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DOMINANT ATMOSPHERIC POLLUTANTS IN MALAYSIA

S.C. POH AND C.P. TSO
Faculty of Engineering
University of Malaya
Kuala Lumpur 22-11
Malaysia

ABSTRACT

This article presents a brief summary of the various types of pollutants that are contributing to the problem of air pollution in Malaysia, as well as the mention of some episodes in air pollution that have given rise to concern here.

INTRODUCTION

Environmental problems confront every developing nation and Malaysia is no exception. Among the most insidious of these problems faced by Malaysia is that of air pollution. Much of the pollutants that are being added into the atmosphere come from vehicle exhausts and factory emissions. Comparisons of air pollutant emissions from fuel combustion between 1975 and 1983 are shown in Figure 1. Generally speaking air pollution problems are mainly confined to limited regions, where there is rapid urbanization and concentrated industrialization. In Malaysia, the best example of such a region of rapid growth is the Kuala Lumpur – Petaling Jaya industrial region. This region is part of a more extensive region comprising Kelang, Subang Jaya and Shah Alam, as shown in Figure 2. There are also problems at isolated locations, for example, air pollution due to sandblasting at quarries at Padang Rengas in Perak and Kampung Bambun Jabi in Johor (Sahabat Alam Malaysia, 1983), pollution by small industries using inefficient combustion techniques such as open burning of refuse at sawmills. Some of the major sources of primary pollutants are shown in Figure 3. The following is a summary of the various types of pollutants.

CARBON MONOXIDE

Carbon Monoxide (CO) may be formed through one of 3 ways, namely incomplete combustion, high temperature reaction between carbon dioxide and carbon-containing materials and dissociation of carbon dioxide at high temperatures. Some of the biological and geophysical sources include volcanic action, natural gas emission and seedling germination and seedling growth. The most important man-made source of this pollutant is the petrol-driven vehicle. This is because of incomplete combustion, owing either or both to insufficient oxygen during the combustion process or the duration of combustion being too short.

YEAR	SULPHUR DIOXIDE	CARBON MONOXIDE	NITROGEN OXIDE	HYDRO- CARBON	PARTICLE	TOTAL
1975	207206 (31.3) [†]	240976 (51.9)	50382 (10.8)	27885 (6.0)	12256 (2.6)	464545
1983	133046 (28.6)	322394 (48.7)	74144 (11.2)	39720 (6.0)	18536 (2.8)	662000
PERCENTAGE INCREASE	55.7	33.8	47.2	42.4	51.2	42.5

