4.1 Description

Carbon monoxide (CO) is a colourless, odourless, tasteless gas.

2.4.2 Major sources

Carbon monoxide is emitted by natural and anthropogenic sources. Natural ambient concentrations of CO range between 0.01 to 0.23 mg/m^3 (WHO 1999). Anthropogenic sources form CO from incomplete combustion of carbonaceous fuels in motor vehicles, heating and industrial facilities, thermal power plants, and incinerators.

2.4.3 Human health effects

CO absorbed through the lungs reduces the blood's capacity to transport available oxygen to the tissues. CO bonds with haemoglobin (Hb) to form carboxyhaemoglobin (COHb), which lowers the oxygen level in blood. The consequent reduced oxygen availability can give rise to a wide range of health effects.

The relationship between ambient CO concentrations in air and COHb levels in blood depends on a number of factors. The major factors are the duration of exposure and the pulse rate of the exposed person (that is, the intensity of physical effort), as well as the rate of CO uptake. Body size, lung condition of the exposed person, and barometric pressure influence the rate of CO uptake.

The health effects of CO are usually related to blood levels of COHb expressed as a percentage. Under normal conditions, the COHb concentration in the body is about 1.2 to 1.5 %. The "no-observed-effects" level is about 2% COHb, which can be related to an 8-hour exposure (moderate activity) to 15 to 20 mg/m^3 of CO in the atmosphere.

Certain neuro-behavioural effects can be expected at about 5% COHb (moderate activity for 8 hours at 40 mg/m^3) that can be related to observable ambient concentrations. These include: impaired learning ability, reduced vigilance (i.e reduced ability to detect small changes in the subject's environment), decreased manual dexterity, impaired performance of complex tasks, and disturbed sleep activity.

An exposure to concentrations of 45 mg/m^3 of CO for more than two hours adversely affects a person's ability to make judgements. Two to four hours of exposure at 200 mg/m^3 raises the COHb level in the blood to 10 to 30% and increases the possibility of headaches. Exposure to 1000 mg/m^3 raises the COHb level in blood to more than 30% and causes a rapid increase in pulse rate leading to coma and convulsions. One to two hours of exposure at 1830 mg/m^3 results in 40% COHb in blood, which may cause death.

Individuals most at risk to the effects of CO include those with existing cardiovascular or chronic respiratory problems, the elderly, young children and foetuses. The synergistic effect of CO with other pollutants promotes illness in people with respiratory problems.

2.4.4 Other environmental effects

There are few, if any, other significant environmental effects of exposure to CO. Plants both produce and metabolise CO and are only harmed by prolonged exposure to very high levels.

2.5 Ozone

2.5.1 Description

Ozone (O_3) is a pale blue gas with a characteristic smell. It is a reactive oxidant gas that is a major constituent of atmospheric smog. Ozone is a secondary air pollutant, that is, it is not emitted directly into the atmosphere, but rather it is formed in the atmosphere as a result of chemical reactions that involve primary pollutants.

Ground level ozone is formed in the air by the photochemical reaction of sunlight and nitrogen oxides (NO_x), facilitated by a variety of volatile organic compounds (VOCs), which are photochemically reactive hydrocarbons.

Ozone concentrations are influenced by the intensity of solar radiation, the absolute concentrations of NO_x and VOCs, as well as their relative ratio. Diurnal and seasonal variations occur in response to changes in sunlight. In addition, ground-level ozone accumulation occurs when sea breezes cause circulation of air over an area or when temperature-induced air inversions trap the compounds that produce smog.

2.5.2 Major sources

There is no direct emission of O_3 to the atmosphere. Most of the O_3 in the troposphere (lower atmosphere) is formed indirectly by the action of sunlight on nitrogen dioxide. The precursors of ground-level ozone are emitted by both natural and anthropogenic sources. Volatile organic compounds (VOCs) occurring naturally due to emissions from trees and plants may account for as much as two thirds of ambient VOCs in some locations. Anaerobic biological processes, lightning, and volcanic activity are the main natural contributors to atmospheric NO_x.

Motor vehicles are the main anthropogenic sources of the ground-level ozone precursors of hydrocarbon and NO_x. Other anthropogenic sources of VOCs include emissions from the chemical and petroleum industries and from organic solvents in small stationary sources such as dry-cleaners. Significant amounts of NO_x originate from the combustion of fossil fuels in power plants and industrial processes.

About 10 to 15% of tropospheric O_3 is transported from the stratosphere where it is formed by the action of ultraviolet radiation on oxygen. In addition to O_3, photochemical reactions produce a number of oxidants including peroxyacetyl nitrates (PAN), nitric acid and hydrogen peroxide, fine particulates and an array of short-lived radicals. As a result of the various reactions that take place in the atmosphere, O_3 tends to build up downwind of urban centres, where most of the NO_x is emitted from motor vehicles.

2.5.3 Human health effects

Short-term adverse health effects of ozone have been observed from hourly exposures to ozone concentration as low as 200 $\mu g/m^3$. These effects include eye, nose and throat irritation, coughing, throat dryness, thoracic pain, increased mucous production, chest tightness, and nausea. Pulmonary function decrements in children and young adults have been reported at hourly average ozone concentrations in the range of 160 to 300 $\mu g/m^3$, as well on long term exposure to ozone. The synergistic effects of ozone and other pollutants (sulphates and nitrogen dioxide) have been reported. Also, there is no reported threshold value for ozone.

Evidence suggests that exposure to short-term peak concentrations of ground-level ozone damages human health but that these impacts are relatively mild and reversible at ground-level ozone levels exceeding current WHO guidelines (120 μg/m^3 over 8 hours). The current WHO guidelines for O_3 and other air pollutants are listed in Table 2.2.

2.5.4 Other environmental effects

Elevated ground-level ozone exposures affect agricultural crops and trees, especially slow-growing crops and long-lived trees. Ozone damages the leaves and needles of sensitive plants, causing visible alterations such as defoliation and change of leaf colour.

In addition to physiological damage, ground-level ozone may cause reduced resistance to fungi, bacteria, viruses, and insects, reducing growth and inhibiting yield and reproduction. These impacts on sensitive species may result in declines in agricultural crop quality and the reduction of biodiversity in natural ecosystems.

It should be borne in mind, that ground-level ozone is part of a complex relationship among several air pollutants and other factors such as climatic and meteorological conditions and nutrient balances.

2.6 Lead

2.6.1 Description

Lead (Pb) is a grey-white, soft metal with a low melting point, a high resistance to corrosion, and poor electrical conducting capabilities. It is highly toxic.

Most lead in ambient air is in the form of fine particles with an aerodynamic diameter of less than 10 μm. Ambient air also contains organic lead compounds as gases.

2.6.2 Major sources

Lead is naturally available in all environmental media in small concentrations. From the atmosphere, lead is transferred to soil, water, and vegetation by dry and wet deposition. Lead binds strongly to soil, with a half-life of several hundred years. Natural atmospheric lead concentrations are estimated to be in the range of 0.00005 μg/m^3. Urban concentrations are around 0.5 μg/m^3.

Mining, smelting and processing of lead and lead-containing metal ores generate the greatest part of lead emissions from stationary sources. In addition, the combustion of lead-containing wastes and fossil fuels in incinerators, as well as power plants, industries, and households release lead into the atmosphere.

As a result of the extensive use of alkyl-lead compounds as fuel additives (“anti-knock” additives), vehicular traffic is the largest source of atmospheric lead in many urban areas, where leaded gasoline is still used, accounting for as much as 90% of all lead emissions into the atmosphere.

Lead-based paint and dust contaminated by such paint represent significant sources of human exposure to lead in several countries. Lead-acid batteries contribute to the contamination of all environmental media during their production, disposal, and incineration. Lead compounds may also be used as stabilisers in plastics. Other lead-based products include food-can solder, ceramic glazes, crystal glassware, lead-jacketed cables, ammunition and certain cosmetics.

2.6.3 Human health effects

Human exposure to lead is primarily through ingestion and inhalation. Children up to about six years of age constitute the population group at the highest risk from lead exposure through ingestion. Lack of essential trace elements such as iron, calcium, zinc and vitamin C and D, and poor nourishment may increase the absorption of lead by the human body.

Inhalation poses the highest risk of exposure to environmental lead in adults. Inhaled airborne lead represents a relatively small part of the body burden in children. WHO defines a critical level of lead in blood at 100 μg/L. WHO also advises that it appears that 1 μg of lead per cubic metre of air directly contributes approximately 19 μg/L of blood in children and about 16 μg/L of blood in adults. Table 2.2 gives the WHO health-based guidelines for lead in the atmosphere, along with other air pollutants.

Lead affects several organs of the human body, including the nervous system, the blood-forming system, the kidneys, and the cardiovascular and reproductive systems. Of most concern are the adverse effects of lead on the nervous system of young children: reducing intelligence and causing attention deficit, hyperactivity, and behavioural abnormalities.

Adult women of reproductive age are also a high-risk group because lead levels of pregnant women are closely correlated with those of newborns. People who are exposed to lead on the job, such as traffic police inhaling airborne lead particles, also suffer adverse health effects. Among adults lead levels in blood are linked to an increased incidence of high blood pressure.

There is evidence to show that persons exposed to large quantities of lead store it in their bones and this lead may leach into their blood long after the exposure. Pregnant women can expose their foetus to lead based on their own exposure as children.

2.6.4 Other environmental effects

Terrestrial and aquatic plants show a strong capability to bioaccumulate lead from water and soil in industrially contaminated environments. Lead can also be taken up by grazing animals, thus entering the terrestrial food chain.

2.7 Volatile Organic Compounds

2.7.1 Description

Volatile organic compounds (VOCs) comprise a very wide range of individual substances, including hydrocarbons (alkanes, alkenes, and aromatics), halocarbons (e.g. trichloroethylene) and oxygenates (alcohols, aldehydes and ketones.) All are organic compounds of carbon and are of sufficient volatility to exist as a vapour in the atmosphere.)

2.7.2 Major sources

VOCs are probably the second most widespread and diverse class of emissions after particulate matter. The variety of sources is quite large and the specific sources vary greatly for the individual compounds.

