Communication

Atmospheric Pollution
Background, Present and Future work

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Introduction
The study of air pollution, its sources and its effects on human activity, as well as the transport and fate in the atmosphere of each component is today given considerable importance. Although two of the best known phenomena are global warming and ozone depletion, in fact these are only two facets of what is a very complex and incompletely known cycle.

An air pollutant may be any substance in the atmosphere which, at a high enough concentration, may be harmful to life or property. Such a pollutant may originate from natural or anthropogenic sources or both. Sources are many and varied. They include cars, smoke stacks and other industrial emissions as well as natural dust. Atmospheric conditions have a major effect upon the pollutants. Wind, temperature distribution, turbulence, depth of emission point, as well as the stability of the atmospheric conditions all play a part in the dispersal of pollutants.

Most commonly, pollutants harm life through their effects on the respiratory system. Vegetation may also be adversely affected. Buildings as well as metallic surfaces can easily be eroded by long term accumulation and concentration of various pollutants on their surfaces.

Description
Most of the air we breathe is composed of nitrogen and oxygen. About one percent is composed of naturally occurring constituents such as carbon dioxide and water vapour. A small part of this, however, is composed of pollutants including gases and particulate matter (suspended aerosols composed of solids and liquids).

Anthropogenic air pollution comes from both fixed and mobile sources. Mobile sources account for around 50% of such pollution. Natural sources include dust from farm fields and desert, smoke from forest fires and volcanic ash emitted into the troposphere and stratosphere. One can classify pollutants according to two broad categories: primary and secondary air pollutants.

Primary air pollutants enter the atmosphere directly from various sources and the five main ones are: carbon monoxide, hydrocarbons, particulate matter, sulphur dioxide and nitrogen oxides. Carbon monoxide which is a major pollutant in urban air is a product of incomplete combustion of fossil fuels. Apart from cigarette smoke the internal combustion engine is the principal source. This gas is extremely poisonous. The WHO specifies an upper limit of 10 ppb over an 8 hour average for human beings.Although stable it is relatively short lived because it is quickly oxidized to carbon dioxide by hydroxyl radicals.

Hydrocarbons (HCs) or volatile organic compounds (VOCs) are those composed of hydrogen and carbon. Methane is the most abundant and is an active greenhouse gas. Other volatile organics such as benzene and derivatives are highly carcinogenic. The major sources of all types of hydrocarbons are the natural decomposition of organic matter and the evaporation of gasoline from vehicles.

Particulate matter comprises solid particles or liquid droplets small enough to remain suspended in air. Such particles may be of a very complex chemical composition and include soot, smoke, dust, asbestos fibre and pesticide as well as metals (Hg, Fe, Cu, Pb). These particles are characterized by size. Particles larger than 10 microns settle out in less than a day while particles smaller than one micron remain suspended for weeks. High concentrations of particles containing sulphur and silica from volcanoes and deserts often reach the stratosphere and cause cooling of the earth's surface. Tropospheric particles cause human respiratory illness. Of particular interest are particles from diesel vehicles where these are strongly impregnated by highly carcinogenic aromatic compounds. This may be one of the important mechanisms giving rise to lung cancer in urban areas.

Most sulphur dioxide emissions come from the burning of fossil fuels containing sulphur. They cause acute respiratory problems and are an important source of acid rain. Most man-made emissions can be avoided by the use of low sulphur fuels and scrubbers.

Nitrogen oxides (NO_x) are formed mainly from nitrogen and oxygen during high temperature combustion of fuel in cars. This is another contributor to acid rain. The use of catalytic convertors in vehicles removes most of these emissions. It is thought that NO_x's contribute to heart and lung problems and may also be carcinogenic.

The second category of air pollutants comes from the chemical reactions between the above primary pollutants and other atmospheric constituents such as water vapour. These normally require the availability of sunlight. The result is photochemical smog. Smog is mainly composed of ozone (O_3), peroxyacetylnitrate (PAN) and other oxidants. Ozone formation is closely linked to weather conditions namely, high temperatures, low winds, intense radiation and low precipitation. All these conditions are prevalent in the Mediterranean and favour smog production, which averages 40 ppb as opposed to continental Europe at 15 ppb. HC's are necessary for the buildup of ozone in the atmosphere. In the absence of HC's the reaction cycle would not be interrupted and ozone would not accumulate except from natural sources and stratospheric mixing.

Ozone is naturally present in the stratosphere and its absorption of UV acts as a natural shield against high UV levels reaching the earth's surface. It is hazardous as an oxidant in smog where it contributes to inflammation in the lungs and increases the incidence of acute episodes of asthma and reduces heart and circulatory functions. It is also poisonous to plant life. Factors that encourage the formation of smog include: numerous sources of primary pollutants, inversions that inhibit turbulent mixing of air, little cloud cover permitting high UV intensity, light winds unable to disperse pollutants and terrain that allows accumulation of pollutants.

Ozone and NO_x pollution in the troposphere is widespread and is not confined merely to urban areas. It is possible that emissions from soil contribute substantially to NO_x pollution. This tropospheric NO_x concentration influences the concentration of oxidants such as OH and O_3.

Local Experimental Work

Many questions remain unanswered concerning the reasons why ozone concentrations continue to be high in both urban and rural areas and work at the University of Malta is part of a European incentive aimed at tracking the dispersion of such pollutants across Europe.

