Air Pollution in Jakarta, Indonesia

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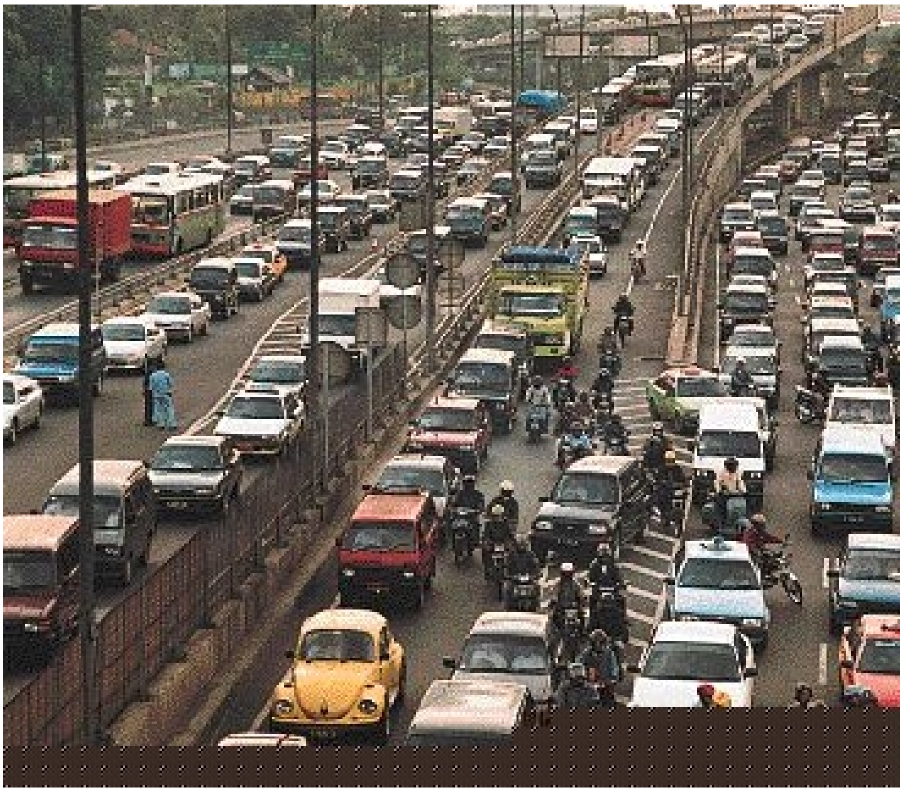

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I INTRODUCTION

Clean air is a basic condition for health. Health is at issue especially with regard to ozone and particulate matter. Clean air is necessary for healthy environment and for maintaining the biodiversity. But there is always a condition that we actually do not want it to exist to our air, which called air pollution. Air pollution aggravates respiratory problems, and leads to an increase in sickness absenteeism, an increase in the use of health care services – more medication and hospital admissions – and even to an increase in premature mortality. These are indications that air pollution is one of the contributing factors to the development of chronic obstructive pulmonary disease and an increase in the number of people with these problems, for example, through chronic effects on the respiratory system and through interaction with the body's immune system *(DE BOER, 1998)*.

Air pollution, both indoors and outdoors, is a major environmental health problem affecting developed and developing countries alike. It comes from sources of dust, gases, and smoke, and is generated mainly by human activities but also naturally. When inhaled, air pollutants affect the lung and respiratory tract but can also be taken up and transported by the blood stream throughout the body. Through deposition in the environment, air pollutants can also contaminate food and water *(WHO, 2000)*.

Indoor air pollutants are an even greater threat to the health of millions. Some 2,000 million people throughout the world, use coal and biomass materials (cow dung, crop residues and grass) as fuel for heating and cooking. It is a major source of indoor pollution. The domestic burning of these fuels is an inefficient process that produces many pollutants, some of which may be carcinogenic. The problems are worsened in areas where people spend most of their time indoors. The greatest threat in this case is to women and children living in poverty. Even today, homes of the poor in developing countries are dangerous, unhealthy places – a rule of thumb states that a pollutant released indoors is 1000 times more likely to reach people's lungs than a pollutant released outdoors *(WHO, 2000)*.

Coal burning for heating and cooking in developing countries results in indoor particle concentrations of up to 10,000 $\mu g/m^3$, a level that is much higher even than ambient concentrations in polluted cities in Asia *(WHO, 2000)*.

II AIR QUALITY IN JAKARTA

II.1 About Jakarta

II.1.1 A Diverse History and Landscape

Jakarta, the capital of the Republic of Indonesia, long time ago known as Batavia, is as diverse as Indonesia itself. Jakarta laid southern the equator from 106°48' of Longitude and 6°17' of Latitude *(EBERLEIN, 1996)*. Jakarta is located on the island of Java. This island has a dramatic population growth in the 20th century, growing from 29 million at the turn of the century to about 125 million today *(ENERGY INFORMATION ADMINISTRATION, 1999)*. In 1995, Jakarta houses about 11.5 million people, representing the heritage of the archipelago's 13,677 islands and of countries such as the Netherlands, Portugal, China and Malaysia. Muslims, Christians, Buddhists and Hinduists live scattered throughout the city in ethnically and religiously clustered neighborhoods *(WRI, 2000)*.

Jakarta's landscape is equally varied. Glass and chrome skyscrapers have sprouted up haphazardly between traditional *kampung* (the traditional settlement of the poor) villages. To the east and west, the city has converted Jakarta Bay's coastline into an international harbor; to the south a sea of red-tiled rooftops spreads deep into the heartland of the island of Java, broken only by occasional rice paddy fields *(WRI, 2000)*.

II.1.2 A Fast-growing City

Jakarta, the eleventh largest city in the world, has a fast growing population. In 1950, there were about 1.4 million residents. The population increased to 2.7 million in 1960, to 6 million in 1980, and to 11.5 million in 1995. By 2015, Jakarta is expected to be the fifth largest city in the world, with a population of 21.2 million – 15 times its size in 1950. Part of this growth is due to "natural increase" - people already in the city having babies - and part is due to migration. Based on the migration survey in Jakarta, it is explained that every 100 migrants in Jakarta about 50 came to the city because either spouse or their parents migrated to Jakarta[1]. In other words, 50% of the migrants were simply following the 'primary

[1] See Suharso: *Cityward migration and educational attainment in Jakarta, Indonesia*, paper presented at the Regional Seminar of Experts on Population Dynamics and Educational Planning, Bangkok, 10-18 September 1973 (Bangkok, UNESCO Regional Office for Educational in Asia; mimeographed) *(SETHURAMAN, 1976)*

migrants'. Of the latter, 60% migrated in search of job opportunities; 11% came to study in Jakarta; 8% came on job transfer and the rest migrated for miscellaneous unspecified reasons *(SETHURAMAN, 1976)*.

Jakarta has been a center of trade in Indonesia since the late 16th century, when The Dutch East India Company founded a city called Batavia near Jakarta Bay. Like many megacities, it is the country's center of government, finance, commerce and education. Jakarta's industries include textiles, chemicals and electronic devices, and 17% of the nation's industrial production occurs there *(WRI, 2000)*.

II.1.3 Cost of Growth

Yet Jakarta's economic growth has had its costs. For the past 30 years at least, waves of migrants have flocked to the city in search of better lives because per capita income in Jakarta is 70% higher than the overall national average. In combination with high birth rates, the explosion of the migrant population within the city's borders has far surpassed the government's capability to provide the basic needs of many of the city's residents such as adequate infrastructure and housing *(WRI, 2000)*.

Consequently, the central city of 8 million residents, packed together at densities of 32,000 people per square mile (12,435 people per square kilometer), actually operates without a waterborne sewage system *(WRI, 2000)*.

Because of its rapid growth, vehicles and industry are now a major source of environmental pollution. Thus, like many of the world's megacities, Jakarta now faces some of the world's worst urban environmental problems from choking air pollution to contaminated and insufficient water supplies *(WRI, 2000)*.