Hydrocarbons arise substantially from gasoline evaporation and incomplete combustion and from leakage of fuel from distribution systems. Oxygenates arise in vehicle exhaust and are also formed in atmospheric chemical reactions. Evaporation of solvents, used for example in paints, or industrial degreasing processes, causes the release of hydrocarbons, oxygenates and halocarbons to the atmosphere.

Certain VOCs are also naturally occurring. For example, toluene, the most prevalent hydrocarbon in the troposphere, is emitted from vegetation, petroleum seeps and coal deposits.

2.7.3 Human health effects

No generalisations on the health effects of VOCs as a group can be made, as health effects are compound-specific. Some VOCs are of significant toxicity and are proven or potential carcinogens. For example, benzene, (found in the exhaust emissions of motor vehicles from combustion of fuel) has toxic and carcinogenic effects. Also, another group of compounds, polycyclic aromatic hydrocarbons (PAHs) are semi-volatile organic compounds (SVOCs), and are mutagenic and carcinogenic.

2.7.4 Other environmental effects

Many VOCs are of significance in relation to their environmental effects, particularly their contribution to secondary pollutant formation and to stratospheric ozone depletion. VOCs also contribute indirectly to formation of atmospheric acidity.

2.8 Ozone Depleting Substances

2.8.1 Description

While ground level ozone in the troposphere is a pollutant resulting in human health, environmental and global warming effects, stratospheric ozone is vital to life on earth. It acts as an umbrella, filtering out the sun's harmful ultraviolet rays.

Ozone depleting substances (ODSs) are a wide variety of man-made compounds that react with and destroy the stratospheric ozone in the presence of sunlight. The following ODSs have been identified as being used in Trinidad and Tobago:

CFC-11	mainly used for servicing large centrifugal air-conditioning systems, as a propellant for aerosols and in the manufacture of rigid polyurethane foams;
CFC-12	mainly used in the manufacture and servicing of domestic refrigerators, mobile air-conditioners, central air-conditioning

	systems and as a propellant for aerosols;
CFC-113	used in small quantities to clean printed circuit boards and in the servicing of biomedical equipment;
CFC-114	used as a propellant for aerosols;
CFC-115	imported as part of the refrigerant R-502 and used in low-temperature refrigeration such as cold storage rooms and by food processors;
Halon 1211	used in portable fire extinguishers;
Halon 1301	used in fixed flooding fire protection systems mainly in computer rooms and telephone exchanges;
Tetrachloro-methane	used as a solvent in a number of laboratories; and
1,1,1-Trichloro-ethane	used as a metal cleaner in large engineering workshops and laboratories and also as a paint stripper.

2.8.2 Major Sources

ODSs are leaked or intentionally released into the atmosphere from air-conditioners and refrigerators during repair and maintenance or after disposal. Other ODSs are released during use.

2.8.3 Human Health Effects

Though ODSs themselves have little to no direct human health effects, the increase in UV-B radiation reaching the earth as a result of their release certainly do. Increased UV-B exposure has been linked to skin cancers, increased vulnerability to infectious diseases and cataracts.

2.8.4 Other Environmental Effects

Increased UV-B levels can also alter the life cycle of plants and result in crop damage. In the ocean, scientist have found that UV-B radiation interferes with the photosynthesis of plankton, the base of the marine food chain, it has caused mutations in some marine organisms and harmed the eggs of others (Steger and Bowermaster 1990).

2.9 Greenhouse Gases

2.9.1 Description

The temperature of the earth is regulated by the atmosphere, which has the ability to block heat from the sun and at the same time trap a certain amount of heat around the earth's surface. Greenhouse gases are those which increase the ability of the atmosphere to trap heat in the atmosphere. Greenhouse gases include carbon dioxide and a wide range of others such as methane, chloroflorocarbons, nitrous oxide and tropospheric ozone.

2.9.2 Major Sources

Energy production, transportation, forest fires and decomposition of garbage are some of the main sources of the greenhouse gases carbon dioxide and methane. The major sources of N_2O are natural, and include lightening, volcanic eruptions and the action of soil bacteria. Chlorofluorocarbons are emitted during the repair and operation of refrigeration equipment.

The world is not only producing more greenhouse gases, the capacity to process the main greenhouse gas, carbon dioxide, by photosynthesis is being lost through deforestation.

2.9.3 Environmental Effects

The presence of greenhouse gases in ever increasing concentrations produces the greenhouse effect, the main effect of which is a rise in the temperature of the earth's surface. Environmental effects that result from this global warming are poorly understood. An increase in temperature may cause a rise in sea level. This can have diverse consequences: flooding, salt-water intrusion in wetlands and ground-water supplies and the destruction of crowded coastal communities.

Other possible effects are changes in weather patterns and increased incidence of hurricanes and droughts. Reduced dissolved oxygen in water and increase in the range of infectious diseases are also likely.

Table 2.2

W.H.O. HEALTH-BASED GUIDELINES FOR CERTAIN AIR POLLUTANTS

Compound	Health endpoint	Observed Effect Level **(µg/m³)**	Uncertainty Factor	Guideline Value **(µg/m³)**	Averaging Time
Particulate Matter	No safe level can be defined.				
Sulphur Dioxide	Changes in lung function in asthmathics. Exacerbation of respiratory symptoms in sensitive individuals.	1000 250 100	2 2 2	500 125 50	10 minutes 24 hours 1 year
Nitrogen Dioxide	Slight changes in lung function in asthmatics.	365-565	0.5	200	1 hour
Carbon Monoxide	**Critical level of** COHb <2%	n.a.	n.a.	100 000 60 000 30 000 10 000	15 minutes 30 minutes 1 hour 8 hours
Ozone	Respiratory function responses	n.a.	n.a.	120	8 hours
Lead	Critical Level of Pb in blood: <25µg of Pb per litre of blood	n.a.	n.a.	0.5	1 Year

3.0 GENERAL ASSESSMENT OF THE AIR POLLUTION PROBLEM IN TRINIDAD AND TOBAGO

3.0 Ambient Air Quality Assessment

The fact that we are a small twin island state under the influence of the North East Trade Winds for most of the year does not preclude us from having the periodic air pollution episodes that are a common feature for larger and more industrialised countries. Advisories issued by the Meteorological Office at Piarco are sometimes used to inform the public about impending events that may lead to reduced atmospheric visibility (e.g. Sahara dust visitation in combination with severe bush fires). This is especially so in the months of April – November when Sahara dust is most frequent and can cause a marked reduction in atmospheric visibility (3-4 km) that may last a few days or as much as 20 days from back-to-back episodes (Personal Communication, Meteorological Service). This seasonal phenomena which also occurs for part of the dry months (January to May) can produce very hazy conditions in localised areas that are experiencing severe bush fires.

Although there are no permanent air quality monitoring networks for the country to inform and track trends on particular pollutants, there have been two synoptic ambient studies done to date on PM_{10}. The first was conducted in 1998, and was a collaborative effort among the EMA, the United States Environmental Protection Agency (USEPA) and the Pan American Health Organisation (PAHO) with the assistance of the University of the West Indies, St. Augustine (UWI). The second was conducted in 1999 by the Town and Country Planning Division (TCPD) on behalf of the Government of the Republic of Trinidad and Tobago (GORTT).

The first PM_{10} study, entitled "Suspended Particulate Matter Concentrations along the East-West Corridor, Trinidad, W.I" (Rajkumar and Siung Chang, 2000) was conducted in 1998. The air quality-monitoring programme was designed to collect PM_{10} samples over a six-week period from a network of 18 stations along the populated east-west urban corridor in Trinidad. The results showed that the daily maximum PM_{10} concentrations approached the USEPA 24-hour ambient standard (150 $\mu g/m^3$) only on days when Sahara dust was present in the atmosphere. The mean levels of PM_{10} ranged between 46 – 88 $\mu g/m^3$, with the higher mean levels reflecting the proximity of these stations to heavy road traffic, an important source of airborne particulate matter. Median values obtained from the study during non-Sahara dust periods have been extrapolated to show the likely contribution of vehicular traffic and roadside dust to ambient PM_{10} concentrations in Trinidad. The results show that vehicular traffic and roadside dust contribute only about 30 – 40 $\mu g/m^3$, which suggests that during Sahara dust episodes a significant portion of the PM_{10} concentration in the air can be attributed to this phenomena. Although the study was only for a six-week duration, the relationship between PM_{10} and Sahara dust is an important one, especially when consideration is being given to setting ambient standards at the national level.

The other ambient monitoring programme was executed by the TCPD. This project was split into three phases; the third being the data collection program. This phase included actual measurements of air quality parameters (NO_x, SO_x, VOCs, TSP/PM_{10}/$PM_{2.5}$, NO_3 in TSP, SO_4 in $PM_{2.5}$ and metals in PM_{10}) in the study areas of Point Lisas (2 stations) and Chaguaramas (1 station) over a 4-week period. Results obtained for the study indicated that with the exception of a single measurement of TSP which exceeded the USEPA 24-hour average of 150 $\mu g/m^3$ in the Point Lisas central area, the levels of all the other reported parameters were within accepted international ambient standards.

3.1 Other Analyses of Air Pollution

There have been several pollutant inventory studies done to characterise air pollution sources and estimate loads. Some of these studies used simplified models (Rajkumar 1995, EMA/UNDP 1998, EMA 2000b) and one based on actual consumption data (EMA 2000b). Apart from these specific pollutant inventory studies, the EMA has been operating an investigation and complaints desk since 1995, and has complied a wealth of data. The complaint data have been analysed and categorised, and the result illustrated in Figure 3.1. It is apparent from Figure 3.1 that the air complaints cover many sectors, however two main activities stand out, autobody repair and mechanics as well as woodworking.

Information from the inventory studies done for Trinidad and Tobago has categorised air pollution sources into either point or non-point source emitters. It has been previously pointed out that point sources refer to sources that release air pollution from a discernible point such as a stack from a factory. Non-point sources (also known as area sources) are those from which air pollutants are discharged in a diffused manner such as burning of agricultural fields or road side dust.