We have at present installed three data gathering points: at Giordan lighthouse in Gozo, at the University building in Xewkija, Gozo, and at the main University campus at Msida. At all three locations ozone values are recorded every ten seconds and later averaged to half hourly values. Recently, recordings of carbon monoxide also began at Giordan lighthouse. Meteorological parameters such as wind speed and direction, temperature and humidity and daily weather maps are also recorded to enable interpretation of the results at a later stage. These data are being used in climate model predictions. The base stations set up so far are capable of being expanded to monitor far more pollutants than at present and may also be used to study the dispersion of local emissions, which will thus help to suggest ways of minimizing them. This work is coordinated closely with that of the Department of the Environment. One of the major questions which needs to be addressed is that involving particulate pollution from diesel vehicles. This programme is expected to start as soon as the necessary equipment arrives.

It is perhaps also worth stating that the data at Giordan lighthouse show unexpected night-time ozone 'occurrences' which can only be explained by stratospheric mixing due to the land effect. It is planned to study this further by raising a tethered meteorological balloon to a height of one kilometre with instruments suspended below to record the vertical profile over the boundary layer. Such work has not yet been performed in the Central Mediterranean.

Major Air Pollution Issues

Global Warming

Carbon dioxide is an important greenhouse gas. It is present naturally, but it is also a major product of fossil fuel burning.

Numerical climate model predictions indicate that increased warming by greenhouse gases may add about one degree Celsius to the global mean temperature by the year 2025 and three degrees within a hundred years. Although there is much uncertainty in the exact values quoted, warming appears inevitable with major long term consequences for life on Earth. Carbon dioxide is the most abundant greenhouse gas, but additional greenhouse gases are methane, nitrous oxide, CFC's (now being phased out) and ozone. All of these have been increasing substantially over the last few decades and the total contribution to global warming has been the subject of much detailed discussion. Some of the main questions which need to be resolved are: the effect on vegetation and plant growth rates, the rate of warming, the effect of this rate of warming on ocean levels, the effect of warming on cloud cover and aerosols, the change in rainfall patterns, the magnitude and distribution of temperature changes, the possible reduction of greenhouse gas emissions within the context of sustainable economic development, and the absolute accuracy of the numerical models, given that these are extremely complex.

Ozone Depletion

The depletion of ozone in the stratosphere as opposed to the troposphere is another global environmental concern related to pollution. Stratospheric ozone absorbs ultraviolet light and thus performs an essential function in reducing this to a level safe for life on earth. Removal of this stratospheric layer of ozone would have serious consequences for many forms of life on the planet. In the last decade major reductions of this ozone concentration have been observed and it is now fairly clear that this is due to man-made CFC's and NO_x's.

Conclusion

The subject of atmospheric pollution and its long and short term effects is an extremely complex one. This article has presented an oversimplified view in order to tempt more of the local scientific community to take an active interest in the subject and to participate in the forthcoming seminar on the subject on the 9th April 1999. The keynote speaker is Professor Paul Crutzen a Nobel Prize Laureate in atmospheric chemistry. The programmme is presented below. All those interested are encouraged to attend.

Atmospheric Pollution Seminar Program

Friday 9th. April 1999. L-Imgarr Hotel, Gozo

Morning Session Chairman: Dr R Ellul

9.00 AM	Opening,	Hon Dr Francis Zammit Dimech, Hon Mrs Giovanna Debono, Prof R Ellul Micallef, Dr Gerhard Kunz	Minister for the Environment Minister for Gozo Rector Ambassador, FRG

9.20 AM	Prof. P Crutzen,	MPI Mainz,	'Ozone in Atmospheric Chemistry'
10.00 AM	Dr H Gusten,	IMK Karlsruhe,	'Urban Air Pollution'
10.30 AM	------------ Coffee break -------------- 10.45 AM		
10.45 AM	Mr M Nolle,	Univ. of Malta	'Background Measurements'
11.05 AM	Dr A Micallef,	Univ. of Malta	'Urban Hot-Spots Particle Modeling'
11.25 AM	Dr D Soderman	Ericе/FIS	'Modeling of Saharan Dust Transport'
11.45 AM	Dr A Vella,	Univ. of Malta	'Particulate Air Pollution and certain Health Problems in Malta'
12.05 PM	Mr D Bugeja	EPD	'Air Pollution Programmes'
12.25 PM	------------ -Lunch ---------------- 2.00 PM		

Afternoon Session Chairman: Dr C Sammut

2.00 PM	Prof A Vella,	Univ. of Malta	'Review of Studies on Pollution in Urban Malta'
2.20 PM	Mr M Spiteri,	EMDP	'Non Spatial Environmental Planning'
2.40 PM	Dr L Korugic,	Univ. of Malta	'Environmental Effects of Plastics and Rubbers'
3.00 PM	Mr J Sacco	Univ. of Malta	'Relationship between Atmospheric and Blood Lead Concentrations'
3.20 PM	Ms M Attard,	Univ. of Malta	'Role of Transport in Urban Environments'
3.45 PM	------------ Coffee Break ------------- 4.00 PM		
4.00 PM	Dr A Micallef,	Univ. of Malta	'FUELFAC for Mapping Fuel Consumption on Roads'
4.30 PM	Prof E Mallia,	Univ. of Malta	'Alternative Electric Vehicles'

5.00 PM Discussion and Closing, Chairman: Dr R Ellul