[†] FIGURES IN BRACKETS REPRESENT PERCENTAGE VALUES

Figure 1: Air pollutant emissions (metric tons) from fuel combustion

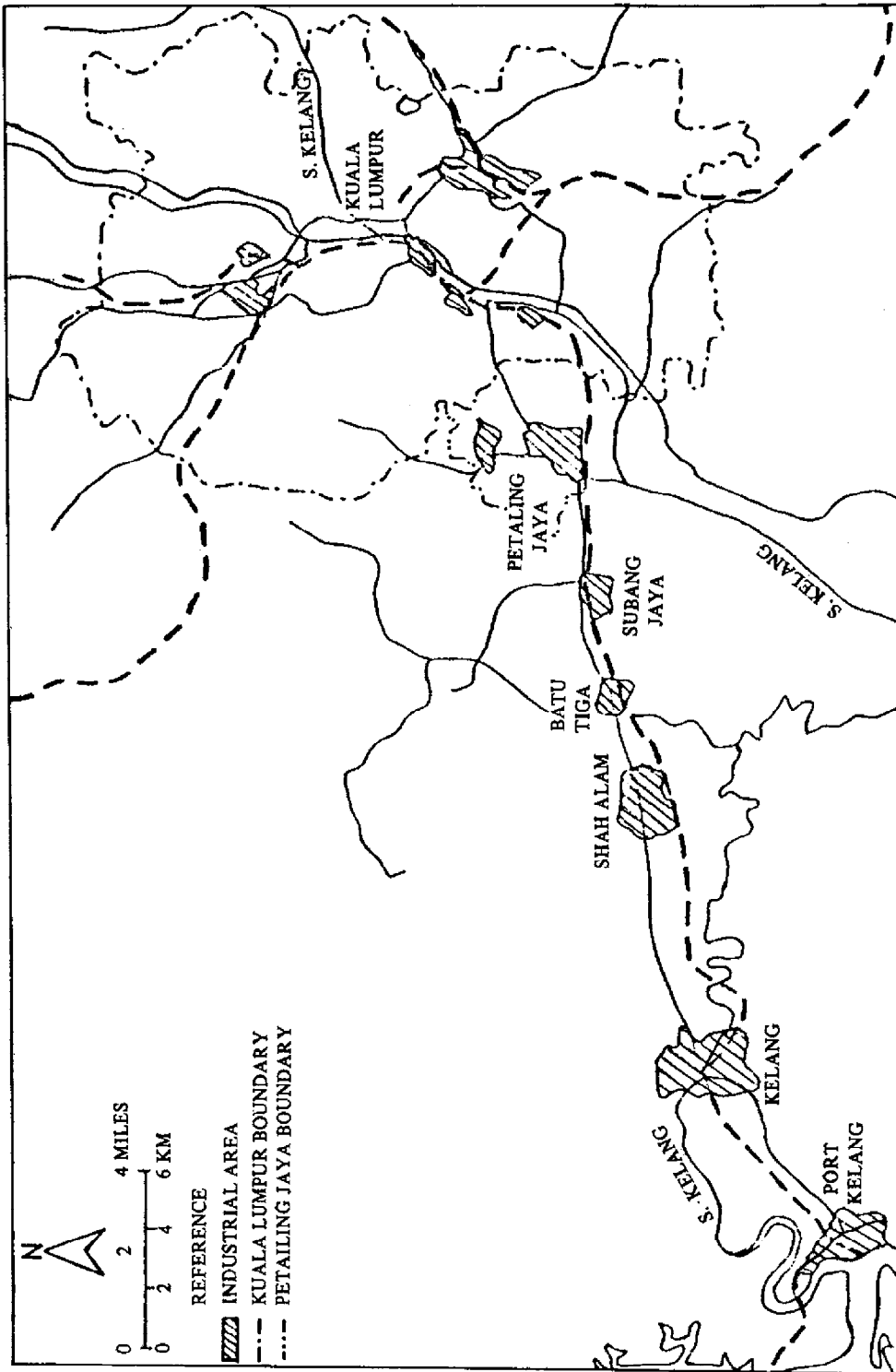


Figure 2: Industrial areas in the Kelang Valley (Sham Sani, 1981)

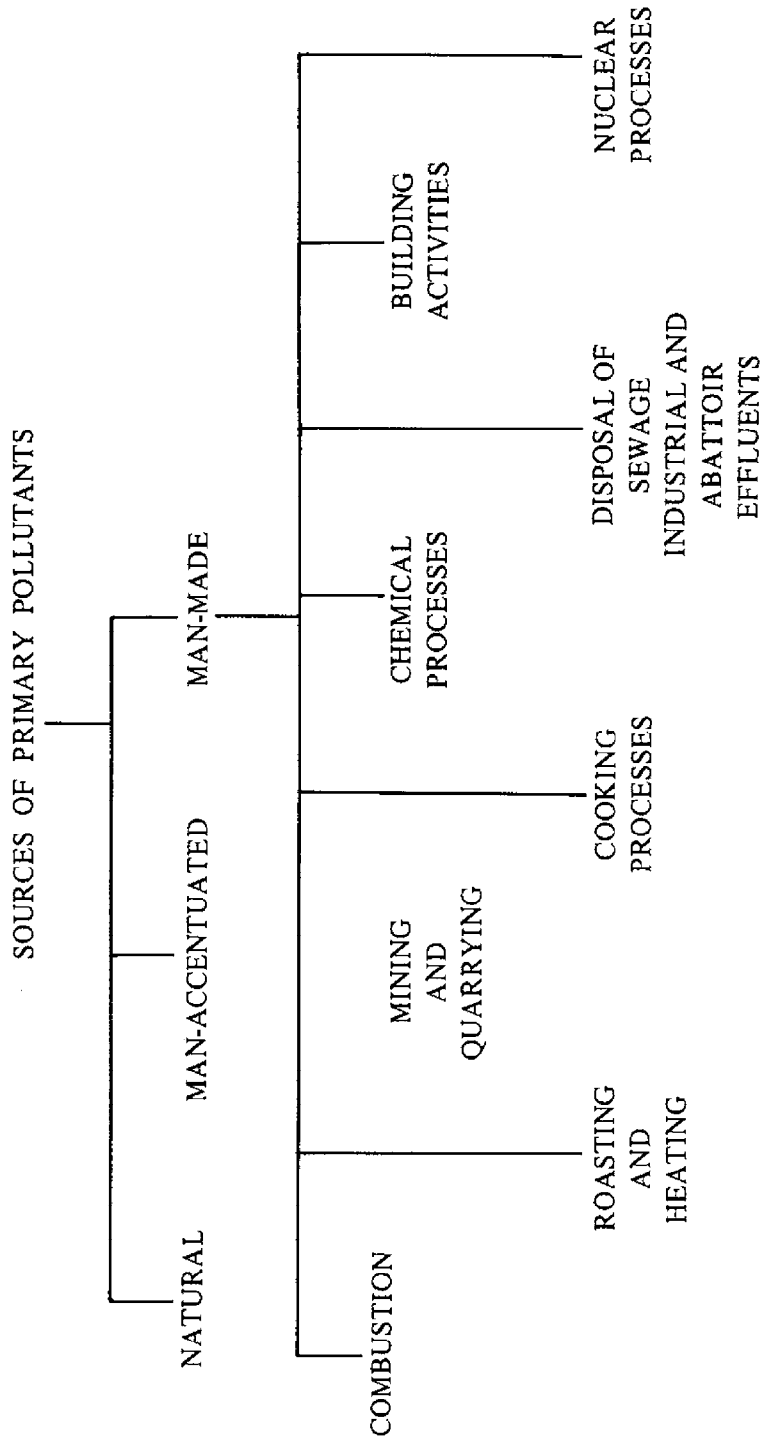


Figure 3: Some major sources of primary pollutants (Sham Sani, 1979)