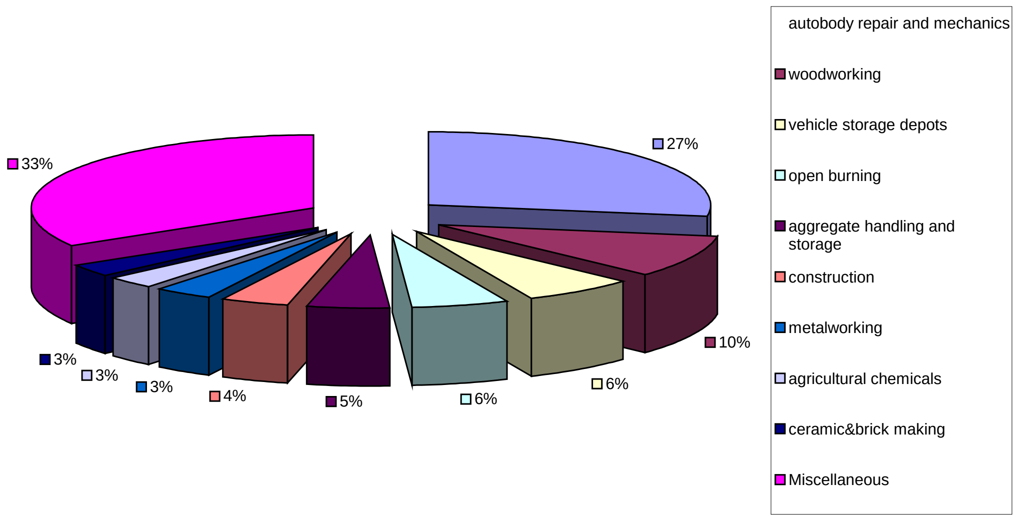

Figure 3.1. Analysis of air complaints made to the EMA between August 1995 and April 2000.

3.2 Air Pollutant Loads by Source

Figure 3.2 shows the individual air pollutant loads, using the most recent data available, which was extracted from the various reports mentioned in section 3.1. Based on an analysis of the data presented in Figure 3.2 with respect to TSP the major anthropogenic sources were from the manufacturing (milling 18%, urea 9% and cement 6%), quarrying (40%), transportation (road transport 10%) and agriculture sectors (6% burning of sugar cane fields). In the case of SO_2 the major sources were from the manufacturing (petroleum refining 19% and cement 7%), and transportation (road 63% and sea transport 9%) sectors. For NO_x the major sources were from the manufacturing (ammonia 5%), power generation (26%) and transportation (road transport 59%) sectors. For VOCs the major sources were from the manufacturing (petroleum refining 25% and ammonia 41%), and transportation (mainly road 21%) sectors. For CO the major sources were from manufacturing (58% petroleum refining), agriculture (9% burning of sugarcane fields) and transportation (mainly road 28%) sectors. Major sources of chlorine (Cl_2) and ammonia (NH_3) were from the manufacturing of these chemicals while particulate Pb was mainly from road transport (96%).

Based on the analysis of the greenhouse gases CO_2, CH_4, N_2O, NMVOC for year 1990 as presented in Figure 3.2 and in Figures 3.3 – 3.6 the main source of CO_2 was from the combustion of fossil fuel for energy production and transportation. These sources contributed 66% of the total anthropogenic or human-related carbon dioxide emissions, with industrial processes contributing the remaining 34% (Figures 3.4 – 3.6). With respect to non-CO_2 green house gas (GHG) emissions the waste sector (i.e. solid waste disposal on land and wastewater handling) contributed the majority of the total load of CH_4.

3.2.1 Point Sources

The inventory reports have identified the following economic sectors as the main contributors for point source releases:

Manufacturing	related to the processing of raw materials, intermediate and final products from various commodities e.g. ammonia, methanol, chlorine, urea, paints, petroleum hydrocarbons, beer, glass, clay, asphalt, sand and gravel, lead-acid batteries, cement and lime, iron and steel and sugar, milling;
Electrical power generation	as a result from firing gaseous and liquid fuels;
Wholesale and retail trade of fuel	during storage, filling and refuelling; and
Transportation	fossil fuel combustion from all modes of transport.

Only 2 percent of the EMA's air pollution complaints and investigation database can be classified in the point source category. This included manufacturing (petroleum refining, sugar refining, iron and steel, asphalt batching plants), community, social and personal services (hospital incinerators, dry-cleaning laundries), wholesale and retail trade (restaurants, fuel tank filling). One such complaint was black smoke and noxious odours associated with an asphalt batching plant located in east Trinidad. Residents from the Mausica area complained vociferously about the impact that the facility's emission was having on their health which including itching skin, rashes, headaches and dizziness. The EMA investigated the complaint and confirmed that heavy clouds of black smoke was emitted from the operation as a result of old equipment, lack of maintenance and no engineering controls. Three other asphalt plants were found to be in a similar condition.

3.2.2 Non-Point Sources

The main economic sectors responsible for non- point sources of air pollution as identified from the inventory reports and EMA's complaints and investigation database include:

Mining and quarrying	from blasting, loading, unloading and crushing;
Construction	site preparation and complete construction
Agriculture	slash and burn, burning of agricultural fields, aerial crop spraying;
Community, social and personal services	malodours from sewage treatment plants, dumps, landfills, burning of landfills and dumps; and
Wholesale and retail trade	automotive body repair and maintenance shops.

Two complaints in the category of non-point sources are worthy of mention. The first is associated with noxious fumes and gases from an oil-producing field in south-western Trinidad, which left parents, teachers and children in the area with runny noses and eyes, vomiting, itching skin, rashes, headaches, and dizziness. An extensive investigation was conducted which led to the closure of the oil production facility and relocation of the school away from the source of pollution.

In the second case, residents, motorists and other users along the Beetham to the Audrey Jeffers Highway complained that smog, dust and objectionable odours from the burning of the Beetham Landfill resulted in runny noses and eyes, and sore throats. At the time of the incident the haze in the atmosphere was exacerbated by the presence of Sahara dust which further reduced visibility along the highway corridor.

This incident prompted a study to be carried out on the lung function of Beetham residents (Davis and Melville [illegible]9) by UWI and the EMA with support from the community police. The results of testing of this small sample of residents (thirty-eight) showed that approximately fifty eight (58) percent showed some abnormality in lung function.

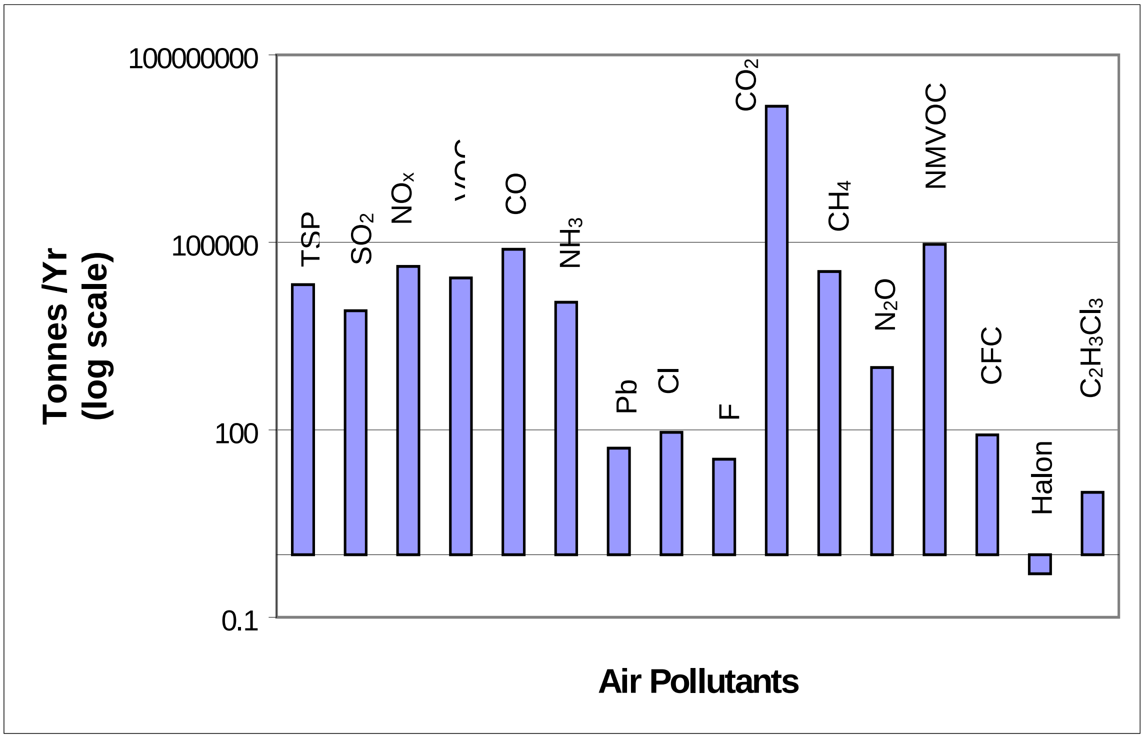

Figure 3.2. Individual air pollutant loads for Trinidad and Tobago.
For TSP, SO_2, NO_x, VOC, CO, NH_3, Pb, Cl_2 and F_2: data was extracted for the year 1996 (EMA/UNDP 1998). For CO_2, CH_4, N_2O, NMVOC: data was extracted for the year 1990 (EMA 2000b). For CFC, Halon and $C_2H_3Cl_3$: data was extracted for the year 1999 (EMA 2000b). Where data on individual air pollutants are presented it is an aggregate of both point and non-point sources.

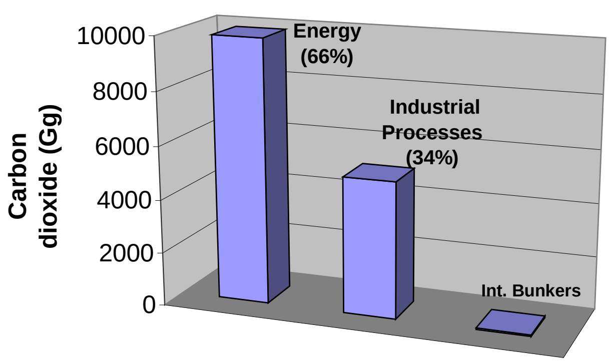

Figure 3.3: Carbon dioxide emissions in Trinidad and Tobago by sector in 1990.

