METROPOLIS IN DECAY-AIR POLLUTION

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Air pollution in Metro Manila has turned from bad to worse. The metropolis has now acquired a canopy of pollution, a dark haze resembling the dark clouds of an approaching storm. The air when still and humid, especially in the traffic congested areas, smells and contains particles and gases that make breathing difficult. In fact, one experiences a feeling of drowsiness, nausea and headache when breathing this air for some time.

Can we remain indifferent to this situation. Aren't we concerned about the ill effects of the pollutants in the air we breath? Shouldn't we take positive measures to arrest and reverse the trend in the contamination of the air for our own survival, for our children, and for the coming generations?

Most of the pollutants in the air are gases, vapors and particulates from the combustion processes, by-product and wastes from the physico-chemical processes of industrial and manufacturing plants, leakages from storage tanks and pipelines of industrial complexes, and from natural decomposition processes and other human activities.

Sources of Air Pollution

Motor vehicles (jeeps, buses, trucks, and cars and other heavy construction equipment) are number one contributors, emitting about 70% of the pollutants in the air which consist of the oxides of nitrogen, carbon and sulfur, the hydrocarbons, the halogenated and gaseous compounds of lead and the particulates of lead and soot.

Data on the number of vehicles registered in Metro Manila during the last three years show a trend of about 16,000 additional units per year as shown below:

Type	1985	1986	1987
Gasoline	340,359	304,898	359,469
Diesel	117,159	169,321	130,960
Total Units	457,516	474,219	490,429

With the relaxation the government's importation policy on used cars (hopefully not the old cars which do not pass the stringent environmental pollution standards of the exporting countries), an increase in the number of vehicles (old!) in Metro Manila is imminent. With the problem of availability and cost of spare parts, the number of old and poorly maintained vehicles, hence, polluting vehicles will rise in the coming years. Likewise, the undisciplined driving which results in non-uniform or erratic changes in driving speed increases the amount of emissions from vehicles. Compounded by practically no improvement in traffic management or procedures to ease traffic congestion and the continued use of leaded gasoline, the air pollution level in the metropolis could reach a disaster point.

The number two contributor to air pollution are the power generating plants or electricity generating plants of the National Power Corporation, of other government and private agencies, commercial establishments, and industrial and manufacturing plants which burn bunker oil, diesel, coal and other fossil fuels. These plants generate the same type of pollutants as the vehicles although composition may vary depending on the type and source of the fuel and the operating conditions.

Moreover, manufacturing plants such as cement factories, distilleries and other chemical plants, other industrial complexes, incinerators, etc. add pollutants in the air. In 1983, of the 4,059 firms inspected by NEPC, about 41% were found to be air pollutive firms. There are 1,733 of these firms in Metro Manila. It is said that 800 manufacturing and industrial plants discharge about 100 tons of air pollutants daily (Lingkod-Tao Kalikasan, Primer No. 12).

Health Effects of Pollutants From Vehicle Emissions

Carbon Dioxide (CO_2)

Normally, carbon dioxide poses no danger to health. However, during the past century, the average concentration of CO_2 has risen, so has the average temperature of the earth.

CO_2 permits the passage of ultraviolet (UV) and visible light from the sun to the earth's surface but absorbs infrared light. This prevents infrared light from passing through into the atmosphere, thus, raising the temperature of the earth (the Greenhouse Effect). An imminent danger is that of the melting of the polar ice caps which can raise the level of the oceans several feet high.

Carbon Monoxide (CO)

Carbon monoxide has been shown to produce detrimental effects on higher plant life by inhibitng the nitrogen fixing bacteria. On humans and other animals, it interferes with the transfer of oxygen through the body by forming a coordination complex with hemoglobin in the red blood cells. Carbon monoxide displaces oxygen (200 times more strongly bound than oxygen to the hemoglobin) and prevents the oxygen from being transported through the bloodstream depriving the various organs, especially the heart and the brain, of the needed oxygen. A complicating fact is that cigarrette smoking can raise the level of carbon monoxide in the lungs to between 400 and 500 ppm [USEPA Air Quality Criteria for Carbon Monoxide", AP-62, USEPA, Washington, D.C. (1970); A.C. Hexter and J.R. Goldsmith, Science 172, 265 (1971)'.