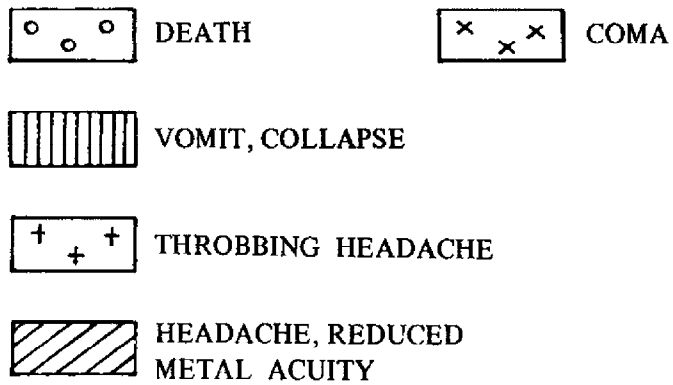
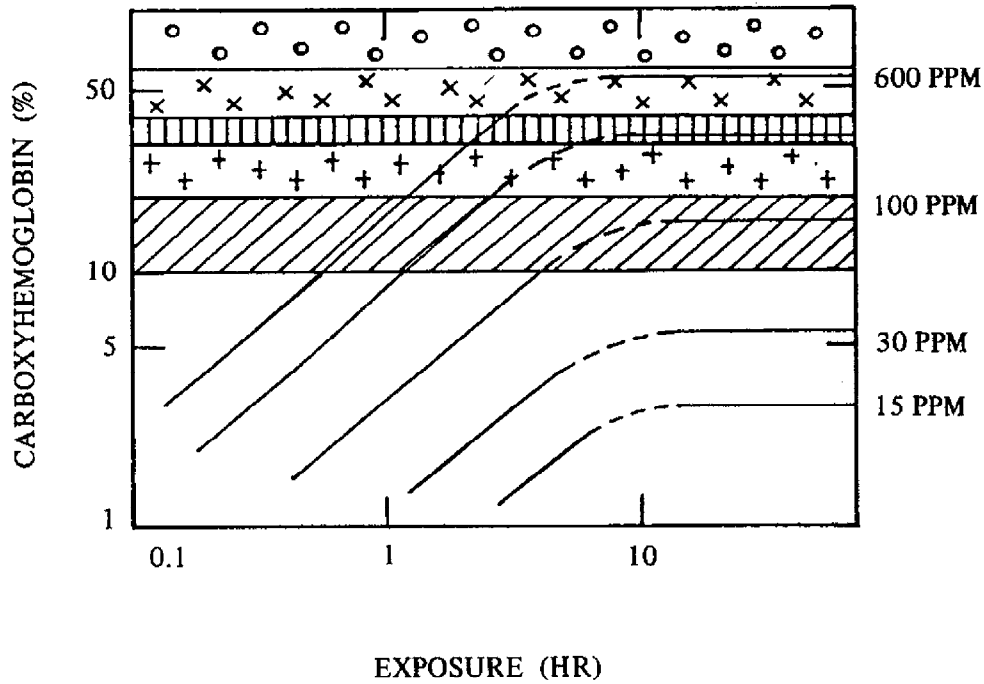


Figure 4: Physiological response of normally healthy adults at light activity to various carbon monoxide exposures (Williamson, 1973)

There are at present more than 2.6 million motor vehicles in Peninsular Malaysia with about half a million concentrated in the Kelang Valley. The valley has been shown to possess a relatively low ventilation volume (Sham Sani, 1979) and this may lead to a serious build-up of CO pollutant. The CO that is introduced into the atmosphere is quite stable, and is removed through a slow conversion process to CO₂. The mean lifetime is about 3 to 5 months. Microorganisms in the soil also contribute to the removal of CO.

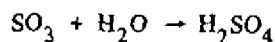
Perhaps the most significant effect of CO is its impairment of the functioning of the central nervous system. This is due to a decrease in the oxygen-carrying capacity of the blood owing to the formation of carboxyhaemoglobin (COHb), a compound of CO and the haemoglobin in the blood (Lynn, 1976). The level of COHb in the blood depends upon the amount of CO in the atmosphere and the duration of exposure. The type of activity the subject is engaged in affects the duration at which equilibrium level is reached (Williamson, 1973; Lynn, 1976). The effects of CO exposure on humans are shown in Figure 4.

The build-up of CO in town centers where there is high vehicular congestion may lead to reduced mental acuity on the part of the people residing or working around these places. The Division of Environment has carried out kerbside monitoring of CO level along some major roads in Kuala Lumpur in 1981 and found that the 8-hour average values ranged from 4.6 p.p.m. to 18 p.p.m. Levels of as high as 50 p.p.m. were also recorded compared to the World Health Organisation's recommended long term goal of 9.0 p.p.m. (Division of Environment, 1982).

SULPHUR OXIDES AND ACID RAIN

Both sulphur dioxide (SO₂) and sulphur trioxide (SO₃) are formed from the combustion of sulphur-bearing fuels. They are collectively designated as SO_x. The greatest contribution of SO_x comes from the burning of fossil fuels such as coal and fuel oil in stationary sources. In Malaysia, 52% of the total SO_x emitted annually comes from industries followed by power stations with 46%.