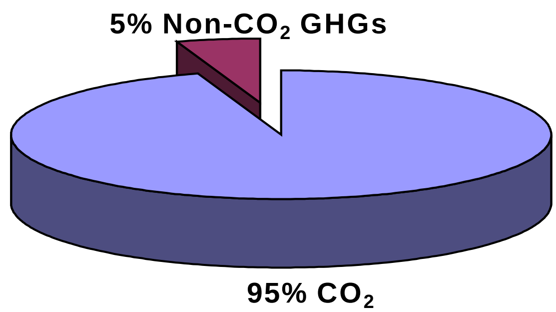

Figure 3.4. Greenhouse gas emissions in Trinidad and Tobago from the energy sector in 1990.
Total CO_2 from fuel combustion is 9,887 Gg. Non-CO_2 GHGs from fuel combustion total 520 Gg (CO_2 equivalents of CH_4 and N_2O were used).

Main releases for N_2O were generated from agricultural fields, while NMVOCs were from combustion of fossil fuel for energy production including transportation, as well as releases from industrial processes (Fig. 3.5).

It should be noted that the data summarised in the above Figures are given in carbon dioxide equivalent, meaning that since different greenhouse gases have different radiative abilities, the resulting warming effects of other gases have been converted to the warming effect of carbon dioxide.

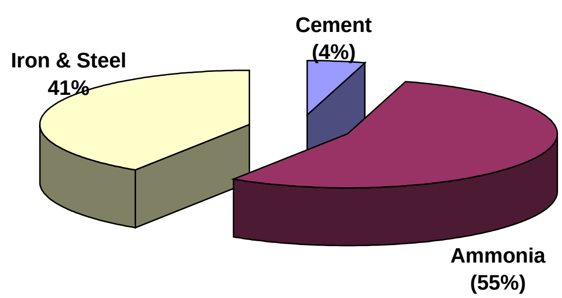

Figure 3.5. Non-CO_2 greenhouse gas emissions in Trinidad and Tobago for the energy sector in 1990. (CO_2 equivalents of CH_4 and N_2O were used).

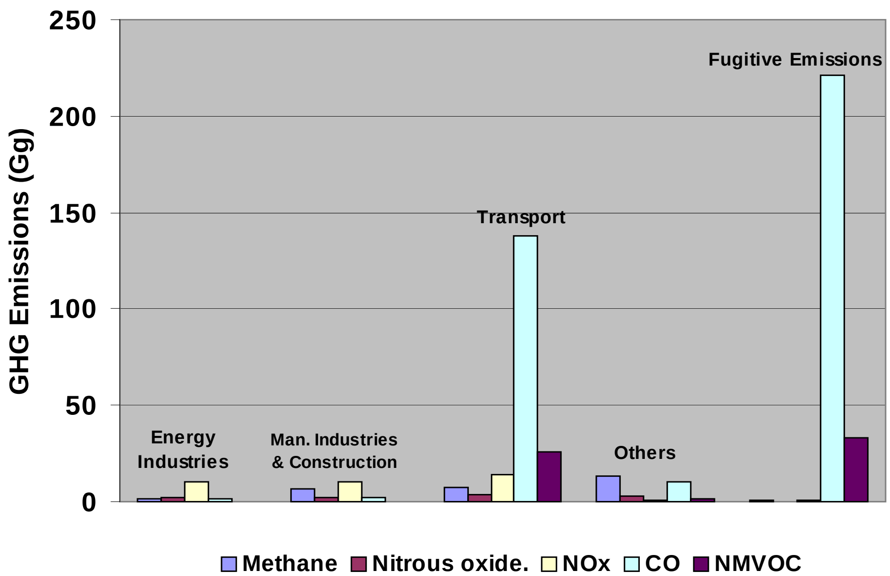

Figure 3.6. Carbon dioxide emissions from relevant industrial processes in Trinidad and Tobago in 1990.
The total CO_2 emission for industrial processes is 5,100 Gg.

Trinidad and Tobago does not produce ozone-depleting substances (ODSs) and imports all of its requirements. In 1999, the main CFCs consumed were from the servicing of air-conditioning and refrigeration systems (CFC-12) which represented 82% of total ODS consumed. Other CFCs (CFC-11, 113, 114 and 115) consumed but of lower importance are those used as propellants for aerosols, manufacture of rigid polyurethane foams, cleaning printed circuit boards and servicing biomedical equipment. Halons, the type used in fixed flooding fire protection systems, although having the highest ozone depletion potential, represent only 0.5% of the total ODS consumed. 1,1,1-Trichloroethane which represents approximately 11% of the total ODS consumed is used mainly as a metal cleaner, solvent and paint stripper. Consumption data on ODS complied for the years 1986 – 1999 has shown a peak in 1989 followed by a general decrease.

Consumption data is a good guide in determining emissions of ODS. This is because discharged or leaked ODS in existing installations is replaced by new consumption. In new installations, without recycling, ODS will also be eventually released into the atmosphere, and need to be replaced by new consumption.

3.4 Important Sectors of Relevance to Air Pollution in Trinidad and Tobago

3.4.1 The Transport Sector

This sector has been singled out for particular analysis in light of the increasing negative impacts emissions and other pollutants from motorised vehicles have on land, air and water and on the quality of human life, agricultural crops and the wild flora and fauna of the country. Emissions from motor vehicles with spark-ignition engines (e.g. gasoline-fueled vehicles) are from the exhaust, engine crank case and fuel system. The major pollutants emitted from gasoline-fuelled motor vehicles are carbon monoxide, sulphur dioxide, hydrocarbons, oxides of nitrogen, and lead only if leaded fuel is used. For a given fuel quality, concentrations of many of these pollutants are influenced by such factors as: the air-fuel ratio in the cylinder at the time of combustion, ignition timing, combustion chamber geometry, engine parameters such as speed, load, and engine temperature, and the use of emission control devices.

The major pollutants emitted from diesel-fueled vehicles, emitted primarily in the exhaust emissions, are: particulate matter (including smoke), oxides of nitrogen, sulphur dioxide, carbon monoxide and hydrocarbons. For a given fuel quality, diesel engines tend to have low hydrocarbon and carbon monoxide emissions and considerably higher particulate matter emissions than gasoline-fueled vehicles. For heavy-duty vehicles, carbon monoxide and hydrocarbon and nitrogen oxides emissions in the exhaust also vary with driving modes, engine speed and load.

In 1998 a pilot programme to analyse emissions from motor vehicles and to enforce provisions of the Motor Vehicle and Road Traffic Act prohibiting emission of visible vapours from vehicles was jointly conducted by the Transport Division of the Ministry of Works and Transport and the EMA.

The programme tested vehicles on the road using portable equipment and at the Port of Spain Licencing Division using a fixed analyser. Although the report on the programme was unable to make generalisations on the emission levels of the Trinidad and Tobago fleet because of the small sample size, a significant proportion of the sampled vehicles failed United Kingdom standards for carbon monoxide and hydrocarbon emission levels. Moreover, many vehicles could not be tested because the level of smoke being emitted would have clogged the filtering system and fouled the equipment.

The greenhouse gas inventory of 1990 identified the transport sector as a significant contributor to greenhouse gas emissions. It accounted for about 15% of total carbon dioxide emissions in the energy sector; road transportation accounting for 1340 Gg of carbon dioxide out of a total of 1478 Gg for the transportation sector. Over the period 1990 – 1994, there was a 5.25% decline in the consumption of gasoline, with an 83% increase in diesel consumption over the same period, presumably as a result of the conversion to diesel engines by public transport vehicles such as taxis to cater for the cheaper diesel price.

It is noteworthy to mention the marked preference shown by the travelling public for individual private transportation and private commercial transport (taxis and maxi-taxis) relative to the use of available public systems such as buses. For example, customer levels for the public bus service decreased from 16.3 million in 1990 to 6.4 million passengers in 1998. As of April 2000, the number of registered vehicles in Trinidad and Tobago stood at 297,656 compared to 251,829 in 1998, an increase of over 45,000 in just over a year.

Interestingly, Latin America and the Caribbean is reported as having higher motorization levels* than other developing regions except Eastern Europe (Onursal and Gautam 1997). Further, from the data presented on motorization levels in 1990, for the countries in South America, Central America and the Caribbean region, Trinidad and Tobago had the highest motorization level (276 motor vehicles per 1000 people). With this trend, it can be expected that the transport sector will continue to be a significant source of air pollution for years to come.

3.4.2 Manufacturing Sector

Due in part to the different and varying processes involved in the manufacturing sector a wide range of air pollutants are expected to be emitted. Although the data presented above represents but a small fraction of the types of pollutants (TSP, NOx, CO, VOC, Cl_2, Pb, NH_3, SO_2) that are likely to be emitted, continued industrial development and expansion without proper air pollution controls will see the introduction of other air pollutants into the atmosphere. Implementation of air emission control devices along with proper inspection and maintenance programmes are seen as the first line of defence in reducing the present level of emissions. Process changes and switching to cleaner production technologies would then be the ideal follow-up activities, further reducing air polluting emissions.

3.4.3 Power Generation

The higher combustion temperatures involved in power generation favours the formation of oxides of nitrogen. This, coupled with the high volume released and its photochemical reactivity (precursor in the formation of ground level ozone), makes NO_x from power generation an environmentally important air pollutant. Electrical power generation in 1993 stood at 3.8 million MWH (or approximately 16,000 tonnes of NO_x released). With increased production capacity and the introduction of another power generation source, the power generation output now stands 5.5 million MWH, or an increase in NO_x by 1.4%. Continued economic growth and development, which normally translates into an increased demand for electricity, would indicate that NO_x emissions will continue to increase unless measures are instituted to conserve or reduce energy consumption. Switching to alternative forms of energy (e.g. solar, wind or wave) as well as increasing

* Motorization is defined as the number of motor vehicles per thousand people.

the use of energy saving appliances, machinery and lighting are some of the measures to reverse NOx emissions from power generation.