Nitrogen Oxides (NO_x)

Prolonged exposure to nitrogen oxides has been shown to be detrimental to both plants and animals. The direct effects of atmospheric NO_2 [USEPA, "Air Quality Criteria for Nitrogen Oxides," AP-84, USEPA, Washington, D.C. (1971)] include acute respiratory diseases in man, increased incidence of acute bronchitis in infants and children, structural changes in the lung collagen of rabbits, morphological changes in the living mass cells characterized by degranulation in rats, pneumonitis and alveolar distention in mice, tissue changes in the lungs, heart,

liver and kidneys of monkeys, and in plants - leaf abscission, chlorosis, and decreased yield.

In addition to the direct effects, NO_x has been found to be an initiator of photochemical smog. It undergoes complex reaction pathways some of which are:

The NO_x in the atmosphere undergoes reaction with the solar radiation to produce the reactive oxygen, 0, which initiates a number of the important reactions with the hydrocarbons and other compounds and radical present as pollutants in the air. The hydrocarbons form aldehydes or ketones and radicals some of which speed up production of NO_2 and NO_3. Ozone, O_3 , also form radicals with the hydrocarbons which may also react with dioxygen, O_2 , to form peroxide radicals. The aldehydes, ketones, and acids formed, whose structures depend on the initial hydrocarbons, eventually condense to form aerosols which limit visibility (smog) and disturb atmospheric conditions which could result in temperature inversion.

Other compounds which may be present in photochemical smog are the eye irritants (lachrymators) and the extremely toxic oxidants such as peroxyacetyl nitrate and the related peroxybenzolynitrate produced by the reaction of NO_2 with peroxide radicals and the carcinogenic and mutagenic polychlorinated hydrocarbons and the polynuclear aromatic compounds produced from the combustion of diesel, gasoline or any fossil fuel.

Oxides of Sulfur(SO_2 and SO_3)

These oxides are irritants to the linings of the respiratory tract. It reacts with moisture to form acids which gather in the respiratory membranes. However, since these oxides have strong suffocating odors, which serve as a warning direct injury from prolonged exposure is limited although SO_2 pollution may cause complications among those with respiratory diseases.

The oxides of sulfur and nitrogen form acids with moisture. The accumulation of these pollutants in the air may aggravate the problem of acid rain which have caused damage to fisheries in about 2,500 lakes in Sweden, about 1,750 lakes in Norway and nearly 20% of the lakes in Canada (UNEP State of the Environment, 1983).

According to the WHO, Manila's average SO_2 concentration during the period from 1973-1980 was 73 microgram/cubic meter, which exceeded that of New York, Los Angeles, and Chicago whose SO_2 concetration were 59, 35, and 34 microgram per cubic meter, respectively, and comparable to Frankfurt and London with 79 and 78 micrograms per cubic meter, respectively (Lingkod Tao-Kalikasan, Primer Series No. 12)

Lead Compounds and Lead Particulates

Regular and premium gasoline contain 2.5 to 4.0 grains of tetraalkyl lead per gallon of gasoline. While the use of this additive in developed countries had been regulated and gradually phased out, here in the Philippines, the talk of phasing out this additive which was supposed to start in 1985 with a total phase out in 1989, was just a "false alarm" and still too far away from reality.

A bothering fact about the use of this additive is that dibromeothane and dicholorethane are also added to gasoline to prevent the deposition of lead and lead oxide deposits inside the engine. During combustion, these compounds are vaporized and emitted into the atmosphere as finely divided particles of lead and the halogenated compounds of lead and the hydrocarbons. More than 98% of the total lead in the atmosphere comes from the combustion of leaded gasoline [Moore and Moore, 1976]

The fine lead particles (less than 2 μm in size) when inhaled are easily retained by the human lungs causing respiratory problems.