II.1.4 Jakarta Sprawl

One of the primary challenges for Jakarta will be to manage urban encroachment onto rural land. Since 1955, the metropolitan region has increased more than threefold. As is the case with most megacities, Jakarta's urban fringe is growing much faster than the city itself. Most of this expansion is due to population pressures; land in the central city is expensive and occupied, so immigrants must settle on the outskirts. Already, the suburban area of *JABOTABEK* (Jakarta-Bogor-Tangerang-Bekasi) is colliding into suburbs of the neighboring city of Bandung, creating an urban region that stretches 75 miles (120 kilometers) from west to east and 125 miles (200 kilometers) from north to south *(WRI, 2000).*

Unplanned, this expansion is occurring at the expense of prime agricultural land and ecologically sensitive areas. Businesses and houses cluster along main roads, while large tracks of land between the roads stay vacant. If this urban sprawl continues, the city will undoubtedly be faced with higher infrastructure costs and energy consumption levels in the future *(WRI, 2000).*

II.1.5 JABOTABEK

Speaking of Jakarta Metropolitan area, then one would rather mention the term "JABOTABEK". It is the term to define the constitution of four cities; Jakarta, Bogor, Tangerang and Bekasi. The three latter cities are located in the south, west and east from the core city Jakarta. The gateway from these cities into Jakarta may be stated to be easy, especially from Tangerang and Bekasi. Industrial settlements (Tanjung Priok, etc) or new Real-estates (for example: Villa 2000, Concord 2000, Waterfront, Kemayoran, etc) and important traffic axes are responsible for this easy access development. Around 19 million people are now living in the JABOTABEK region *(HEINTEL and SPREITZHOFER, 1999).*

The first Jakarta Master Plan was established for the period 1965-1985. The aim was a growth in concentrated areas. Series of research, such as the Jakarta Metropolitan Area Transport Study, the Sewerage Master Plan, the Railway Master Plan and diverse Street Concepts were conducted, with the following results: Proposals in the Street Nets Department was accepted *(HEINTEL and SPREITZHOFER, 1999).*

The second planning phase may be defined as the beginning of a strategical plan, as a reaction of ongoing migrations, worsening living conditions and a shrinking job market. These lead to a great need of multi-regional coordination *(HEINTEL and SPREITZHOFER, 1999).*

The region plan JABOTABEK – a city region in West Java with an extension of 6160 km, which are located around the capital city Jakarta with its main cities Bogor, Tangerang and Bekasi – was at the beginning of the 2nd Five Year Planning established *(HEINTEL and SPREITZHOFER, 1999).*

Figure 1: The JABOTABEK Region ***(HEINTEL & SPREITZHOFER, 1999)***

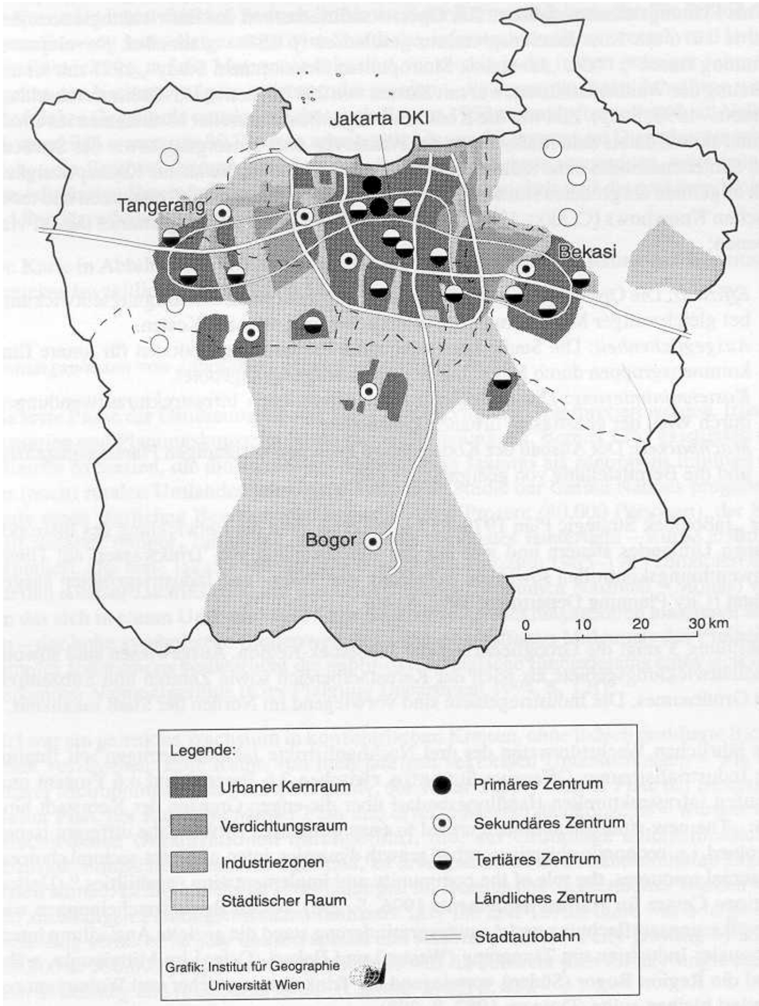


Figure 1 shows a rough classification of the JABOTABEK region. Also noted are the city development areas, the core city and the center and sub-center of the city. The area growing rate per year of the three neighboring districts since the beginning of the industrialization is between 3.6 – 4.6% *(HEINTEL and SPREITZHOFER, 1999).*

Tangerang (at the west) and Bekasi (at the east) were aimed to be industry areas, the region Bogor (at the south) on the other hand as a settlement area *(HEINTEL and SPREITZHOFER, 1999).*

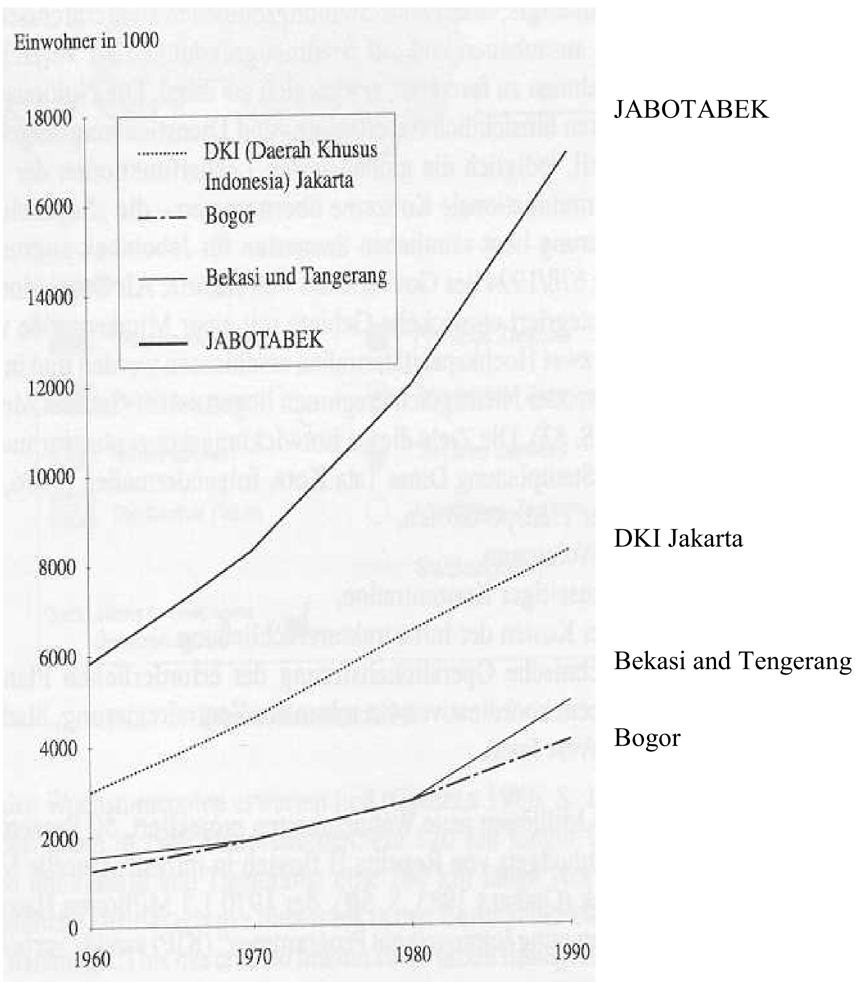
The axis development reaches its culmination today in two main flows; a 120 km long east-wet corridor connects Bekasi with Jakarta and Tangerang, a 200 km long north-south-axis lies wide over the southern district border until the second biggest agglomeration area in Java, Bandung. Every day people live outskirts of Jakarta (in Botabek) has to travel in the morning and in the evening to reach their activities place in the core city. This travelling movement contribute the air pollution problem to the city *(HEINTEL and SPREITZHOFER, 1999).*

The development since 1980-1990 depicts the obvious need of a coordinated urbanization in the Botabek region: In this decade alone has the population growth 3.5 million more, which equals a 336% gain, or around 16% mean growth/year (Table 1) *(HEINTEL and SPREITZHOFER, 1999)*.