3.4.4 Wholesale and Retail Trade

Apart from manufacturing sector evaporative emissions or losses from bulk fuel terminals (above ground tanks), the other major sources of VOCs are truck filling stations and service station operations. Like NO_x, VOC is an important precursor in the formation of ground level ozone. The current dependence on gasoline, diesel, jet naptha and crude oil and the prediction that this would remain so for some time, demands that some modifications to the core business be instituted. Changes in the way bulk fuel is stored, and loaded into tanks are needed. For example, storage could be changed from fixed roof tanks to floating roof tanks, and loading techniques changed from splash loading to submerged loading, along with the introduction of vapour recovery systems at service stations. These changes would ensure that this sector becomes a minor contributor to VOC releases in the future.

4.0 STATUS OF INSTITUTIONAL ADMINISTRATION AND LEGISLATIVE CONTROLS AND POLICY SPECIFIC TO AIR POLLUTION

4.0 Air Pollution from Stationary Sources

Presently there is no legislation that refers specifically to the direct control of air pollutants emitted by stationary anthropogenic sources. Existing legislation addresses non-specific air pollutants. For instance, smoke, odours and fumes constitute an actionable nuisance when they interfere with the use and enjoyment of property. The Public Health Ordinance (1950), section 69 imposes a duty on the part of local authorities to initiate action to abate nuisances. The enforcement agencies for this legislation are: the Municipal Corporations and the Ministry of Health. Provision for the control of air pollution as a nuisance also exists under the Municipal Corporations Act (1990), with penalties of $500.

The Petroleum Act (rev. 1980) contains provision for the prevention of air pollution, with the enforcing agency as the Ministry of Energy and Energy Industries. The Ministry also has responsibility for enforcement of provisions for the prevention of uncontrolled flow of gas in accordance with the Drilling Regulations made pursuant to the Mines, Borings and Quarries Act (rev. 1980).

4.1 Air Pollution from Mobile Sources

Rule 13 of Regulation 38 made under the Motor Vehicles and Road Traffic Act, Chapter 48:50 section 100, states that every driver of a motor vehicle:

"shall not permit sparks, smoke or visible vapour of any avoidable nature which would cause annoyance or danger to the public to come from any motor vehicle in his charge on or near any public road…"
(Visible Vapour Rule)

Accordingly, Transport Officers and Police Officers may serve fixed penalty notices (tickets) charging the driver with the commission of an offence and requiring the driver to pay a fixed penalty within fourteen (14) days or to appear in court to answer a complaint. On summary conviction in court, the penalty for a breach of the Act or Regulations is a fine not exceeding $1000.00 or imprisonment for up to six months.

Also, section 100 of the Motor Vehicles and Road Traffic Act (1997) adds authority for the Minister to make regulations for :

(q) health, safety or environmental matters…including the prescribed vehicle emissions, use of unleaded fuels…"

Provision is also made under the Motor Vehicles and Road Traffic (Amendment) Act, No. 25 of 1997, section 14 for the de-registration of a vehicle for causing an environmental hazard. The enforcement agency is the Licensing Authority, and the penalty is cancellation of licence.

Table 4.1. Laws relating to Air Pollution in Trinidad and Tobago

Law	Enforcement Agency	Penalty
Motor Vehicles and Road Traffic Regulations, made pursuant to the Motor Vehicles and Road Traffic Act (rev. 1980), Regulation 38, Rule 13 – visible emissions	Licensing Authority, Police Service	$60.00
Motor Vehicles and Road Traffic (Amendment) Act, No. 25 of 1997, Section 14 – deregistration for causing an environmental hazard.	Licensing Authority	Cancellation of License
Section 44, Customs Act, Ch. 78:01 (rev. 1980), " The President…may prohibit importation of any goods whatsoever.."	Customs and Excise Division	--
Petroleum Act (rev. 1980), Section 29 (I) (j) – Prevention of air pollution	Ministry of Energy and Energy Industries	--
Public Health Ordinance (1950), Sections 69 and 70 – Nuisance Public Health Ordinance (1950), Section 70 (1) (m) –prohibits black smoke from chimneys	Municipal Corporations; Ministry of Health	$500.00

Table 4.1 Continued. Laws relating to Air Pollution in Trinidad and Tobago

Law	Enforcement Agency	Penalty
Municipal Corporations Act (1990), Section 221 (I) – Nuisance	Municipal Corporations	$500.00
Standards Act No. 18 of 1997, Section 15 (I) – Power to make environmental standards	T&T Bureau of Standards	$15,000.00
Consumer Protection and Safety Act (1985), Section 21 (I)- Conduct detrimental to the health of consumers	Ministry of Consumer Affairs	$10,000.00
Environmental Management Act (2000) Sections 49-51- Authorises the EMA to develop a legal regime for management of air pollution	EMA	$100,000.00
Gas Cylinders (Use, Conveyance and Storage) Act (rev. 1980), Section 2 – Control of gas cylinders.	Ministry of Energy & Energy Industries	$750.00
Drilling Regulations made pursuant to the Mines, Borings and Quarries Act (rev. 1980), Regulation 18 (I) – Prevention of uncontrolled flow of gas.	Ministry of Energy & Energy Industries	$1,000.00 plus costs
Section 4 (2) of the Trade Ordinance No. 19 of 1958- Prohibiting importation of environmentally harmful products. Legal Notice No. 69 of 1999- places certain prohibitions on the import of Ozone Depleting Substances and equipment using ODSs pursuant to the Trade Ordinance 19 of 1958	Ministry of Trade	— —

4.2 State of Enforcement of Existing Law related to Air Pollution Control

With respect to enforcement of laws related to air pollution from stationary anthropogenic sources, available data indicate that for the years 1997 and 1998, there were no enforcement proceedings under the Public Health Ordinance for control of emissions of black smoke and similar nuisances.

With respect to enforcement of the "Visible Vapour Rule" which controls air pollution from mobile sources, available data indicate that for the years 1997 and 1998, there were 38 and 214 enforcement proceedings respectively. In 1999, there were 1,199 such enforcement proceedings. This is largely attributable to the EMA's pilot project of a squad of "Special Reserve Police" serving as "Environmental Police Officers", enforcing specific laws with provision for environmental protection, including the Motor Vehicles and Road Traffic Act.

In general, the factors influencing non-enforcement of environmental laws include:

(a) failure to use regulatory power, such as to create bylaws, rules etc.;
(b) antiquated and outdated regulations;
(c) vagueness or absence of specific standards in the law;
(d) inadequate resources, especially financial resources;
(e) lack of punitive sanctions.

4.3 Environmental Management Act, 2000

The general functions of the EMA include: the development and establishment of national environmental standards and criteria; monitoring compliance with the standards, criteria and programmes relating to the environment; pollution prevention and control, and conservation of the environment; and co-ordination of institutional linkages, locally, regionally and internationally.

Overall, the EMA is required to develop and implement a programme for the management of air pollution. Section 49 (1) of the Act mandates the Authority to investigate the environment generally and such premises and vehicles for the purpose of:

(a) ascertaining the extent of air pollution and the significant sources of pollutants which by their release cause or contribute to such pollution; and

(b) characterising or describing the environment.

The Authority is also required to maintain a register of air pollutants (in accordance with prescribed rules) which shall contain data identifying the quantity, conditions or concentrations relevant to the identification of each pollutant. Registration of significant sources of air pollutants is also required.

The Act also allows the Authority to require and grant permits to authorise any process releasing air pollutants subject to such terms and conditions as it deems appropriate.

Permit conditions may relate to the design, construction, operation, maintenance and monitoring of the facility and processes releasing the air pollutants. The Act also prohibits the release of any air pollutant into the environment which is in violation of any applicable standards, conditions or permit requirements.

4.4 Policy Objectives for the Air Pollution Control Strategies

The National Environmental Policy of Trinidad and Tobago articulates the goal of the policy as:

" the conservation and wise use of the environment of Trinidad and Tobago to provide adequately for meeting the needs of present and future generations and enhancing the quality of life ".

Government's approach to attaining this goal is to pursue a strategy of sustainable development, meaning improving the quality of human life while living within the carrying capacity of supporting ecosystems.

Further, the specific objectives of the Policy are to:

(a) prevent, reduce or eliminate various forms of pollution to ensure adequate protection of the environment and consequently the health and well-being of humans;

(b) conserve the biological diversity of the country and the stability and resilience of the ecosystems;

(c) undertake retrospective analyses or evaluations to correct past development decisions that might be inimical to the continued environmental health of the country.

These objectives emphasise pollution prevention, conservation and environmental remediation.

With respect to pollution control, the Policy is clear that Government will promote a co-operative environmental management approach with industry and interested stakeholders to promote consensus and partnership in achieving environmental targets. In addition, Government will operate an integrated environmental management system that will cover all major solid, liquid and gaseous emissions to air, land and water. Pollution control will be enforced through a system of permits or licence that will set pollution limits or performance standards. Compliance with codes of good practice may be required of "less polluting" facilities.

The Policy also states several approaches that will be utilised in controlling air pollution. These include: the establishment of ambient air quality standards as well as emission limits for stationary industrial plants, reductions in production and use of polluting products, and substance-oriented approach for integrated pollution control of that substance.

It is in the context of these policy objectives that the following national strategies and programmes have been formulated for the control of air pollution in Trinidad and Tobago.

5.0 STRATEGIES FOR AIR POLLUTION CONTROL

5.0 The strategies described in this section are separated into those that are general in application and are targeted towards overall management and control of air pollution and those that are focused on a particular sector source.

5.1 General Application

These strategies address primarily ambient air quality management and overall performance of the air pollution control programmes.

5.1.1 National Ambient Air Quality Standards

National ambient air quality standards and criteria for Trinidad and Tobago are being established. These will serve as the air quality objectives (targets) for the setting of limits for pollutants (or substances containing pollutants) that may be released into the ambient air by various sources, whether new or existing, industrial or transport sector-based, point or non-point in origin.