The SO_x emitted into the atmosphere together with oxides of nitrogen (NO_x) that is produced by high temperature combustion of coal, oil, gas or gasoline in power plants and internal combustion engines react with rain water to result in the phenomenon known as acid rain. A simplified mechanism for the formation of droplets of sulphuric acid (H₂SO₄) due to the presence of SO₃ in the air can be represented by the reaction:



Acid precipitation has been monitored by the Malaysian Meteorological Service (MMS) since 1976. The monitoring stations in the Kelang Valley are located at Petaling Jaya, Port Kelang, Shah Alam, Serdang, Jalan Raja Chulan and Ulu Kelang in Kuala Lumpur. Rain samples are collected on a daily basis and set to the Department of Chemistry for pH determination. The pH level runs from 14 (alkaline) to 1 (acidic), the neutrality mark being pH 7. Natural rain water should have a pH of about 5.6. On this scale, a change of one unit indicates a tenfold increase.

Comparisons of readings have been made between stations at Petaling Jaya in the Kelang Valley and Tanah Rata at Cameron Highlands which is located 219 km north of Kuala Lumpur. Petaling Jaya represents the country's industrial district and the other a remote mountain resort. The findings give pH readings of about 4.5 in Petaling Jaya as compared with 5.4 for Tanah Rata. As emissions of SO_x is going to increase with greater industrialization, there is therefore a need for greater vigilance over this problem.

Sulphur dioxide affects materials such as paints, textile fibres, leather and paper largely in the form of sulphuric acid (Stern, 1977).

Acid rain has recently become a problem of global concern. It affects lakes, rivers and ponds, killing off everything from indigenous fish stocks to microscopic vegetation. It accelerates corrosion, resulting in the destruction of historical monuments and cultural treasures (Stern, 1977) Fig. 6. By contaminating public drinking water, it poses a substantial threat to human health. It has been described as "an insidious malaria of the biosphere".

LEAD

Airborne lead in urban centres is a hazardous pollutant, and comes mainly from the exhaust of petrol-driven vehicles. Lead is introduced into engines as tetraethyl lead to improve the smoothness of performance of high compression engines. The petrol used in Malaysia has one of the highest lead contents in the world – at 0.84 grams per liter (Sahabat Alam Malaysia, 1983).

A survey (NST Nov. 28, 1982) has been carried out by Lim Heng Huat and Domala Zakariya from the Department of Social and Preventive Medicine at the University of Malaya and Khoo Hoon Eng from the Universiti Kebangsaan Malaysia on the levels of lead in the blood and milk of expectant mothers in Kuala Lumpur and Kuala Langat. Their findings show that the mean lead level of 60 expectant mothers from Kuala Lumpur is $17.3 \mu\text{g}$ of lead per 100 ml of blood. The mean lead level for another group of 63 pregnant women from the rural district of Kuala Langat is $15.7 \mu\text{g}$ of lead per 100 ml of blood. The recommended safe level is between 30 to 35 μg of lead per 100 ml of blood. Research has shown that at $40 \mu\text{g}$ of lead per 100 ml of blood, damage could be done to a foetus or infant.

The mean lead level in the milk of 89 mothers from Kuala Lumpur is $0.0253 \mu\text{g}$ of lead per ml of milk, while that for 91 mothers from Kuala Langat is $0.0211 \mu\text{g}$ of lead per ml of milk. An urban new-born baby's estimated daily lead intake from mother's milk is $15.5 \mu\text{g}$, while that for a rural baby is $12.9 \mu\text{g}$. These figures are below the daily tolerable lead intake level for new-born babies recommended at $87 \mu\text{g}$.

The children, lead poisoning can impair learning ability and may result in lower I.Q., irritability and plain clumsiness. Symptoms of lead poisoning in the adult include fatigue, irritability, headaches and slowing of thought. Prolonged exposure may result in kidney disease, hypertension and permanent weakness in wrists and fingers.

Malaysia follows a guidelines on ambient lead standard which has been adopted by the U.S. – the lead level should not exceed $1.5 \mu\text{g}$ per m^3 of air over a period of 3 months. Anything beyond this level is considered a health hazard.

Air pollution due to lead is not only confined to urban centers but is also found in industries, especially those dealing with the manufacture of lead-acid batteries, electronics, paints and metal reclamation. A survey carried out by the Factories and Machinery Department of the Ministry of Labour shows that about 10,000 workers are affected by lead pollution (NST Sept. 11, 1983).

Plans are afoot to meet representatives from the Trade and Industry Ministry, Petronas and other oil companies about reducing the lead content in petrol. On the emission of lead from industrial sources, the Department of Environment has already set up guidelines for the State Governments on the creation of buffer zones between industrial and residential areas. These zones, which will be adopted when new factories are set up, will be between 200 to 300 m for light industries, and up to 3 km for heavy industries.