Table 1: The Population Growth in JABOTABEK 1960-1990 ***(HEINTEL & SPREITZHOFER, 1999)***

	1960		1970		1980		1990	
	in Million	in %	in Million	in %	in Million	in %	in Million	in %
DKI Jakarta (Core city)	2,97	51	4,57	55	6,49	54	8,22	48
Bogor	1,31	23	1,86	22	2,74	24	4,01	23
Tangerang & Bekasi	1,54	26	1,90	23	2,67	22	4,87	29
JABOTABEK (Total)	5,83	100	8,33	100	11,89	100	17,01	100

Figure 2: The Population Growth in JABOTABEK 1960-1990 ***(HEINTEL & SPREITZHOFER, 1999)***



II.2 AIR POLLUTION IN JAKARTA

II.2.1 General Acknowledgement of Air Pollution

II.2.1.1 Pollutants in the Air

The common picture of air pollution is of smoking industrial chimney and traffic exhausts affecting the surrounding populations – ambient air pollution. Even though the main sources of air pollutants are man made – traffic and industry – natural sources also contribute, such as particles from volcanic eruptions *(WHO, 2000)*.

Pollutants are substances which, when present at high enough concentrations, produce harmful effects on people and/or the environment *(HOLPER, 2000)*. Another definition of air pollutants with the same meaning is classified by WHO *(WHO, 2000)* as suspended particulate matter, gases and vapours that are present in the atmosphere in abnormally high concentrations.

II.2.1.1.1 Carbon monoxide

The principal source of carbon monoxide (CO) is vehicles powered by petrol engines. Industrial plants and other operations that result in incomplete combustion of carbonaceous fuels are also important sources. Other significant and often forgotten sources of the gas are cigarette smoke (mainstream smoke contains up to 4% of CO) and domestic heating appliances which, if poorly flued, can produce high and often lethal CO concentrations indoors *(WHO, 1972)*.

When inhaled, CO combines with haemoglobin (Hb), whose vital function is to transport oxygen. Since CO has an affinity for haemoglobin some 240 times that of oxygen, the prime result of this reversible combination is to decrease the capacity of the blood to transport oxygen from the lung to the tissues *(WHO, 1972)*.

In practice, carboxyhaemoglobin (COHb) concentrations in the blood depend on the CO concentrations in the air breathed, duration of exposure, and pulmonary ventilation, which in turn is determined largely by the activity of the subject. When the concentration of CO in the ambient air is below that which would be in equilibrium with the blood, the subject of course exhales CO. Similarly, in a person absorbing CO, the time required to reach a given level will also depend on the initial concentration in the blood. About 3 hours are needed at rest for the COHb to reach 50% of the equilibrium value, but the rate of elimination is increased by exercise and by raising the partial pressure of oxygen of the inspired air. Table 2 indicates the relationships between selected ambient concentrations of CO, time of exposure and blood levels. The assumption is made that initial CO saturation is virtually zero or "basal" and that the subject is engaged in light activity *(WHO, 1972)*.

Table 2: Relationship between Ambient CO Concentrations, Exposure Time and Levels of COHb ***(WHO, 1972)***

Ambient CO		COHb Level (%) at		
mg/m³	ppm	1 hour	8 hours	equilibrium
117	100	3,6	12,9	16,0
70	600	2,5	8,7	10,0
35	30	1,3	4	5,0
23	20	0,8	2,8	3,3
12	10	0,4	1,4	1,7

In any discussion of the relevance of CO as an air pollutant, note must be taken of the fact that the gas is naturally present in the blood in concentrations up to 0.8% of carboxyhaemoglobin as a result of catabolic process *(SJÖSTRAND, 1949; COBURN et al., 1969, from WHO, 1972)* and is often present in high concentrations in the blood of smokers who inhale tobacco smoke. CO concentrations of over 15% saturation have been found in smokers. It is generally agreed that individuals should be protected against continuous carboxyhaemoglobin levels of approximately 4% or over. Table 3 lists 3 levels of ambient CO and the time required for the blood to reach 4% saturation.

Table 3: CO Concentrations required to reach 4% COHb Levels ***(WHO, 1972)***

Ambient CO*)		Time (hours)
mg/m³	ppm	
29	25	24
35	30	8
117	100	1

*) Light activity at sea level with initial "basal" values is assumed.

II.2.1.1.2 Sulfur dioxide

Sulfur dioxide is produced when coal and oil are burnt or when minerals are 'roasted' to remove the sulfur. In some countries, coal and oil contain significant amounts of sulfur. Unless special steps are taken to remove sulfur dioxide, it is released into the atmosphere.

Power stations and industrial plants, which are often sited close to cities, can produce large quantities of the gas *(HOLPER and NOONAN, 2000)*.

As well as affecting human health, sulfur dioxide can be harmful to plants, turning leaves yellow and drying, bleaching and even killing, foliage. In the atmosphere, sulfur dioxide can form acidic particles, or react with cloud droplets, contributing to acid rain *(HOLPER and NOONAN, 2000)*.

II.2.1.1.3 Nitrogen dioxide

Nitrogen dioxide (NO_2) and nitric oxide (NO) are often referred to collectively as nitrogen oxides, or NO_x. NO is emitted by both motor vehicles and stationary combustion sources, while NO_2 originates in chemical and nitration industries and occurs in conjunction with the photochemical oxidant process *(WHO, 1972)*.

It should be emphasized that NO2 may have distinct biological effects apart from those associated with the photochemical pollution complex. The gas can exist as a primary pollutant in areas unaffected by photochemical oxidant pollution requiring independent criteria and guides *(WHO, 1972)*.

II.2.1.1.4 Particles

Particles in the air (also known as aerosol) come from a number of sources, including motor vehicles, industrial processes and wood burning. Secondary formation of particles (formation from gaseous emissions) can also contribute significantly to particle levels. Some atmospheric particles are from natural sources. These include wind-blown dust, pollen, sea salt and material from volcanic eruptions *(HOLPER and NOONAN, 2000)*.

Fine particles (particles with a diameter of 10 micrometers or less) can be inhaled deeply into the lungs and have been associated with a wide range of adverse respiratory symptoms. Long- and short-term exposure to such particles has been linked with increased deaths from heart and lung disease. Lead compounds, which are emitted by motor vehicles fuelled with leaded petrol, are cumulative poisons. They slowly build up in the body *(HOLPER and NOONAN, 2000)*.

II.2.1.1.5 Urban Haze

Urban haze is mainly due to fine particles, which cause scattering or absorption of light. Haze is typically brown and limits visibility. The term 'air toxics' is often used when referring to atmospheric pollutants. Air toxics are gaseous, aerosol or particulate pollutants, which are present in the air in low concentrations with characteristics such as toxicity or persistence so as to be a hazard to human, plant or animal life *(HOLPER and NOONAN, 2000).*

II.2.1.1.6 Photochemical smog

Sometimes, under certain meteorological conditions, the combined effects of a number of air pollutants are worse than individual effects. Photochemical smog, sometimes seen as a whitish haze present over cities during summer, is an example of this *(HOLPER and NOONAN, 2000).*

Photochemical smog is formed on still days when sun shines on air containing Volatile Organic Compounds (VOCs) and oxides of nitrogen. Volatile Organic Compounds include hydrocarbons, as well as alcohols, aldehydes and ethers. VOCs in the air arise mainly from automotive fuels and industrial solvents. Chemical reactions driven by sunlight and involving VOCs and oxides of nitrogen from ozone, a gas harmful to humans, animals and plants *(HOLPER and NOONAN, 2000).*

In addition to ozone, photochemical smog contains a number of other harmful secondary pollutants such as peroxyacetyl nitrate and adelhydes, which are severe irritants, particularly to the eyes. (Ironically, ozone in the stratosphere is essential for life as we know it. This ozone layer prevents much of the sun's harmful ultraviolet light reaching us) *(HOLPER and NOONAN, 2000).*

II.2.1.1.7 Ozone

Only one reaction forms ozone in the lower atmosphere – the addition of an oxygen atom to an oxygen molecule in the presence of a third molecule *(MACDONALD, 1989)*:

$$O_2 + O \rightarrow O_3 + M$$

The oxygen atoms are derived primarily from the photolysis of nitrogen dioxide (NO_2) according to *(MACDONALD, 1989)*:

$$NO_2 + h\upsilon \ (\lambda < 398\ nm) \rightarrow O + NO$$

where $h\upsilon$ denotes a photon of ultraviolet radiation. One further reaction completes the "nitrogen cycle" for ozone formulation. This reaction is the molecule-molecule exchange between ozone and nitric oxide, which reforms nitrogen dioxide *(MACDONALD, 1989)*:

$$O_3 + NO \rightarrow NO_2 + O_2$$

The transient concentration of ozone is thus fixed by the ratio of nitrogen dioxide to nitric oxide according to

$$[O_3] \cong 0.021\ ppm \ \frac{[NO_2]}{[NO]}$$

where [ ] denotes concentration. During the day, with its flux of solar ultraviolet radiation, there is a continuous cycle of formation and destruction of ozone, accompanied by the conversion of nitrogen dioxide to nitric oxide. The equilibrium concentration of ozone in these circumstances is fixed by the *ratio* of NO_2 to NO in the background atmosphere *(MACDONALD, 1989)*.