The national ambient air quality standards will provide a basis for protecting public health from the adverse effects of air pollution, and for eliminating, or reducing to a minimum, those air pollutants that are known to be or are likely to be, hazardous to human health and well-being and the environment.

These standards have been largely based on the guidelines for criteria pollutants, established by the WHO in "Guidelines for Air Quality" (WHO 1999).

These standards specify maximum levels over specified averaging times, for the criteria pollutants (total suspended particulates, PM_{10}, carbon monoxide, sulphur dioxide, oxides of nitrogen, lead and ozone). Ambient air quality guideline values for other air pollutants (non-criteria) based on non-carcinogenic and on carcinogenic health endpoints will also be established.

5.1.2 National Ambient Air Quality Monitoring System

A national ambient air quality monitoring system will be developed and implemented. Its primary purpose is to ascertain the following: the quality of the ambient air in various key locations in Trinidad and Tobago, the extent of air pollution, the significant sources of pollutants, which pollutants contribute to the pollution and the characterisation or description of air pollution.

Ambient air monitoring fulfils a central role in national air quality management, as it provides the necessary sound scientific basis for the following: policy and strategy development, objective setting, measurement of compliance against set targets and enforcement action.

The ambient air monitoring network should be designed with the following key objectives in mind:

(a) informing the public about air quality and raising awareness;
(b) determining population exposure and health impact assessment;
(c) identifying threats to natural ecosystems;
(d) assessing point or area source impacts;
(e) determining compliance with established Ambient Air Quality Standards.

The limitations of monitoring should also be noted, for example in determining population exposure, and hence it should be used in conjunction with other objective assessment techniques.

5.1.3 Other Means of Ambient Air Quality Assessment

Because of the inherent limitations of ambient air quality monitoring, other means for ascertaining the quality of ambient air should be devised to supplement the data obtained through monitoring. In this regard, other objective assessment techniques and models (such as air dispersion models, source emission inventories) should be defined and standardised for use in Trinidad and Tobago.

5.1.4 Air Quality Indices and Other Performance Indicators

Air quality indices to provide an indication of the quality of the ambient air in certain population centres should be established. Other performance indicators should be established to measure and assess not only the quality of the ambient air, but also the overall effectiveness of the strategies and programmes for air pollution control.

5.1.5 Health Studies

Health studies to determine the effects of specific sources of pollution on various segments of the population need to be designed and conducted. The information obtained through these studies will be critical in identifying priority areas and in developing future air quality management strategies.

5.1.6 Official Linkages with Relevant Agencies

For the effective implementation of proposed air pollution controls and co-ordination of enforcement of existing legislation, linkages must be established with the following agencies:

(a) Fire Services Department for control of open burning;

(b) Ministry of Food Production and Marine Resources and the Forestry Division, Ministry of the Environment for controlled agricultural burning, as well as for control of forest and bush burning, and for promotion of environmentally sound agro-industrial practices;

(c) Town and Country Planning Division with respect to ensuring land use and physical development consistent with planning approvals granted;

(d) Ministry of Health, and other relevant Ministries and agencies, and municipal and regional corporations for enforcement of existing laws with air pollution control provisions;

(e) Non-Governmental Organisations (NGOs) and Community Based Organisations (CBOs) for dissemination of information and implementation of community-based air pollution control programmes;

(f) Trade and industry associations for development of industry "codes of good environmental practice" and promotion of their use.

5.1.7 Special Programme for Control of Hazardous Air Pollutants, including Persistent Organic Pollutants (POPs)

Because of the risk (proven and potential) posed to human health and the environment, as well as the nature of some hazardous air pollutants, in terms of being persistent in the environment and bio-accumulative, it is essential that programmes are designed and implemented to reduce and eliminate these substances from being released into the environment, and eventually from use. These substances include dioxins and furans.

Consideration must also be given to contingency measures in cases of emergencies that may result in the release of these substances in high quantities into the environment.

5.1.8 Public Awareness Programmes

Educating the public on the sources of air pollution, the various air pollutants, their adverse health and environmental effects and the actions that can be taken to reduce and eliminate such pollution is essential in securing public support for the EMA's initiatives in this area.

5.2 Strategies for Control of Air Pollution from Stationary Sources

5.2.1 Registration And Characterisation of Industrial Sources of Air Pollution

As part of the strategy for air pollution control from industrial sources, facilities/sources (significant) must be registered and their contribution to air pollution assessed. Facilities/sources shall be characterised based on the following factors:

(a) type of industry;
(b) type of air pollutants emitted;
(c) whether facility includes point source emissions, non-point (area) source emissions;
(d) quantity of air pollutants emitted.

The characterisation and subsequent classification of sources of air pollution are critical, as this impacts on the development of emission inventories. (See section 5.1.3)

Legal rules shall be established for the procedure for the registration of these sources from which pollutants may be released into the environment, and for the procedure for the characterisation of such sources.

5.2.2 Limits for Emissions of Air Pollutants from Stacks and Fugitive Sources

National emission standards shall be established. These national standards will specify the quantity, condition or concentration of pollutants or substances containing pollutants that may be released into the environment generally, or by specific sources or categories of sources.

With respect to emissions from major point sources, stack emission standards shall be established. With respect to fugitive and other non-point sources of air pollution, the national ambient air quality standards will be applied to assess the quality of the ambient air. Non-compliance with these standards will serve as a trigger for abatement action by potential source(s) of the air pollution.

These emission limitation standards will be incorporated into legal rules established under the Environmental Management Act, 2000.

The development of the standards was guided by the following principles – that the standards should be feasible, practical and effective, bearing in mind technological, legal, economical, and social factors, and be enforceable, flexible and evolutionary in nature.

5.2.3 Measures to Encourage Compliance with Standards

Strategies must be implemented to “encourage” compliance with prescribed Stack Emission Standards and Ambient Air Quality Standards. The following approaches recommended by WHO (1999) offer various benefits towards industry compliance with emission controls:

(a) command and control
(b) economic instruments
(c) co-regulation
(d) self-regulation.

5.2.3.1 “Command and Control” Measures

As stated in the National Environmental Policy, Government’s approach to environmental management is predicated on the “command and control” approach, in which pollution control will be enforced through a system of permits or licences which will set pollution limits or performance standards for air, water, waste and hazardous substances. Permits may include environmental monitoring and reporting requirements. (Businesses with impacts too insignificant to justify regular monitoring may simply be required to follow codes of good procedure.)

Hence, the “command and control” measure will form a major part of the strategy for control of air pollution from industrial sources. In accordance with the Environmental Management Act (2000), industry will be required to comply with the established standards for air pollution control and with procedures and other requirements with respect to relevant air pollution permits or licences. These will constitute “environmental requirements” and compliance with the specified requirements will be checked by government inspectors.

In addition, new developments or major changes to existing sources that may significantly impact the environment (including emissions of air pollution), will be required to obtain a Certificate of Environmental Clearance, and for certain designated activities, an Environmental Impact Assessment (EIA) may be required to be performed.

The “command and control” approach is well suited for application in Trinidad and Tobago as the process of “commanding” i.e. specifying the requirements for emission limits, permits and monitoring, is transparent and provides a degree of certainty to industry. Also, the “control” aspect is based on the “polluter pays” principle and instils public confidence in the system.

The “command and control” system also poses several drawbacks. It is considered to be time-consuming to implement, expensive, rigid and legalistic. These systems often focus on end-of-pipe solutions instead of more comprehensive pollution prevention approaches. While it may establish a minimum condition, the system, by itself, provides no incentive to minimise emissions.

Many of these shortcomings of the traditional “command and control” approach will be overcome in the overall programme for management of air pollution control rules. In any event the experience of other countries suggests that “command and control” measures are complementary to and a necessary prerequisite for more evolved compliance programmes.

5.2.3.2 Economic Instruments

Section 34 of the Environmental Management Act, 2000 empowers the Environmental Management Authority to develop, promote and implement appropriate incentive programmes which encourage the voluntary use of effective environmental management systems and the achievement of improvements in environmental quality. Further, with the approval of the Minister, the Authority may impose pollution charges or user fees to encourage the protection and conservation of the environment.

As part of its national strategy, the EMA should investigate the use of these instruments in controlling air emissions in Trinidad and Tobago. Important factors to be considered in determining the feasibility and type of economic instruments to be used include:

(a) the sources of air pollution, and their respective location, size and quantity of emissions, and associated risk to human health and the environment;

(b) the longevity of the particular sources;

(c) the state of development of the local economic market;

(d) the mechanism and resources required to administer such a system of economic incentives.

Reversing the current prices of leaded and unleaded gasoline is an example of an effective economic incentive strategy that will immediately produce the desired results of significantly phasing out the use of leaded gasoline.

5.2.3.3 Co-regulation

As mentioned in Chapter 4, Government's policy emphasises the promotion of a co-operative environmental management approach between Government, industry and interested stakeholders.

In the "co-regulation" approach, Government prescribes environmental rules and guidelines, while compliance with the legal requirements is conducted in a collaborative manner by industry and the Government. The rules specify the air pollutants to be monitored (stack as well as ambient), the sampling protocols, monitoring requirements, record-keeping and reporting requirements. The responsibility lies with the industrial facility to conduct the required monitoring of emissions and air quality, and to report accordingly to the regulatory authority. The Authority will then develop national registers of air emissions inventories.

As part of its National Strategy for Air Pollution Control, the EMA will develop a system of co-regulation for emissions control. Because of the resources required (skills, finance, etc.), the system of co-regulation is especially well suited for application to large industrial facilities (treated individually or as an industry group), that are significant sources of air pollution. The benefits offered by such an approach include cost effectiveness and partnership with industry.

5.2.3.4 Self-regulation

In the self-regulation approach to emission control, industry groups impose their own environmental guidelines and system of environmental audits to monitor compliance.

The EMA plans to promote the use of the self-regulation approach by industries, in developing Environmental Management Systems (such as the ISO 14000 type), which specify requirements that go beyond compliance with environmental laws. In this way, the EMA will be encouraging overall company-wide environmental management.