Three documented toxicity of lead are gastrointestinal cramps (lead cholic), central and peripheral nervous system effects (lead encephalitis) and anemia. Kidney disease excess, frequency of hypertension, vascular disease and lung cancer have also been suggested although these have not been proven beyond reasonable doubt.

Lead is a general metabolic poison and enzyme inhibitor like the heavy metals mercury and cadmium. Young children are particularly affected by lead and can suffer mental retardation and permanent or semipermanent brain damage. An insiduous effect of lead is its ability to replace calcium in bones and remain there to form a semipermanent reservoir for long term release even well after the initial absorption.

A study conducted by a medical team which examined children with ages ranging from 4 months to 14 years living in the depressed areas in Metro Manila, found substantial lead levels in the children's blood. The team found an average level of about 22.83 micrograms per decaliter with 7.76% of those sampled having lead levels of 30 micrograms per decaliter. Since the US Center for Disease Control had established 30 micrograms per decaliter as a measure for "elevated" blood lead level, the result of this study is quite disturbing. There was also found a significant correlation between increased blood lead level and the proximity of the household to traffic density [Manila Bulletin, Aug. 1, 1986].

The Particulates

The particulates from emissions are largely smoke and soot and lead particles. These particles are in the size range of 0.1-10 um. Because of their large surface area, they absorb the gaseous and liquid pollutants and act as catalysts in the photochemical reactions [Korfmacker et al, Science 207:763 (1980); Nijima and Kahno, Chemosphere 6: 37 (1977)]

The particles between 0.1 and 1 μm, because of their diameters which are comparable to the wavelength of visible radiation, can cause interference phenomena whose effect is to reduce visibility as well as the amount of solar radiation reaching the ground. These fine particles may also form too many nuclei which can cause the formation of water droplets which are too small to precipitate, hence, will only increase cloud cover but no rainfall [W. Bach "Atmospheric Pollution", McGraw-Hill, N.Y. 1972].

The detrimental effect of these fine particulates on plants is the impairment of the circulation of CO_2 and O_2 through plant leaf stomata. In humans and other animals, the respiratory tract is the area with the most damage. The particles which are smaller than 0.1 μm which are inhaled are deposited in the lungs causing respiratory problems.

Data from WHO and the United Nations Environment Program [Lingkod-Tao Kalikasan, Primer No. *12*] revealed that the average suspended particulate matter (TSP) concentration of Manila during 1973-1980 was 85 micrograms per cubic meter, exceeding that of Tokyo and New York with 61 and 65 micrograms per cubic meter, respectively.

The Polynuclear Aromatic and Polychlorinated Hydrocarbons

A recent acticle by Sigsby, J. et al, [Environ Sci. Technol. 21(5):466(1987) indicated that even the non-leaded gasoline, regular and premium, emitted polyaro-

matic hydrocarbons. According to Takashi Handa, et al [Environ, Sci. Technol. 18 (12):895(1984)] carcinogenic and mutagenic polyaromatic hydrocarbons are readily converted to their nitro derivatives which are also direct acting mutagens by exposure to the nitrogen oxides (NO_x). Polycyclic quinones may also be formed from the appropriate polyaromatic hydrocarbons and the active oxygen by chemical oxidation under the high temperature condition in an engine. Muller and Buser (Environ. Sci. Technol. 20(11):1151(1986) who studied the formation of halogenated compounds from the combustion of leaded gasoline, found that the halogenated compounds were mostly phenols and were observed to be ortho-substituted and therefore potential precursors of the halogenated dibenzo-p-dioxins which are acutely carcinogenic and mutagenic substances and hardly biodegradable.

Emissions From Incinerators

In the September 5, 1988 issue of the Manila Bulletin an article carried the concern of various environmental groups over the plan of Manila Mayor Gemiliano Lopez, Jr. to build an incinerator plant in the city and transfer the huge piles of garbage from the "Smokey Mountain" in Tondo to the Engineer Island in Manila Bay. I share the concern of the various groups because of the hazards that would come from the emissions of the incinerator.