Indeed, the daily ozone production per unit of nitrogen oxide (NO_x) to be greater in rural areas with lower NO_x concentrations. Thus, it is not the total concentration of nitrogen oxides that determines ozone concentration, but the ratio of the two nitrogen oxide species. This ratio is fixed by the complicated photochemistry of hydrocarbons and carbon monoxide – a fact that has important implications for regulatory strategies *(MACDONALD, 1989)*.

We can then draw a table listed of pollutants affecting urban and/or regional air quality as the following:

Table 4: Major Pollutants in the Air *(HOLPER AND NOONAN, 2000)*

Pollutant	Sources	Health effects
Carbon monoxide (CO)	Motor vehicles, burning of fossil fuels.	Blood absorbs carbon monoxide more readily than oxygen, reducing the amount of oxygen being carried through the body. Carbon monoxide can produce tiredness and headaches. People with heart problems are particularly at risk.
Sulfur dioxide (SO_2)	Coal and oil burning power stations, mineral ore processing and chemical manufacture.	Attacks the throat and lungs. People with breathing problems can suffer severe illness.
Nitrogen dioxide (NO_2)	Fuel combustion	Affects the throat and lungs.
Volatile Organic	Motor vehicles, fuel combustion,	Some VOCs cause eye and skin irritation,

Compounds (VOC)	solvent use.	headaches or nausea some are classed as carcinogens.
Ozone (O_3)	Formed from nitrogen oxides and hydrocarbons in sunny conditions. These chemicals are released by motor vehicles and industry.	Ozone attacks the tissue of the throat and lungs and irritates the eye.
Lead	Exhaust gases from motor vehicles that use leaded petrol, smelters.	Particles containing lead in the air can enter the lungs. The lead can then be absorbed into the blood stream. Over a period lead can affect the nervous system and the body's ability to produce blood.
Particles	Motor vehicles, burning of plant materials, bushfires.	May cause breathing difficulties worsen respiratory diseases. Some particles contain cancer-producing materials.

II.2.1.2 Trends

Concentrations of sulfur dioxide and suspended particulate matter are decreasing in developed countries, while those of NO_x and ozone are either constant or increasing. In developing countries, increasing traffic and its exhaust as well as industrial emissions are raising concentrations of SO_2, NO_x and O_3 and suspended particulate matter *(WHO, 2000)*.

II.2.1.3 Air Quality Standard for Particulate Matter

Responding to the epidemiological findings which revealed that the health risks for the public due to particle exposure and in particular fine particles, are much more significant than assumed before, the US-Environmental Protection Agency (EPA) amended the National Ambient Air Quality Standards (NAAQS) in 1987. The new NAAQS replaced the previous standard for particles, which was based on Total Particulate Matter (TPM) with new standards for PM_{10} and $PM_{2.5}$. Table 5 shows the revised EPA-NAAQS for particles and current standards for different countries *(HEIL, 1998)*.

Table 5: Current Ambient Air Quality Standards in Selected Countries *(HEIL, 1998)*

Air Quality Standards (values in µg/m³)	NAAQS (USA)		Germany	Indonesia
	PM_{10}	$PM_{2.5}$		
24-hour average	150	65	260	300[2]
Annual average*	50	15	-	150

*arithmetic mean

[2] 98-percentile value

As a tool for easily explaining air quality conditions to the public, EPA developed the Pollution Standards Index (PSI). This system comprises four pollutants including PM_{10}, which are monitored and each translated to an index value. The highest index value is reported as the PSI for the region of measurement. While the PSI ranges from 0 to 500, only values below 100 (Standard Index) are considered healthful *(HEIL, 1998)*. In the following table, only short-term standards for particulate matter are taken into account.

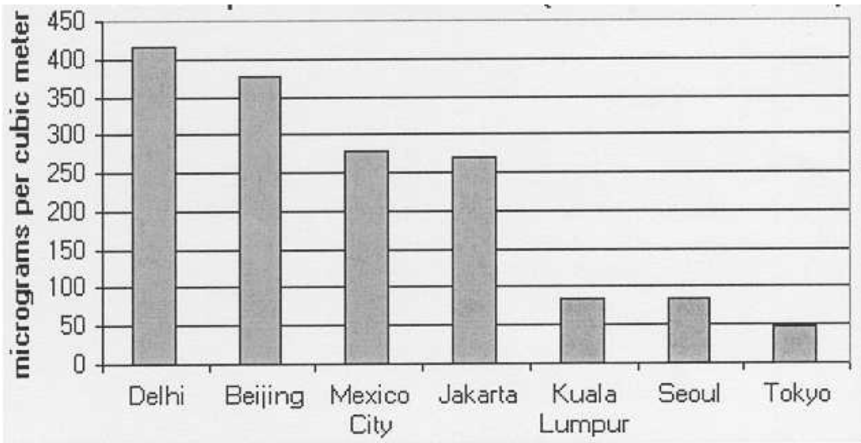
Table 6: EPA-PSI-system for TPM, PM_{10}, $PM_{2.5}$ (24 hour average concentration) ***(HEIL, 1998)***

PSI (NAAQS)	TSP (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	Air Quality Description
0 ≤ 50	0 – 75	0 – 50	0 – 15	Good
51 ≤100	76 – 260	60 – 150	16 – 65	Moderate
101 ≤ 200	261 – 375	160 – 150	66 – 150	Unhealthful
201 ≤ 300	376 – 625	360 – 420	151 – 250	Very unhealthful
≥ 301	≥ 626	430	251	Hazardous

II.2.2 Present Air Quality in Jakarta

Indonesia has made remarkable economic and social progress since 1967. The increase in industrial activity in Indonesia, which centralized in Jakarta, as a consequence of population growth and economic development, has been accompanied by the problems of air pollution. This city ranks as one of the most polluted cities in the world. Only Mexico City and some cities in China and India are regularly more polluted than Jakarta, especially in terms of suspended particulate matter (see Figure 3)*(EIA, 1999)*. One of the consequences of this problem is traffic congestion or transportation. It is estimated that transportation contributes almost 80% of the total air pollution in Jakarta, with other sources, such as industry and households, 20% *(ACHMADI, 1996)*. Congestion has increased dramatically in recent years, and daily commutes can easily turn into 4- or 5- hour ordeals *(WRI, 2000)*.

Figure 3: Total Suspended Particulates in Big Cities in Asia ***(EIA, 1999)***



Air pollution in Jakarta is a severe problem. It is reported that in the last decade, there was an increase of 15% vehicles per annum adding to the traffic congestion. According to the Jakarta Land Transport Organization, there are currently more than 3 million vehicles in Jakarta (1999), and their number is expected to increase every year *(EIA, 1999)*. This increasing number and density of vehicles, is followed with the increasing consumption of oil and other energy sources, like coal. The fast growing of vehicles is one of the major factors to the declining air quality. A survey conducted in 1985 exposed that the lead fumes emitted in the inner city district was 17 times higher than the WHO warning levels. Ambient levels of particulate matter exceed health standards at least 173 days per year *(WHO, 2000)*.

Table 7: Number of Motor Vehicles in Jakarta ***(GUNADI, 1996)***

	1990	1995	2005*)	1990-1995	1995-2005
Cars	485	829	1,790	119	8,0
Buses and Trucks	358	643	1,130	125	5,8
Motorcycles	763	1417	2,308	139	4,1
Total	1,582	2,889	5,228	128	6,0
Population Vehicles per 1000 inhabitant	192	311	436		

*) *Prediction Bappeda (District Planning and Development Agency, 1998*

Vehicle emissions are the most important source of pollutants (44% of particulates, 89% of hydrocarbons, 73% of nitrogen oxides, and 100% of lead). As in any industrializing megacity, there is a greater demand for automobiles which is the leader in causing air pollution which will worsen the current situation. Experts believe that the air pollution found in Jakarta is greater than that of New York or Paris. This situation is caused by the tendency of modern technology to over-exploit natural resources. Physical and material comfort is used as a norm for measuring one's successes or failures. The harmonic interrelationship among the human beings and between human beings and the environment has been vanishing steadily. There are also other factors that contribute the air pollution in Jakarta, which are the burning of solid wastes. This burning of solid wastes comes mainly from households and refuse recyclers *(WRI, 2000)*.