5.2.4 Strategies for Control of Air Pollution from the "Small And Micro" Sector

5.2.4.1 General

Analysis of the EMA's database of complaints revealed that 98 percent was about small- and micro- businesses engaged in activities such as light manufacturing and material processing, commercial trading, food processing, and various trades such as automotive body repair and mechanics, wood working. This sector is contrasted with large, heavy industries, such as the petrochemical plants at the Point Lisas Industrial Estate.

In general terms, these small and micro businesses possess the following characteristics:

(a) they are small scale operations, usually owner operated and controlled, and are not classified as "foreign exchange earners";

(b) owners and employees live in the vicinity of the place of business;

(c) the business place is not located in an industrial estate or commercial district, is located in close proximity to residences and is usually serviced by general municipal garbage collection and disposal services;

(d) the business usually has an informal organisation, in terms of staff responsibilities, education and training requirements, etc.

(e) some of the businesses engaged in skilled trade activity serve as an initial training/working place for young tradespeople (mechanics, automotive body straighteners, woodworkers, etc.).

In light of the potential environmental pollution that can be presented by this sector, as well as the inherent characteristics, strategies with the following attributes have been devised to control air pollution from this sector:

(i) the strategy must be effective in controlling environmental pollution as a whole, with emphasis on source reduction, at a reasonable cost;

(ii) the pollution control strategy must be practical to implement from the perspective of the business owner, and be practical to enforce from the perspective of the regulatory authority. Enforcement must be based on simple and objective criteria and amenable to rapid response, using available human resources.

5.2.4.2 Rules for the Control of Pollution from Specific Industries

In accordance with section 26 (l) of the Environmental Management Act, 2000, the EMA plans to develop rules for the design, construction, operation, maintenance and monitoring of facilities or processes for the control of pollution and the handling of wastes. Based on the analysis of the EMA’s complaints database, the following industries are of high priority: automotive body repair and mechanics, woodworking, service stations, food preparation establishments, use of paints, solvents and other chemicals.

These Rules should specify effective plant layout, processes, equipment and technology for the control of pollution into all media, and make compliance legally mandatory.

The primary benefit of this approach over the establishment of specific standards for pollutant levels is the focus on the cause of the environmental problem, rather than on the pollutant levels. This approach also offers ease of enforcement, the facility for a rapid response to environmental complaints, and keeps the attention of the business owner/operator on environmental performance through mandatory periodic maintenance of equipment.

5.2.4.3 Codes of Good Environmental Practice

The Rules mentioned above could be expanded into "Codes of Good Environmental Practice" for specific industrial activities. These codes will be more extensive than the Rules, and specify, among other requirements, procedures, processes, equipment and technology (process as well as pollution control) that will be effective in controlling environmental pollution at a reasonable cost. These codes should be based on an integrated approach (multimedia management) to pollution prevention, and be amenable to independent auditing.

The codes will define the objective criteria for assessing good environmental practice by the respective industry, and can be utilised for second-party and third-party auditing.

5.2.4.4 Incentive Programmes to Encourage Environmental Probity

Appropriate incentive programmes to encourage voluntary compliance with good environmental practice should be developed, promoted and implemented. One such programme may focus on compliance with the "Codes of Good Environmental Practice". Another programme may focus on overall environmental management, and for this, environmental management systems such as the ISO 14000 type would serve as the objective criteria.

The incentive programmes may include: environmental certification by the EMA or TTBS, and national recognition through environmental awards.

5.2.4.5 Technical Education and Training

Pollution control in the industrial activities conducted by small and micro businesses in this sector can be readily effected through technological and other means. In this regard, the EMA should work closely with all technical training institutions to have incorporated into the respective curricula, programmes on the health and environmental effects of the industrial activity and the technological and other means for minimising such effects.

5.2.4.6 Public Awareness Programmes

Awareness programmes to educate the public on the adverse health and environmental effects posed by various industrial activities, and the action that can be legally taken to abate such activities, should be designed and implemented. These programmes should be disseminated through the mass media as well as through community and trade association meetings.

For maximum benefit, these public awareness programmes should be developed and implemented in conjunction with other critical groups such as: community groups, municipal and regional corporations, religious organisations, Ministry of Education and other relevant Ministries.

Communities will serve as an invaluable ally in encouraging compliance with good environmental practice and hence curbing environmental pollution.

5.2.4.7 Provision of Garbage and Other Waste Disposal Facilities

Primarily because of convenience and cost, many small businesses prefer to openly burn their garbage. As part of the overall national management plan for solid and hazardous waste, facilities should be provided for the garbage and other waste disposal facilities.

5.2.4.8 Siting and Location

Existing legal requirements controlling physical land use should be enforced to ensure that business places that may contribute to air pollution are not located in residential areas, in contravention of the law.

5.2.4.9 Research

The EMA should work with the University of the West Indies, to effect research into appropriate, effective and low-cost air pollution prevention and abatement measures (including plant layout) for small and micro businesses engaged in activities such as: automotive body repair and mechanics, woodworking, and food preparation.

5.2.4.10 Influence Key Relevant Institutional Decision-makers

The EMA should work with key institutional decision-makers in both the private and public sector, to emphasise the importance of good environmental performance among their clients. In particular, dialogue should be held to influence decision-makers of organisations such as financial institutions and insurance companies, to include demonstration of sound environmental performance in their approval criteria for granting financing in the case of financial institutions, or for listing as an approved repair garage in the case of automobile insurance companies. This performance may be evidenced by no significant adverse environmental effects, or, by use of clean technologies.

5.3 Strategies for Control of Air Pollution from Mobile Sources (The Transport Sector)

5.3.1 Vehicle Targeted Measures

As mentioned in Chapter 3, the transportation sector is the most significant source of GHGs. Many of the following strategies will therefore not only minimise and control emissions of criteria pollutants and toxics but also reduce the generation of GHGs.

5.3.1.1 Exhaust Emission Standards for Vehicles

Standards that are legally enforceable are being established by the TTBS for the exhaust emissions of the various classes of motor vehicles in Trinidad and Tobago, such as light motor vehicles and heavy motor vehicles. These standards will establish maximum permissible limits for key parameters of the exhaust of motor vehicles according to the fuel type of the vehicle engine (i.e. gasoline, diesel, compressed natural gas (CNG), other fuel). For gasoline engines and CNG engines, these key parameters should include: carbon monoxide, hydrocarbon, while for diesel engines, the key parameters should include opacity of the exhaust emissions.

The standards established should be effective in controlling air pollution from motor vehicles thus reducing the risk to human health and the environment, while at the same time they should be practical, technically and economically feasible and enforceable.

It is envisaged that the Standards when completed will be incorporated in Regulations under the Motor Vehicles and Road Traffic Act, Chapter 48:50. This legislation will specify appropriate penalties for non-compliance with the specified limits.

5.3.1.2 Inspection of New Vehicles

All new motor vehicles are required to be inspected at the Licensing Office, before registration. The current inspection checklist should be expanded to include checks of the exhaust emissions (using gas analysers) against the numerical limits for key parameters contained in the National Standard on Exhaust Emissions from Motor Vehicles. This programme of inspection before registration will set the foundation for ensuring that all new vehicles comply at the outset with the established exhaust emission standards.

Vehicles whose exhaust emissions do not comply should not be registered until the necessary corrective action has been taken, the exhaust emissions re-analysed and found to be in compliance.

5.3.1.3 "Inspection And Maintenance System" for <u>In-use</u> Motor Vehicles Over a Specified Age

Under the "Testing of Private Vehicles" amendment to Regulations under the Motor Vehicles and Road Traffic Act Chapter 48:50, all private motor vehicles that are five or more years old, are required to be inspected at approved "vehicle testing stations". This inspection currently examines all the automotive systems, including the following, which are related to the exhaust emissions: engine checks, and undercarriage checks of the exhaust system (noise, corrosion, length).

When the Exhaust Emission Standards are incorporated into law, the inspection of in-use vehicles should be expanded to include inspection of the exhaust emissions using exhaust gas analysers. Only vehicles that comply with the standards should be allowed for use in the country.

5.3.1.4 System of Road Checks on Vehicles

As stated in section 4.1, smoke and visible vapour emitted from motor vehicles are controlled under the “Visible Vapour Rule”. This can be enforced through road checks, and stopping vehicles that appear to emit excessive amounts of smoke and other visible vapour, as visually determined by the enforcing officer. These road checks should focus on grossly polluting vehicles.

The system should be further developed to de-register vehicles if they are found in non-compliance with the "Visible Vapour Rule" and the relevant exhaust emission standards on more than a specified number of occasions within a specified time frame.

When a driver has been charged with an offence under the “Visible Vapour Rule”, the enforcement officers should consult the Transport Commissioner so that a “call-in” notice can be despatched. The vehicle can then be tested again, and if the exhaust emissions are not in compliance with the National Standards, the vehicle’s registration may then be suspended or even cancelled.

Vehicle road checks of this nature are easily enforceable and supplement the “Inspection and Maintenance Programmes” described in section 5.3.1.3. Also, because the time and place of these inspections cannot be predicted, they are difficult to defeat through tampering of vehicle components that affect exhaust emissions, or temporary installation of such components during planned inspection and maintenance visits. Nevertheless, in the scheduling of the road checks, the inconvenience posed to drivers and other users of the roads during these occasions should be borne in mind by the enforcement officers.

5.3.1.5 Differential Vehicle Taxes, Registration Fees and Other Fees

The vehicle registration fee or taxing scheme can be designed so that it influences prospective purchasers of new vehicles to buy fuel-efficient and low-polluting vehicles, rather than energy-inefficient vehicles that are in bare compliance with the emission standards. This goal can be achieved by the development of a system of differential vehicle taxation rates, and registration or other fees; i.e. the registration (or other) fee or tax on the vehicle varies according to how low its exhaust emissions are compared with the Exhaust Emission Standards. This system may bring the most environmental benefits when applied to diesel-fuelled, heavy vehicles.