Incinerators are thermal destruction devices used in the disposal of wastes by exposing the wastes to a high temperature of about 900°C or greater in an oxidizing environment. These thermal destruction processes include thermal oxidation and starved-air or pyrolytic incineration which are made to occur in boilers, cement kilns or furnaces burning the wastes as fuel or burning the wastes using a high temperature process.

Studies have shown that combustion processes produce polynuclear aromatic hydrocarbons (PAHs) which are known carcinogens and mutagens. Release of these compounds from municipal inicinerators had been reported in the stack gases [Hangerbrauk et al., National Air Pollution Control Administration Publication, No. 999-ap-33 Durham, N.C. 1967; The Toronto Star News, Nov. 1987] and in the ash residues [Hudrey et al., Environ. Research 7.294 (1974)]. Ian W. Davies et al. [Environ. Sci. and Technol. 10(5) May 1976] studied the formation of PAH in municipal incinerators burning 9.14 tons refuse/hr. with furnace temperature maintained between 800-900°C and burning with 75% excess of oxygen. In this study, the residue dropped from the grate into a tank where it was quenched, freed of magnetic materials and discharged. The gases leaving the furnace entered in an upflow into the water spray towers where these were cooled to 250-300°C and larger particles of fly ash removed. Induced draft fans draw the gases from the spray towers an electrostatic precipitator prior to discharging them through a 55m-high concrete chimney.

His findings showed that gases leaving the furnace contained PAH both as vapor and absorbed as fly ash particulates. Solid residues made up of combinations of quenched ash residues and fly ash collected from the spray towers electrostatic precipitator, also contained PAHs as did the washwater from the incinerator. There were variations in the level of emissions with variations in combustion temperature and refuse composition during normal operations and differing PAH levels in the stack gases during start up, normal operation, and close down of the incinerator. The water used for quenching gained substantially in PAH content during its use in the incinerator together with the more soluble and lower molecular weight hydrocarbons.

Other studies of municipal incinerators showed that complex mixtures of organic compounds were present in fly ash samples at concentration levels of 1-30 µg/g (4 - 7). These mixtures isolated from the fly ash through solvent extraction methods were found to include n-alkanes, polychlorinated, benzenes (PCBs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated phenols (PCPs), and many others. Also present in the extracts are the acutely toxic teratogenic, and mutagenic polychlorinated dibenzofurans (PCDFs) and the polychlorinated dibenzo-p-dioxins (PCDDs) at concentration levels of 1-10 ng/g of fly ash. Since some of the isomers of PCDDs are also actually toxic and carcinogenic (8-10), the formation and environmental fate of PCDDs have been the center of several recent studies (11-25).

Although the precursors and mechanisms of formation of PCDDs in municipal and other incinerators are unknown, these and similar compounds have been formed during combustion processes. In fact laboratory studies have shown that thermal processes, including pyrolysis and the burning of precursors such as PCBs, PCPs and other chlorinated biphenyls produce certain PCDDs and PCDFs (26-28) reinforcing theories that PCDDs and other chlorinated compounds are formed through combustion. Studies also show that compounds which are absorbed on fly ash may also undergo reactions with gases during emission into the atmosphere like, for instance, PAHs which were rapidly oxidized on the fly ash even in the absence of light (29) as well as the gas-particulate reactions of other PAHs which were induced photochemically (30-31).

Results of studies cited above and other similar studies with simple organic compounds (37) suggest that even incinerators with a destruction removal efficiency (DRE) of 99.9999% would still be a health hazard because of the toxic and carcinogenic compounds in their emissions.

Thus, while incineration appears a promising means of disposing wastes primarily because of the remarkable reduction in waste volume (up to 85%) its potential adverse effects on man's health and the environment should be enough of a deterrent against the putting up of incinerators in Metro Manila.

The air is the Almighty's gift to all of us, rich and poor alike. But with the unabated addition of pollutants to the air, we may have to pay dearly for the air we breathe in the days to come.

Need we say more?

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