Jakarta's air pollution is associated with high level of respiratory disease. Respiratory tract infections, for example, account for 12.6% of mortality in Jakarta, more than twice the national average. Lead levels in the surrounding air and environment regularly exceed health standards by a factor of 3 or 4 and are associated with increased hypertension, coronary heart disease, and IQ losses in children *(WRI, 2000)*.

III MEASURING JAKARTA'S AIR QUALITY

III.1 Measurement by BAPEDAL and PCI Project

III.1.1 Perspective

Part of BAPEDAL (Environmental Impact Management Agency of Indonesia) and PCI (Pollution Control Implementation) Project is showing the extent to which motor vehicles, industry and other human activities contribute to air pollution in Jakarta. This project will provide a scientific basis for assessing the sources and environmental risk of fine particles. The results will be used to help establish control programs aimed at reducing pollution problems *(HOLPER, 2000)*.

Visibility problems in cities such as Jakarta are due to particles from many sources and products of photochemical smog resulting from emissions from motor vehicles and some industries *(HOLPER, 2000)*.

The heart of the most highly urbanised and industrial part of Indonesia, greater Jakarta's population is tipped to rise from 20 million to 30 million within fifteen years. With rising population come increasing motor vehicle numbers. Today, there are more than a million motor cycles and over 800,000 cars in Jakarta. Motor cycle registrations have been rising by 7% each year; cars by 10% *(HOLPER, 2000)*.

Indonesia's industry which centralized in Jakarta is growing at about 10% per year. By 2020, industrial activity is projected to be a phenomenal 13 times greater than it was in 1990 *(HOLPER, 2000)*.

Accompanying Indonesia's substantial economic expansion is potential for greatly increased emissions of air pollutants. Without intervention, emissions of sulfur dioxide and oxides of nitrogen are likely to triple during the next 15 years *(HOLPER, 2000)*.

Combine increasing population, motor vehicle numbers and pollution emissions, and a dramatic deterioration in air quality will occur. According to the World Bank, immediate action must be taken to reduce harmful emissions in Jakarta. Appropriate control programs and cleaner production methods are essential *(HOLPER, 2000)*.

III.1.2 Technique of Measurement

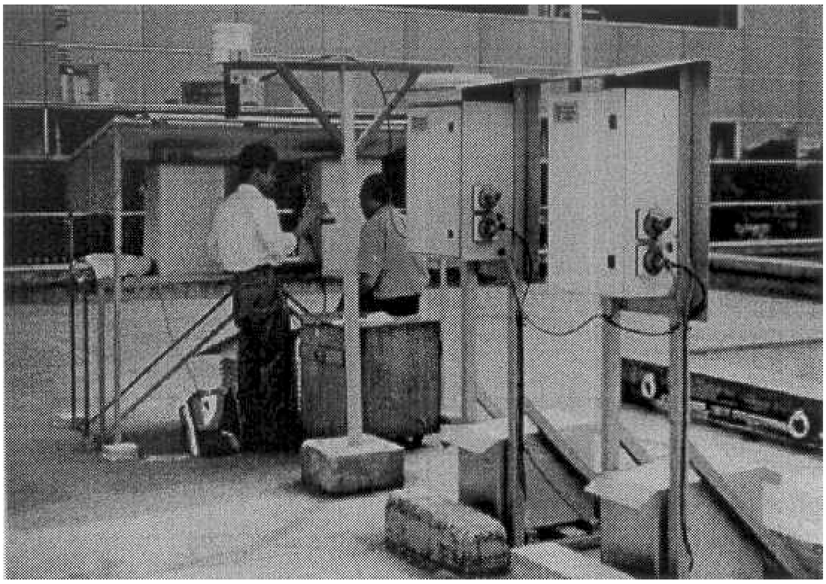
Every week since December 1995, staff from the Environmental Impact Management Agency (BAPEDAL), East Java Pollution Control Implementation (PCI) Project, Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) and Australian Nuclear Science and Technology Organization (ANSTO) climb to the top of JICA (Japan International Corporation Agency) Building at Thamrin Street, one of the busiest roads in central Jakarta. On the roof is an array of sophisticated analytical instruments that sample and continually monitor particle levels and haze in the city air *(HOLPER, 2000)*.

On JICA building roof, the scientists have installed a sensitive monitoring device (Figure 4) for polycyclic aromatic hydrocarbons (PAHs). There are numerous PAHs and many are carcinogenic: they are a significant health threat posed by aerosol particles. Continuous PAH readings are extremely valuable for pinpointing particle sources *(HOLPER, 2000)*.

The BAPEDAL and PCI Project is to discover the composition and daily changes of PM_{10} and even smaller airborne particles, such as $PM_{2.5}$ (particles less than 2.5 microns in diameter). These ultra-small particles penetrate deep into the lungs *(HOLPER, 2000)*.

To measure visibility, the scientists are using a nephelometer. The instrument draws dried air into a long tube. Bright light at one end of the tube illuminates the air. A photomultiplier measures the fraction of light scattered by airborne particles. A simple calculation converts light scattering into a measure of Jakarta's visibility, also known as local visual distance *(HOLPER, 2000)*.

Figure 4: ANSTO Particle Samplers on the Rooftop of the JICA Building in Jakarta
(HOLPER, 2000)



ANSTO has installed two types of fine particle air samplers. $PM_{2.5}$ particles are collected on teflon filters. Polycarbonate filters trap larger particles. Filters are regularly shipped to ANSTO's laboratories in Sydney. The laboratory uses ion beam techniques that require little sample preparation to accurately measure the concentrations of up to 30 elements in the particles collected on the filters *(HOLPER, 2000)*.

The measurements will help determine the composition of particles from car exhausts and other sources of fuel combustion as well as factory emissions, soil dust and sea-salt spray. This will be valuable information for determining the sources of Jakarta's fine particles *(HOLPER, 2000)*.

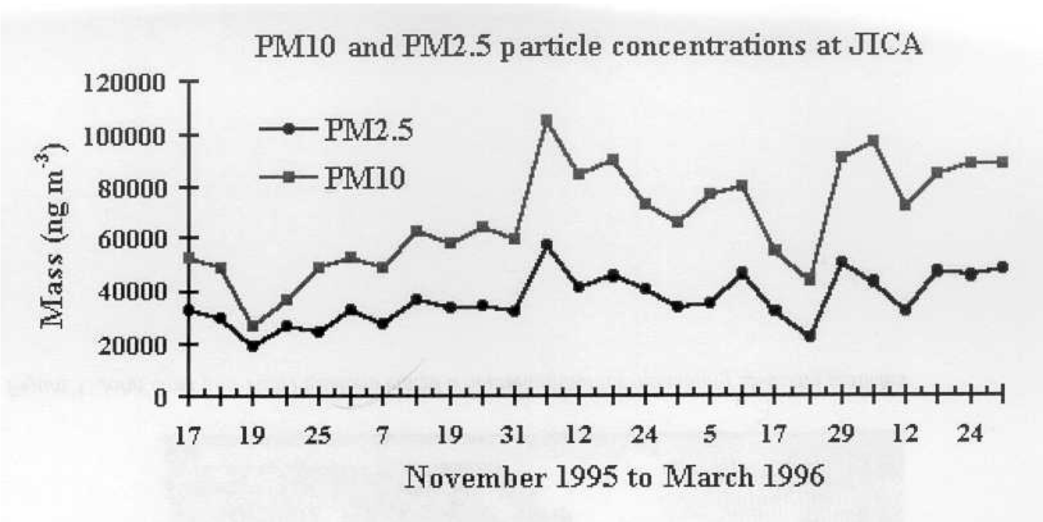
CSIRO's passive air samplers measure levels of sulfur dioxide, nitrogen dioxide and ammonia in the air. The samplers rely on impregnated filter paper absorbing these gases. After exposure, the filters are posted to CSIRO's Melbourne laboratories for analysis *(HOLPER, 2000)*.

III.1.3 Results

1. High concentrations of fine particles in the central of Jakarta are primarily due to motor vehicle emissions. Occasional high lead levels confirm motor vehicles as a significant pollution source.

2. $PM_{2.5}$ levels are usually higher in the central of Jakarta than at any other sites. Nephelometer readings show that local visual distances in Jakarta are poor, typically between 5 and 17 kilometers. Visibility (and therefore fine particle level) is worst at around 7 am and in the evening. The morning peak coincides with peak traffic volume whereas the evening peak may be the result of more complex combination of traffic and domestic emissions, chemical reactions in the air and changes in atmospheric stability.
3. Fine particle concentrations are higher in the dry season than in the wet. However, there is a strong day-to-day variation in particle composition.
4. Sulfur dioxide levels are low, but concentrations in the central of Jakarta are about double those elsewhere.
5. Nitrogen dioxide shows a similar pattern, but at substantially higher concentrations *(HOLPER, 2000)*.