The differential vehicle taxation rates and registration fees scheme can be part of a vehicle replacement programme aimed at taking old, polluting vehicles out of circulation.

The fees and taxes structure should encourage owners to replace their old (15 years and older) polluting vehicles; for example, by providing an increasing margin of rebate off the tax or fees for a new vehicle based on the age of the (old) vehicle being “retired”. Other incentives to encourage voluntary replacement or scrapping of vehicles should be investigated.

5.3.1.6 Vehicle retrofit programmes

Data from the Licensing Office indicates that approximately 60 pecent of the total registered vehicular fleet in Trinidad and Tobago is over 10 years of age. Many of these vehicles were not manufactured with emission controls. Retrofit programmes should be investigated to bring in-use vehicles manufactured without emission controls in compliance with emission standards.

Retrofitting programmes are generally targeted at polluting, high-use vehicles such as diesel-fuelled, heavy commercial-use vehicles. Retrofitting may take different forms including engine work, installing pollution control components, or changing fuel systems to burn cleaner fuels, for example, converting to compressed natural gas.

The feasibility of implementing vehicle retrofit programmes in the country, targeted at heavy-use commercial vehicles, should be investigated. Consideration should also be given to the use of appropriate incentives to encourage voluntary retrofitting.

5.3.2 Fuel Targeted Measures

5.3.2.1 Legally Enforceable National Standards for Fuel

The Trinidad and Tobago Bureau of Standards has established national standards prescribing requirements for the quality of unleaded gasoline, leaded gasoline and automotive diesel fuel. (These standards have compulsory status under the Standards Act). These standards were developed after consideration of not only performance characteristics, but also environmental concerns.

All automotive fuel sold to the public in Trinidad and Tobago is produced by the Petroleum Company of Trinidad and Tobago Ltd. (Petrotrin) and distributed by the National Petroleum Marketing Company Ltd.

The EMA has received numerous claims by motorists, charged under the Visible Vapour Rule, that the quality of the diesel fuel is the cause of the violation. The above-mentioned National Standards will serve as the basis for assessing the quality of the fuel, and in this regard, the EMA should co-ordinate with the relevant regulatory and testing agencies on the implementation of a programme to continuously monitor the quality of diesel fuel supplied for local use. The monitoring programme can include random sampling and inspection, as well as the maintenance of appropriate quality assurance reports relating to batches of fuel sold.

5.3.2.2 Phase-out of Lead in Gasoline

The major source of lead in ambient air is the lead used in leaded gasoline for use in spark ignition combustion engines. Available data indicate that more leaded gasoline than unleaded gasoline is sold in Trinidad and Tobago.

Hence, the single most effective programme for the reduction of lead in ambient air is the phase-out of lead in gasoline, conducted within a broader integrated air pollution management plan.

Under the project of the UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) for the "Elimination of Lead in Gasoline in Latin America and the Caribbean", Trinidad and Tobago is reported to be committed to the phase-out of lead in gasoline by the year 2002.

5.3.2.3 Promotion of the Use of Cleaner Fuels

Programmes should be implemented to voluntarily encourage the use of cleaner fuels such as unleaded gasoline, and compressed natural gas.

Natural gas, which contains predominantly methane (95 to 99 percent) with the balance made up by other gases such as ethane and propane, is recognised as one of the cleaner combusting fuels and hence an attractive fuel for motor vehicles in terms of non-polluting exhaust emissions. However, many practical difficulties have been advanced against the use of this fuel such as: location and number of CNG re-fuelling stations, time taken to re-fuel, low power of CNG fuelled vehicles. A study to quantify in terms of pollution reduction and energy consumption should be conducted to justify Government's investment in the provision of facilities to alleviate these factors.

The EMA should work with other key players in the introduction of cleaner alternative fuels in Trinidad and Tobago.

5.3.3 Transport Management Measures

Increased ownership of private vehicles as well as increased industrialisation and construction which increase the demand for public transport vehicles and heavy vehicles, all contribute to increased traffic congestion. The slow movement of motor vehicles on congested roads results in higher fuel consumption and increased rates of pollutant emissions. Traffic congestion also burdens productivity because of the cost of time lost during travel.

The feasibility of implementing various transport management measures in urban centres and along major roadways should be considered. Also, local factors such as the physical infrastructure in the area, characteristics of the transport system, layout of the urban area, and the transport demand and causes for it (such as presence of trade and business places) should be included in the study.

The following are potentially feasible transport management measures that the EMA plans to explore, for implementation with the relevant agencies.

5.3.3.1 Restrictions on On-street Parking and Street Trading

Traffic flows in heavily congested streets can be improved by imposing on-street parking restrictions, which can be implemented at all times, during the day-time, or only at peak hours. These restrictions require installation of signs and a firm enforcement effort through fining, wheel clamping, and towing. Restrictions of parking on streets should also be considered to ease traffic congestion

Street trading on crowded streets adversely affects traffic flow, and hence controls should be introduced to limit street trading. Like all transport management measures, due consideration needs to be taken of the particular nature of the locality where the measure is to be implemented.

5.3.3.2 Improvement of Road Infrastructure and Network

Poor physical condition of roads requires vehicles to slow down and this can contribute significantly to congestion during certain times of day. An expanded road network will provide alternative routes to various key locations, again contributing to reduced traffic congestion. Traffic flow can be improved through such modifications to existing infrastructure as widening of roads to provide turning lanes, construction of short road links at critical locations and building footbridges and walk-overs for pedestrians.

5.3.3.3 Land Use Planning and Controls; Facilities Planning

Land use planning is a critical strategy in controlling transport-related air pollution, through the establishment of patterns for land development and specific areas for residential, educational, commercial, industrial, and recreational facilities. Planning of this nature controls future population densities in these areas that affect the demand for transport services and hence the associated air pollution. By bringing schools, offices, shops, and recreational facilities closer to residential areas, the amount of travel for work and other activities is reduced.

The location of business places including government offices out of city centres is another option that can be considered in attempting to alleviate traffic congestion and hence vehicular air pollution.

5.3.3.4 Improvement of public transport services

Since congestion-induced air pollution in urban centres is mostly attributed to the growing number of private cars, the improvement of public transport services can be a significant control measure. Although public transport vehicles also emit air pollutants, their contribution to pollution per person transported can be much less than that of private cars.

Improvement of public transport services should focus on means of making the service an attractive option so as to convince vehicle owners to use it. Availability of the service, physical condition of the vehicle, quality of the service, and cost are critical factors.

5.3.3.5 Other transport-related measures

The EMA should include in public education campaigns on reduction of air pollution, promotion of staggered work hours among major employers (including the Government) so as to assist in reducing the influx and outflow of people into the city centre as they proceed to and return from work.

5.3.4 Supporting Research Measures

5.3.4.1 Vehicle Retrofit Technologies

The EMA should work with the University of the West Indies to effect research into the development of practical, effective and low-cost technologies for retrofitting the more highly polluting motor vehicles to reduce exhaust emissions.

For example, one such technology that shows some promise for retrofitting diesel-fuelled urban buses consists of using a secondary filter, which supplements the conventional cartridge-filter. This technology is claimed to reduce the particulate matter emissions by about 50 percent and costs about US $500 (Onursal and Gautam 1997).

Replacing diesel-fuelled engines with CNG or LPG can also produce significant benefits in the commercial transportation sector.

5.3.4.2 Vehicle Carrying Capacity of the Nation-wide Road Network

Research should be conducted into the determination of the maximum number of motor vehicles that the nation-wide road network can sustain. This national quantity will be invaluable in establishing an advisory ceiling under which the total number of vehicles registered in Trinidad and Tobago consistent with the road system should be maintained. This measure will assist in relieving vehicle congestion in major urban areas, with the commensurate reduction in environmental pollution.

5.3.5 Control of Air Pollution from Other Mobile Sources

Air pollution also arises from other mobile sources such as the exhaust emissions of aircraft, and from the stacks of ships. Here, the EMA's strategy is one of working with the relevant regulatory agencies to develop controls under relevant existing legislation.

5.4 Ozone Depleting Substances

The action plan for Trinidad and Tobago and Phases I and II of the UNDP/EMA Institutional Strengthening Programme (ISP) have already defined priorities and strategies for the phase out of ODS. These include the following:

> **Refrigerant Management Plan**: About 75 R12 recovery units were distributed to trained and refrigeration service providers to collect used R12 for reprocessing at one of three recycling centres located in Trinidad.
>
> **Mobile Air Conditioning**: a similar project was implemented for automobile repair shops. Work is ongoing to improve the efficiency of both these efforts.

Halon Banking: Several existing fire suppressant systems utilise ozone-depleting halons. A bank is recommended to store halons that have been retired from use for other users who have replenishment needs. This project is being pursued in conjunction with other Caribbean countries for a regional banking system.

Restriction on imports: ODS and equipment that use ODS requires a licence before importation can proceed. This system, developed under Phase I of the ISP, will be further refined under Phase II.

While Trinidad and Tobago is not a major contributor to global ozone depletion, it must do its part in addressing this serious environmental threat. Moreover, consumers in Trinidad and Tobago may find themselves with obsolete air conditioning, refrigeration and fire suppressant equipment as global supply of these substances gets scarce.

5.5 Priorities for Action

As a high priority, National Ambient Air Quality Standards must be legally established and a national ambient air monitoring network developed. Ambient air monitoring fulfils a central role in national air quality management, as it provides the necessary sound scientific basis for the following: policy and strategy development, objective setting, measurement of compliance against set targets, and enforcement action.

Legal standards controlling air emissions from stacks of industrial sources must be established since heavy industry has great potential to contribute significantly to air pollution. Standards for controlling fugitive emissions must also be established.

To control air pollution from the small and micro business sector, legal controls for levels of opacity, particulate matter and odour will be most effective in abating the nuisance posed by air pollution from this sector. Legal rules for the control of pollution from specific industries and codes of good environmental practice should be developed to control the following high priority industries: automotive body repair and mechanics, woodworking, service stations, food preparation establishments use of paints, solvents and other chemicals.

The support of on-going public education programmes is critical for the achievement of the overall objectives of this National Strategy.

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