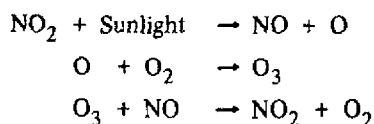
CONCENTRATION ppm	EFFECT
3 - 5	LEAST AMOUNT DETECTABLE BY ODOUR
8 - 12	LEAST AMOUNT CAUSING IMMEDIATE THROAT IRRITATION
20	LEAST AMOUNT CAUSING IMMEDIATE EYE IRRITATION
20	LEAST AMOUNT CAUSING IMMEDIATE COUGHING
20	MAXIMUM ALLOWABLE FOR PROLONGED EXPOSURE
50 - 100	MAXIMUM ALLOWANCE FOR SHORT (30 MIN) EXPOSURE
400 - 500	DANGEROUS FOR EVEN SHORT EXPOSURES

Figure 5 : Effects to SO₂ on humans (Stoker and Seager, 1972)

PHOTOCHEMICAL SMOG

Photochemical smog consists of a mixture of secondary pollutants, also known as "oxidants", which form in the atmosphere as a result of photochemical reactions between nitrogen oxides, hydrocarbons and sunlight. Two of the most harmful of these secondary pollutants are ozone and peroxyacetylnitrate. There is also a wide range of other organic products, especially peroxides and ketones (Stoker and Seager, 1972, Williamson, 1973).

Referring to Figure 6, nitrogen dioxide (NO_2) in the atmosphere, in the presence of sunlight, dissociates into nitric oxide (NO) and an oxygen atom (O). The oxygen atom reacts with the oxygen (O_2) in the atmosphere to form ozone (O_3). The ozone reacts with nitric oxide resulting in the formation of nitrogen dioxide and oxygen. The net effect is a rapid cycling of nitrogen dioxide. Ozone and nitric oxide are formed and destroyed in equal quantities. This cycle may be neatly represented by the following reactions:



The cycle is disrupted when hydrocarbons (RH) are present because of their ability to react with either the oxygen atom produced or the ozone produced. The most likely reaction is that between the oxygen atom and hydrocarbon and the result is a very reactive intermediate species, the hydrocarbon free radical (RO_2). The free radicals thus formed react rapidly with nitric oxide to produce nitrogen dioxide. The consequence of this is that with nitric oxide removed from the cycle, the normal mechanism for ozone removal – that is, through reacting with nitric oxide to form oxygen and nitrogen dioxide – is eliminated, and the concentration of ozone in the air rises. Besides this, the free radicals can react with oxygen and nitrogen dioxide to give peroxyacetylnitrates and with other hydrocarbon and oxygen species to produce additional undesirable compounds (Stoker and Seager, 1972). According to Sham Sani (1983) photochemical smog formation is possible to Kuala Lumpur because the basic ingredients oxides of nitrogen, hydrocarbons and abundant sunshine for its formation are available. Preliminary measurements of ozone in Kuala Lumpur showed a maximum level of 0.06 p.p.m. in the early afternoon. (Sham Sani, 1983).

The effects of photochemical smog on human health include headaches, irritation of the eyes and the mucous linings of the nose and throat. Other effects include damage to plants and vegetation and the deterioration of rubber products, textiles and fabrics.

PARTICULATES

Particulates are solid particles or liquid droplets small enough to remain suspended in the air. They represent a wide range in chemical composition and include a variety of substances in different forms, for example, smoke, grit, dust, ash, etc. The natural sources of airborne particulates include volcanic eruptions, bush fires and wind-blown dust.

The major sources of particular pollutants in Malaysia due to human activity include the burning of industrial wastes such as sawdust and rice husks, combustion of fossil fuels such as coal and oil, open burning of wastes at Municipal disposal sites, exhaust emissions from motor vehicles, road construction, burning of trees cleared for construction or replanting purposes, wearing of tyres and quarrying (Goh, 1983).