Figure 5: PM_{10} and $PM_{2.5}$ Particle Concentrations measured at JICA Building in Jakarta *(HOLPER, 2000)*



III.2 Measurement by BMG (Meteorological and Geophysics Agency of Indonesia)

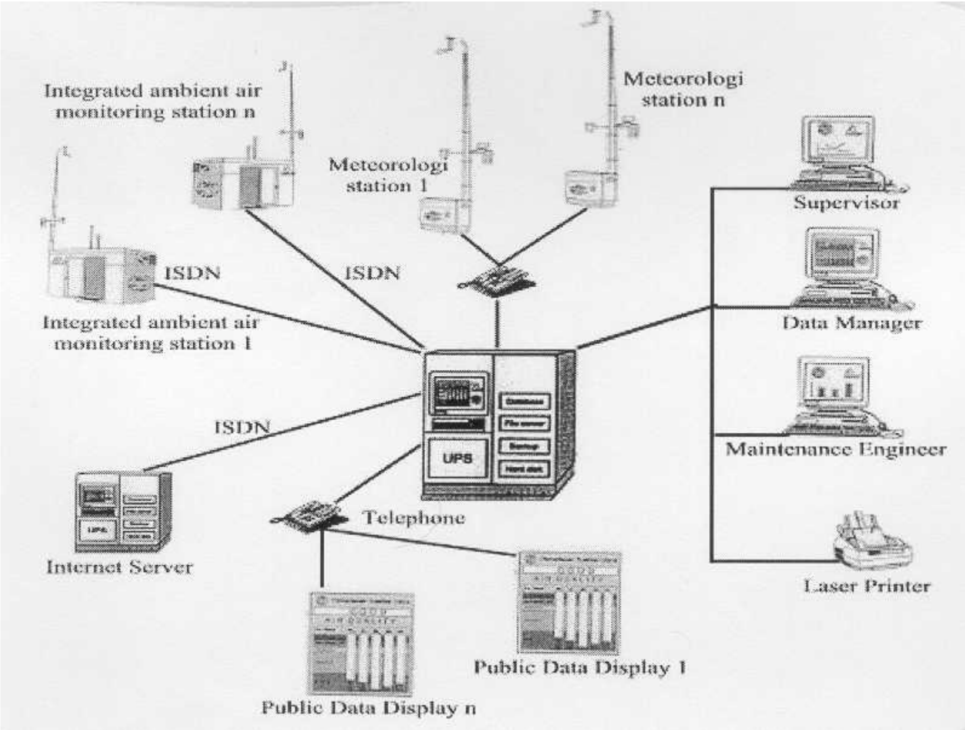
III.2.1 Perspective

There are six air quality monitoring station that has been installed in several areas in Jakarta which are in the central office of BMG, in Bandengan, in Glodok, in Ancol, in Monas and in Cileduk *(BMG-INDONESIAN METEOROLOGICAL AND GEOPHYSICS AGENCY, 1998)*.

III.2.1.1 Technique of Measurement

The schema to install the air quality monitoring station used by Meteorological and Geophysics Agency can be seen in the Figure 6 below:

Figure 6: Regional Ambient Air Monitoring
(BAPEDAL-INDONESIAN ENVIRONMENTAL IMPACT MANAGEMENT AGENCY, 1999)



III.2.1.2 Results

For particles, the highest monthly mean concentration is 310 μg/m^3, occurs on September, and the lowest monthly mean concentration is 273 μg/m^3, occurs on July for 24 hours *(BMG-INDONESIAN METEOROLOGICAL AND GEOPHYSICS AGENCY, 1998).*

For nitrogen oxide (NOx), the highest monthly mean concentration is 73o *ppb*, occurs on October, and the lowest monthly mean concentration is 100 *ppb*, occurs on August for 24 hours (The Indonesian Pollutant Standard Limit for NOx is 50 *ppb*/24 h) *(BMG-INDONESIAN METEOROLOGICAL AND GEOPHYSICS AGENCY, 1998).*

For sulfur dioxide (SO_2), the highest monthly mean concentration is 100 *ppb*, occurs on October, and the lowest monthly mean concentration is 1 *ppb*, occurs on September for 24 hours (The Indonesian Pollutant Standard Limit for SO_2 is 100 *ppb*/24 h) *(BMG-INDONESIAN METEOROLOGICAL AND GEOPHYSICS AGENCY, 1998).*

For surface ozone (O_3), the highest monthly mean concentration is 10.30, 15.83, 15.08, 13.30 *ppb*/h, occurs on July-October (The Indonesian Pollutant Standard Limit for O_3 is 100 *ppb*/h) *(BMG-INDONESIAN METEOROLOGICAL AND GEOPHYSICS AGENCY, 1998).*

III.3 Measurement by LIPI (The Indonesian Institute of Science) and NEDO (The New Energy and Industrial Technology Development Organization) of Japan

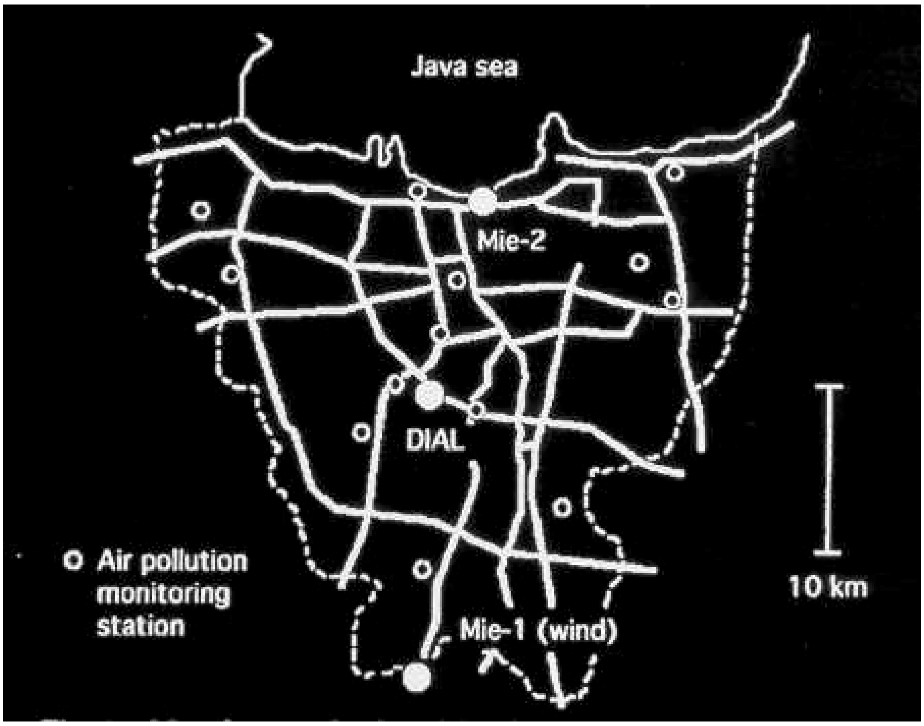
III.3.1 Perspective

Jakarta city faces the Sea of Java to the north, and a typical air pollution phenomenon which is generated by photochemical reactions of pollutants and transportation by a sea/land breeze is believed to be occurring in Jakarta. The wind system in Jakarta is a combination of seasonal wind and sea/land breeze. The seasonal wind is westerly in the wet season and easterly in the dry season. During the transition period, this seasonal wind is weak and there is heavy air pollution *(PINANDITO et al., 1998).*

Lidar is known to be an effective tool for measuring the vertical profiles of aerosols and pollutants such as ozone, SO_2 and NO_2. A lidar network system consisting of two Mie scattering lidars and one differential absorption lidar was constructed to study the air pollution phenomenon in Jakarta. Construction of the lidar was directed by the Optoelectronic Industry and Technology Development Association (OITDA). Mia scattering lidars are for measuring vertical profile of aerosols. One of the Mie scattering lidars has a wedge window conical scanner for measuring wind profile using the time correlation method. The differential absorption lidar (DIAL) system measures ozone, SO_2, NO_2, and aerosols, and has full scanning capability. The two Mie scattering lidars and the DIAL system are controlled from a central data processing system by telephone lines and a local network. Three lidars are installed at three locations (Mie-1 in Depok (south of Jakarta), Mie-2 in Ancol (north of Jakarta), DIAL at Gatot Subroto Street (central of Jakarta)) (see Figure 7) along a line perpendicular to the coast to measure atmospheric boundary layer structure[3] and transportation of air pollutants by the sea/land breeze. The lidar network system was completed in Jakarta in March 1997 *(PINANDITO et al., 1998).*

[3] Atmospheric boundary layer is the layer up to approximately 2 km above the ground *(PINANDITO et al., 1998)*

Figure 7: Map showing the three Lidar Locations in the Jakarta Region *(PINANDITO et al., 1998)*



III.3.2 Technique of Measurement

III.3.2.1 Mie Scattering Lidar System

The two lidars have the same design except that one, called Mie-1 has a conical scanner for wind profile measurement. The lidar system is installed in an air-conditioned container. These lidars employ a compact flash lamp pumped Nd: YAG laser. Fundamental at 1064 *nm* is used instead of the second harmonics, simply because it is invisible and suitable for operating continuously in an urban area without drawing unnecessary attention *(PINANDITO et al., 1998).*

III.3.2.2 Differential Absorption Lidar System

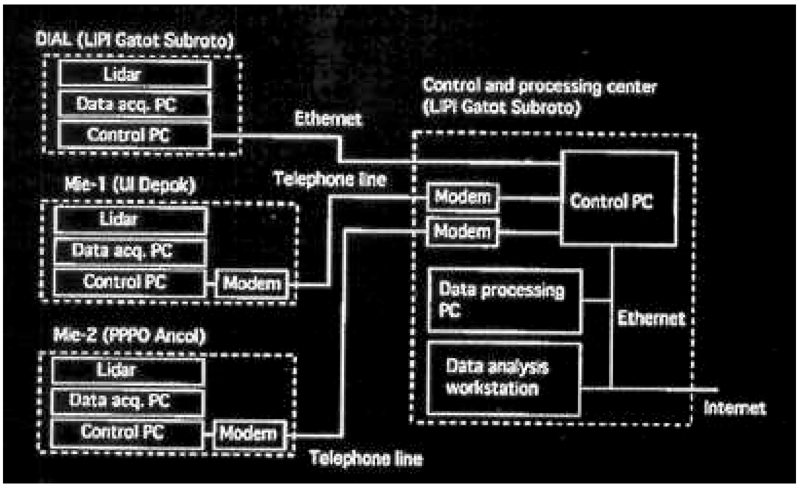
The DIAL system employs two commercial Nd: YAG laser-pumped optical parametric oscillators (OPO; Spectra Physics MOPO 730). The DIAL is designed for measuring distribution of ozone and SO_2 in the 300 *nm* region, and NO_2 in the 450 *nm* region. The beams from two lasers are combined with a polarization coupler. Another feature of the

DIAL is the use of a low power laser at 355 *nm* for detecting obstacles to ensure eye safety during scanning measurements *(PINANDITO et al., 1998)*.

III.3.2.3 Central Data Processing System

The measured data are transferred to this system and analyzed. Figure 8 shows a block diagram of the system which consists of an engineering work station and a PC (Personal Computer). In remote operation mode, the measured data are automatically transferred to the hard disk of the central workstation. The data stored on the hard disk is then processed and analyzed by the work station and the PC *(PINANDITO et al., 1998)*.

Figure 8: Block Diagram of the Central Data Processing System *(PINANDITO et al., 1998)*

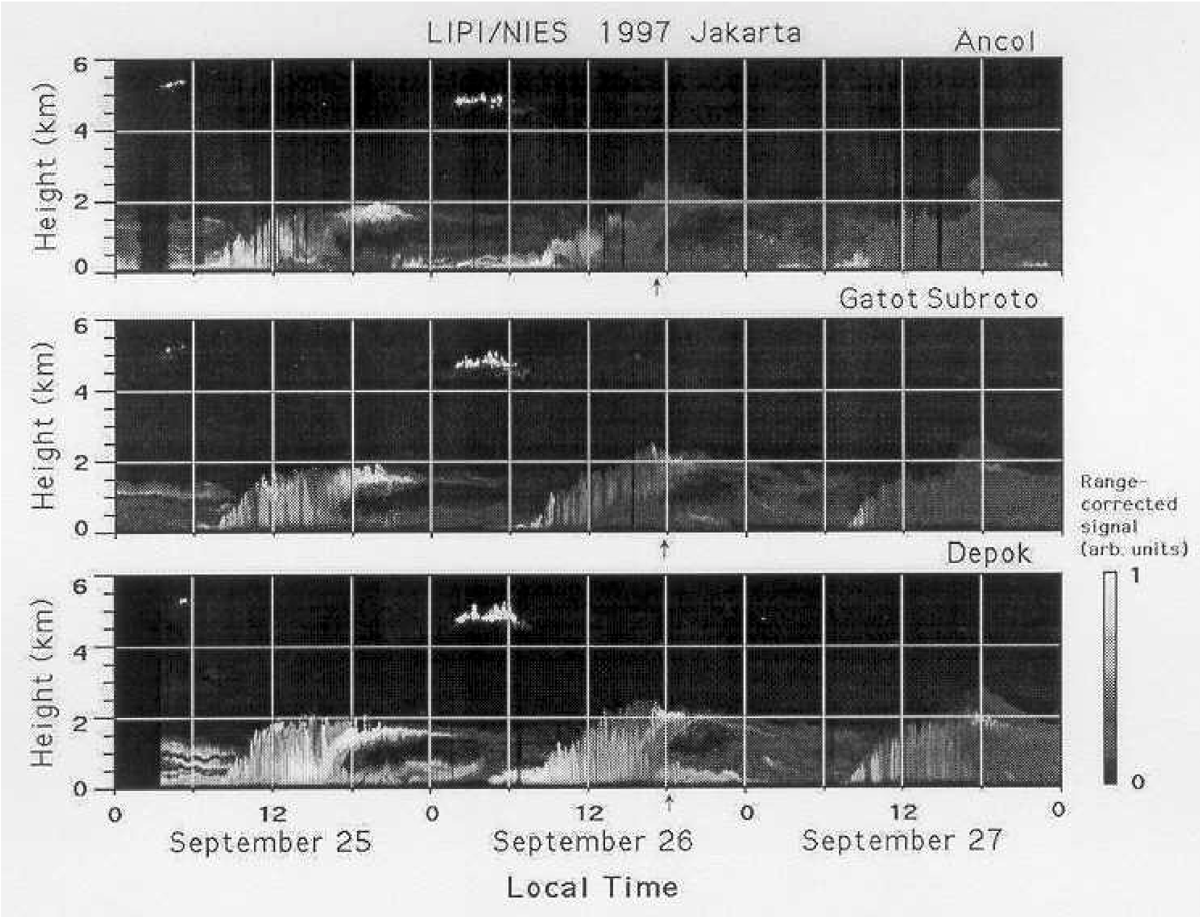


III.3.3 Results

Figure 9 clearly shows the diurnal variation of the planetary boundary layer structure. The mixed layer started to grow in the morning and reached a maximum height of approximately 2.5 km in the afternoon. At around 17:00, air masses with low aerosol concentration entered at a height of approximately 1 km. It is presumed that these air masses were transported by a sea breeze *(PINANDITO et al., 2000)*.

By comparing the time at which the front of the air mass passed over the three locations, we can see that there was a time lag and the air mass was transported from the sea. An arrow at the bottom of each panel of Figure 6 indicates the front of the clear air mass on September 26. The time lag was approximately 65 minutes between Ancol and Depok (distance about 20 km), corresponding to a velocity of 5 m/s *(PINANDITO et al., 2000)*.

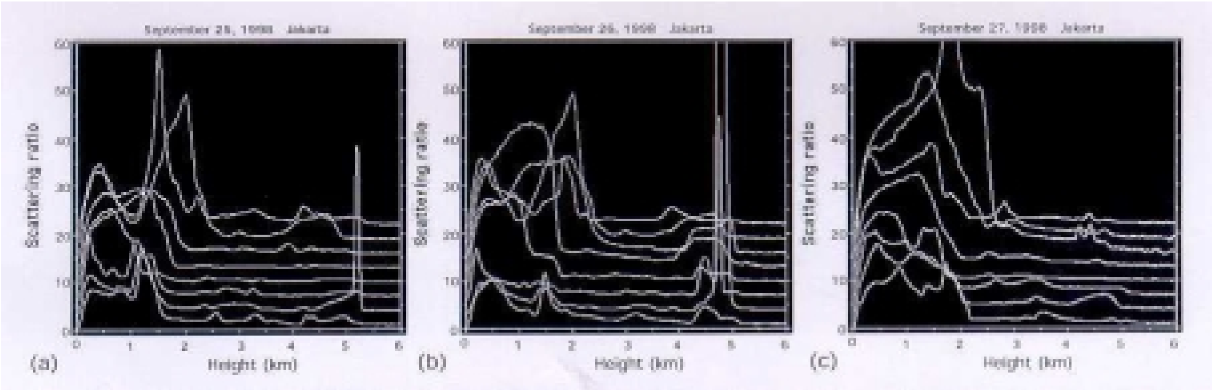
Figure 9: Temporal Variation of the Vertical Profile of Aerosols from September 25 to 27, 1997
(PINANDITO et al.,2000)



To discuss the absolute concentration of aerosols, we derived the scattering ratio (the ratio of the total backscattering to Rayleigh scattering) by solving the lidar equation using Fernald's method) assuming the extinction-to-backscatter ratio or the lidar ratio for aerosols, which is known as the S_1 parameter. We assumed S_1=50 sr, considering the continental polluted aerosol in the Optical Properties of Aerosols and Clouds (OPAC) model *(PINANDITO et al., 2000)*.