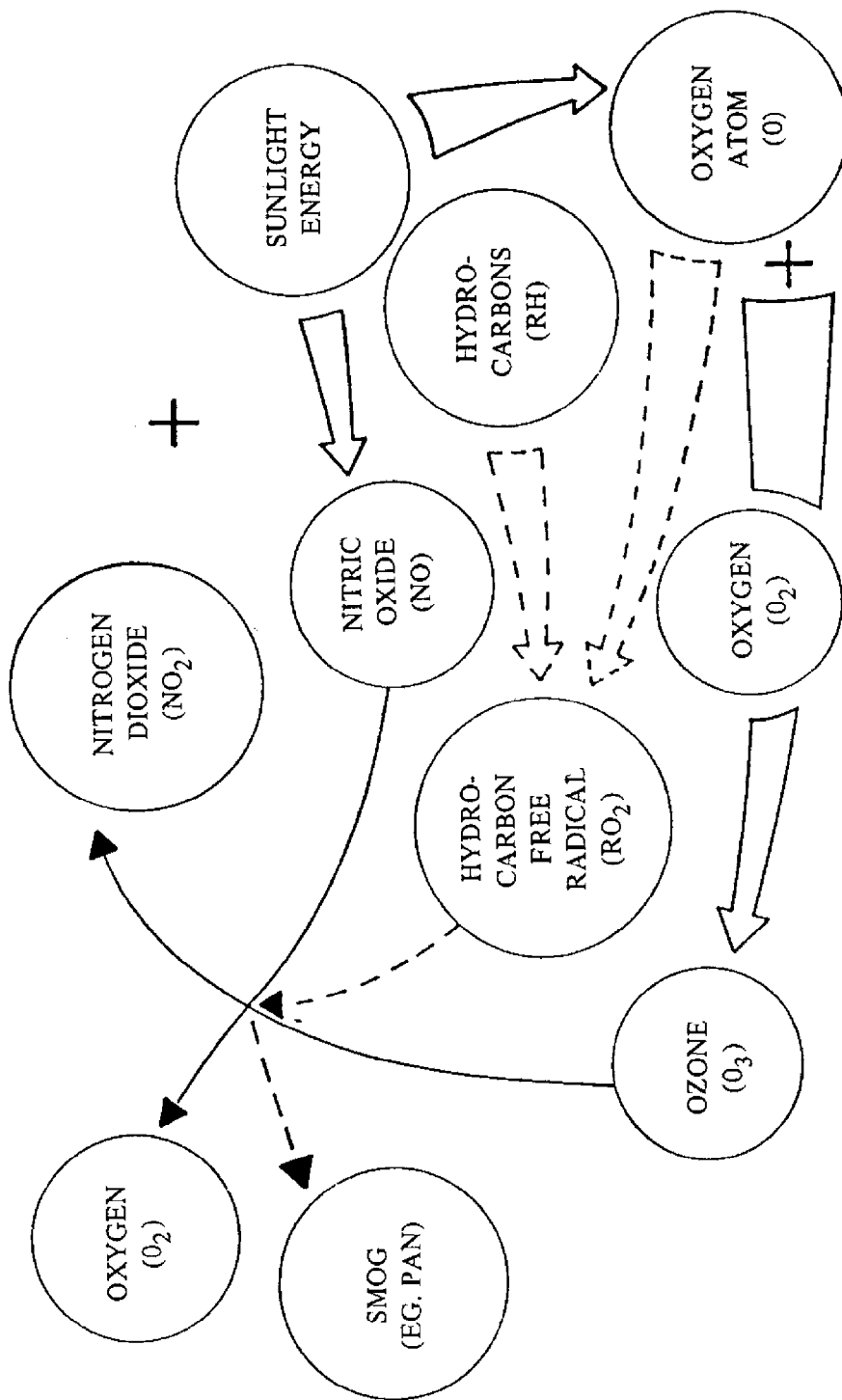


Figure 6: Photochemical cycle of NO₂ with hydrocarbon disruption (Stoker and Seager, 1972)

The fate of particulates in the air is determined by various factors, such as their size and density and the turbulence of the atmosphere. Particles larger than $2\mu\text{m}$ either settle to the ground or are scrubbed out by rainfall, while the smaller particles may remain suspended for considerable periods. The larger particles ($>0.5\mu\text{m}$) cause soiling problems while the smaller particles ($<0.5\mu\text{m}$) are generally considered to be more hazardous to health. This is because the smaller particles may penetrate deep into the lungs whereas the larger particulates are trapped in the nose and throat. Particles that enter and remain in the lungs can exert a toxic effect in three different ways. Firstly they may be intrinsically toxic, e.g. asbestos. Secondly, though they may be inert, they may interfere with the removal of harmful material from the body. Lastly, many of these particles carry absorbed or adsorbed gas molecules and may remain in sensitive areas of the lungs, e.g. carbon in the form of soot possesses a good ability to sorb gas molecules on its surface (Stoker and Seager, 1972).

Measurements of suspended particulates using high volume air samplers at several locations have been carried out both by the Department of Environment and the Malaysian Meteorological Services. The MMS found a mean daily particulate concentration in Petaling Jaya of about $82\mu\text{g}/\text{m}^3$ as compared to $28\mu\text{g}/\text{m}^3$ as recorded in the Cameron Highlands. The DOE recorded average values of about $100\mu\text{g}/\text{m}^3$ at a typical residential area in Damansara Utama, Petaling Jaya, $150\mu\text{g}/\text{m}^3$ at urban and commercial areas in Kuala Lumpur, Penang and Johor Bahru and $200\mu\text{g}/\text{m}^3$ at industrial areas (Goh, 1983). The WHO guideline for exposure limits consistent with the protection of human health for suspended particulate matter is of the order of $60\mu\text{g}/\text{m}^3$. It can be seen that there is a need for greater control regarding this problem.

HAZE

The problem of the haze descended over Malaysia on two separate occasions – one in September 1982 and the other in April 1983. The cause of the haze was conjectured to be a combination of various factors, amongst which were forest fires in neighbouring countries and stable atmospheric conditions. The haze was found to be made up of minute dust and smoke particles.

The April haze lasted for about 2 months and it stretched from Pulau Pinang to Johor, a stretch of about 750 km along the West Coast of Peninsular Malaysia and also covered parts of Sabah and Sarawak. Visibility in certain areas in Malaysia was reduced to 2 to 3 km. The amount of particles in the atmosphere was measured at its highest at about $244\mu\text{g}/\text{m}^3$ on April 14, exceeding the United Nations recommended safety standard of $60\mu\text{g}/\text{m}^3$. Readings were also taken at the Universiti Kebangsaan Malaysia campus in Bangi from April 9 to 18. They showed an average of $103\mu\text{g}/\text{m}^3$. A maximum reading of $121\mu\text{g}/\text{m}^3$ was recorded on April 17, 1983.

The poor visibility caused by the haze affected air flights for a period of about 2 weeks, from April 7 – April 20. Three MAS flights were cancelled and 16 were delayed (NST April 20, 1983). Rural dwellers in Sabah were affected when The 'Flying Doctor' service to 127 remote villages was crippled when some of its aircraft were grounded by the haze. Ship movements were also affected.

TANTALUM AND TIN SLAG DUMPS

The problem of air pollution due to radioactive gases is related to the question of radioactivity and radiation hazard from tantalum ore and tin slag dumps. The tantalum dump problem was brought to light on the island of Penang by a man who lives near

such a dump at Hill Railway Road. In early 1980, he began to suspect that something was wrong when members of his family began to fall sick after a tantalum ore prospector had dumped about 3000 tonnes of ore near his house (NST Nov. 16, 1982). A report was made to the Penang Municipal Council and various organisations such as the Ministry of Science, Technology and Environment, the Department of Environment and Puspatri became interested in the problem.

Measurements have been made but to date there has been no definite conclusions as to the level of radiation or the potential health hazards. The problem is complicated by the fact that not only is there radiation from the dump itself but also the dump is emitting radioactive gases such as radon and thoron which result from the decay of uranium and thorium in the dump. The decay series are shown in Figures 7 and 8. As shown, the naturally occurring Uranium-238 (^{238}U) and Thorium-232 (^{232}Th) give rise to a series of daughter products, including the radioactive radon (^{222}Rn) and thoron (^{220}Rn) gases. These gases are α -emitters and they pose a much greater health hazard than the direct emissions from the dumps as they may get attached to dust particles and thus may be ingested into the respiratory tract, possibly causing damage to internal tissues and organs. Detailed studies elsewhere have established a definite relation between cumulative exposure to radon daughters in air and excess lung cancer deaths (Busigin et al, 1979, 1980).

CONCLUDING REMARKS

In Malaysia the main instruments of pollution control by the Government are the Regulations under the Environmental Quality Act, (1983) incorporating suitable standards for effluent discharges and emissions. For air pollution, this is the Environmental Quality (Clean Air) Regulations 1978 which is dated 28th September 1978 and enforced with effect from 1st October 1978. The regulations apply to the installation of industrial facilities adjacent to residential areas; burning of waste, for example, open burning or burning of agricultural lands for disease and pest control; dark smoke; air impurities, for example solid particles, metals and metallic compounds like mercury, lead, zinc and copper and gases such as acid gases, hydrogen sulphide and oxides of nitrogen. Contravention of the regulations results in a fine not exceeding ten thousand ringgit or to a term of imprisonment not exceeding two years or to both.

Public participation and involvement in the environmental arena is absolutely necessary in order to preserve and maintain environmental quality. Environmental awareness among the public may be achieved through various channels – the mass media, environmental groups and their publications, and education in schools. This awareness includes broadening the understanding of the public regarding the causes, effects and control of pollution. There must be improvements in the availability and dissemination of environmental data, which are to be expressed in simple and precise terms, to all channels including schools, colleges, youth organisations, and people in the rural areas.

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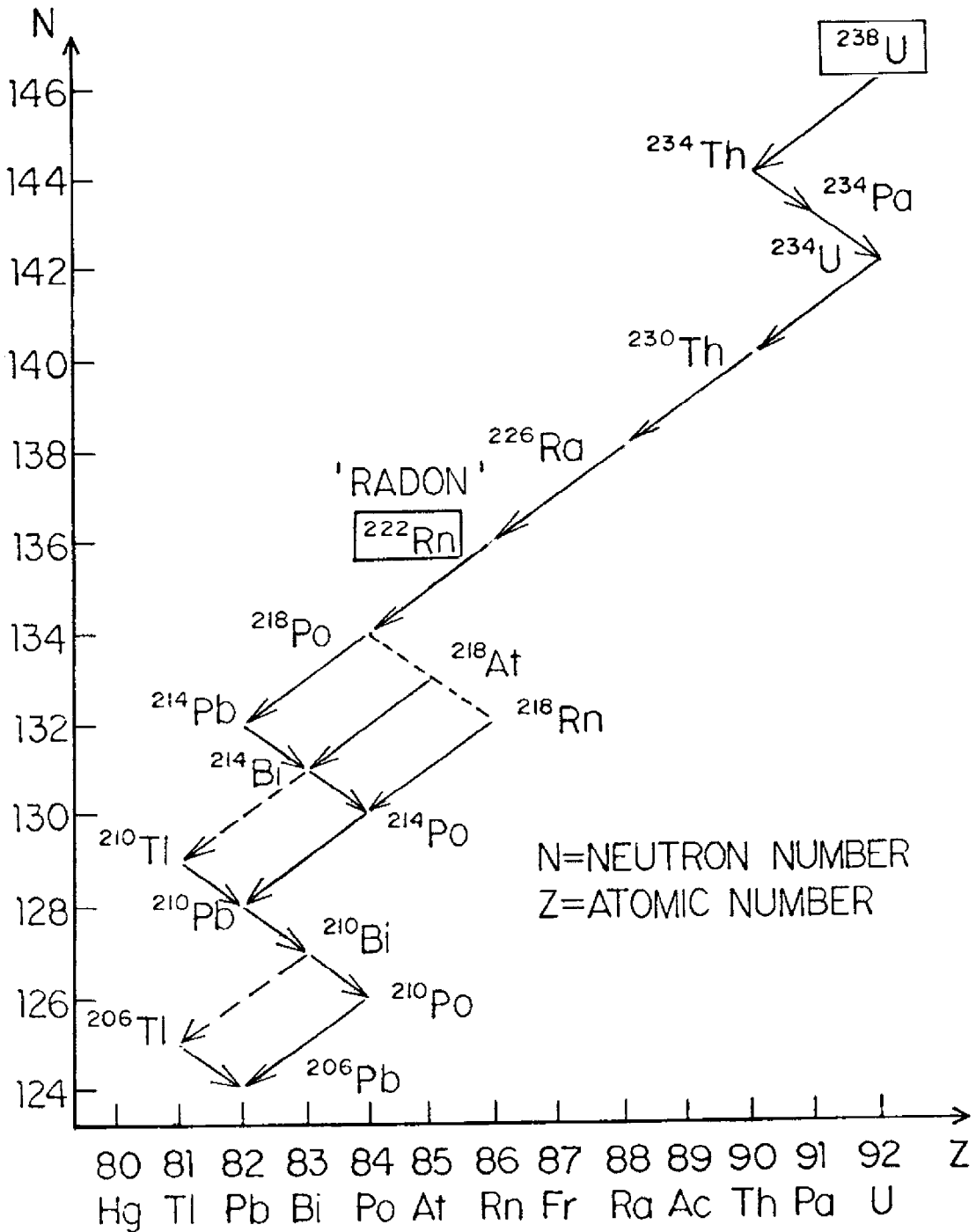


Figure 7: The Uranium-Radium Series

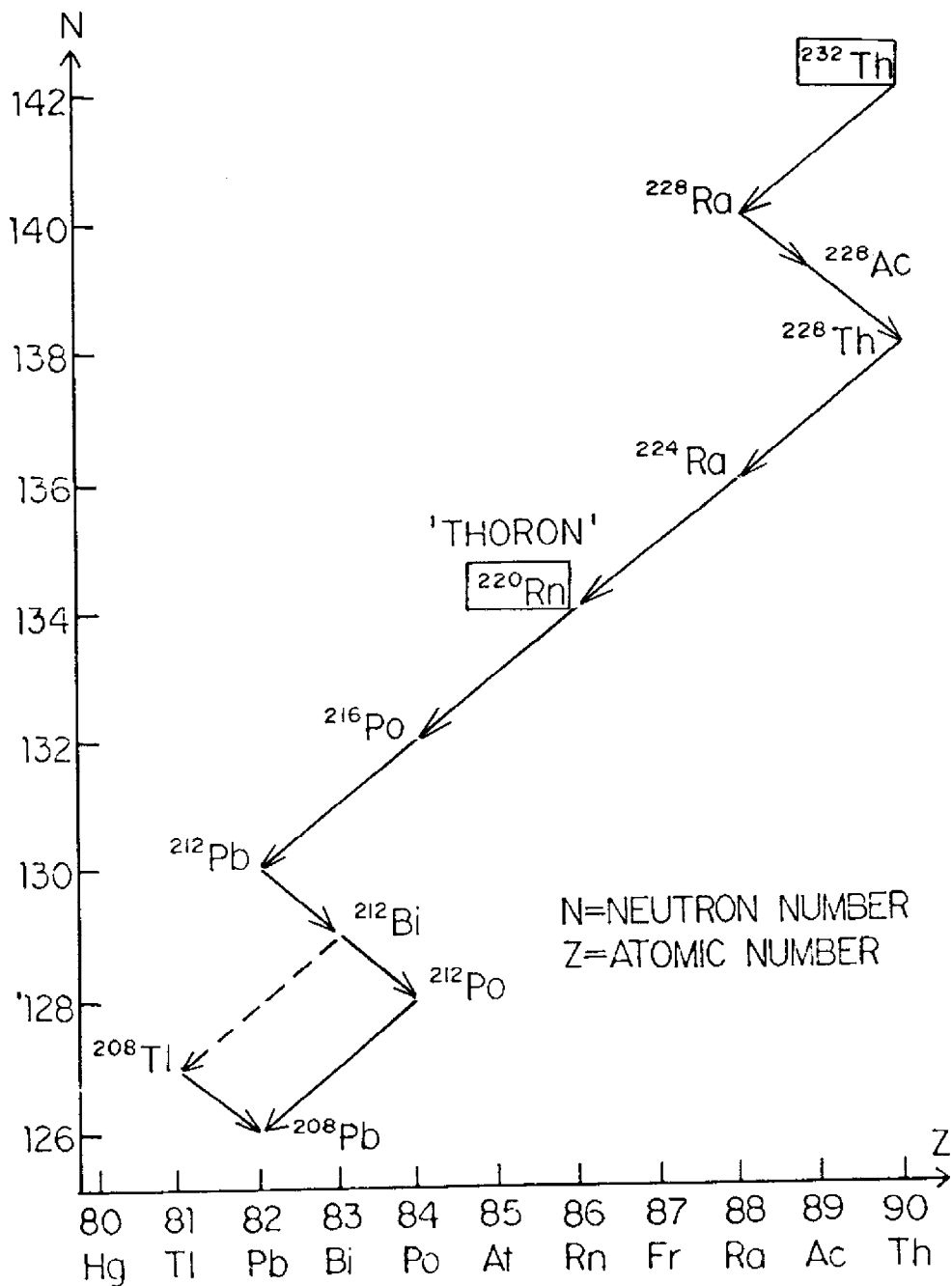


Figure 8: The Thorium Series

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