Figure 10 (a) through (c) show the results. The baseline for each plot is shifted by 3 from the previous one. The scattering ratio obtained is not sensitive to S_1 in this case because the aerosol layer was not optically dense. The results show that the scattering ratio at 1064 *nm* was 14 to 17 in the planetary boundary layer before penetration of the clean air mass from the sea, and approximately 5 in the sea breeze region *(PINANDITO et al., 2000)*.

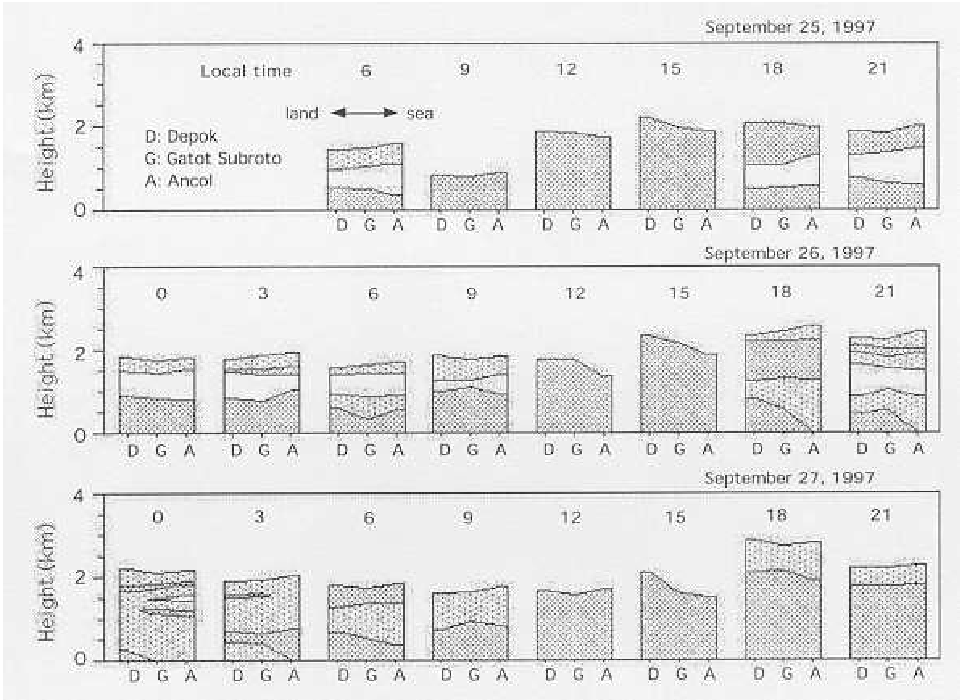
Figure 10: Scattering Ratio derived from the Lidar Data *(PINANDITO et al., 2000)*



The sea breeze velocity of 5 m/s obtained from the lidar data on September 26 agreed qualitatively with the wind speed measured with sonde, but there is not sufficient wind data for quantitative comparison. Northerly wind was observed at 15:00 in Pekayon near Depok, however, the clean and dry air mass from the sea was actually observed at 18:00 with the lidar in Depok. This suggests that aerosols were distributed above the sea near the coast, and it took time to transport the clean air mass located offshore. The wind structure and the aerosol distribution observed by the lidar suggest that the layered structure at the top of the boundary layer in the nighttime was formed by the reverse flow of the sea breeze *(PINANDITO et al., 2000)*.

The spatial structure of the aerosol distribution extracted from the lidar profiles is indicated in Figure 11. Because there are only three locations to indicate spatial structure, we simplify the aerosol vertical profiles and connected the characteristics layered structure by eye. The gray scale in the figure indicates the qualitative aerosol concentration. Figure 11 indicates that the maximum mixed layer height in the afternoon was higher in the inland location. For example, it was 1.75 km at Depok and 1.9 km at Ancol at 3:00 on September 26, 1997. The structure of the aerosol distribution near the surface was complicated *(PINANDITO et al., 2000)*.

Figure 11: Simplified Spatial Structure of Aerosol Distribution extracted from the Lidar Profiles at the three locations *(PINANDITO et al., 2000)*



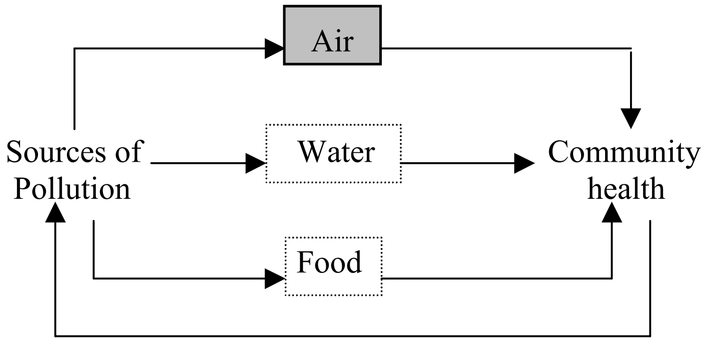
IV PUBLIC HEALTH IMPLICATIONS OF AIR POLLUTION IN JAKARTA

IV.1 Perspective

It is only natural that any air pollution control program may not have any practical results until the mechanism of air pollution and its health effects are revealed by epidemiological studies. The first step of an epidemiological study of air pollution is to establish an association between pollutant exposures and health effects. Estimates of personal exposure to a pollutant which are compared with health effects in the community are usually derived from ambient air quality measurements made at one or more authorized monitoring stations within a community *(KASUGA, 1989)*. This epidemiological study is then done by Achmadi to relate the air pollution in Jakarta and the health effect implications to some groups of people in Jakarta.

Achmadi has defined *Epidemiology (ACHMADI, 1996)* as the study of the distribution and determinants of health related states or events in specified populations and the application of his study to the control of health problems. The overall epidemiological model for the environmental pollution related to health could be drawn as follows:

Figure 12: Epidemiological Model for Environmental Pollution and Health ***(ACHMADI, 1996)***



As shown in Figure 12, potential adverse effects can directly affect a community through air. Using this model, we can see the trends in pollutant sources, transmission level and public health implications *(ACHMADI, 1996)*.

IV.2 Technique of Measurement

Studies were done in 1982 on the ambient level of air pollutants in Jakarta. Scattered and incidental monitoring has been conducted at places believed to be industrial, trade and traffic areas, as well as settlements. The study team then concluded that, in general, suspended particulate matter was an air pollutant problem, since the air pollutants were recorded above the National Air Quality Standard (AQS) level. NO_2 was also recorded above the level of Air Quality Standard in some points of measurement *(ACHMADI, 1996)*.

Relatively more systematic measurements, from which the trend in air pollution could be deduced were made by the Research Center for Urban and Environments Studies in 1984, 1985, 1986, 1987, 1988 and 1999. The available data indicate that, although there were fluctuations, a slight increase in the level of air pollutants occurred. An increase for the period of 1982-1984 was followed by the period 1986-1989. It was forecast that, without action all eight parameters of air pollution will reach or cross the line for Air Quality Standard level, in 5 to 10 years *(ACHMADI, 1996)*.

We then could conclude that, some pollutants in Jakarta showed an increasing level from year to year *(ACHMADI, 1996)*.

IV.3 Public Health Implications

IV.3.1 Survey

Around the world, in many urban and regional centers, particle pollution is emerging as a threat to human health. The finest particles seem to be the greatest problem. The United States Environment Protection Agency estimates that PM_{10} particles – those smaller than 10 microns in diameter – may be the cause of 60,000 premature deaths in the US each year. PM_{10} particles can penetrate deep into the lungs, causing respiratory difficulties. They also trap toxic pollutants and carry them into the bloodstream *(HOLPER, 2000)*.

Studies of environmental pollutants and human health are usually based on several episodes in which sudden peaks of, for example, air pollutants have been associated with immediate morbidity and mortality patterns. Correlation such as measuring the air pollutant associated with the fluctuation in upper respiratory tract disease have been few in Jakarta *(ACHMADI, 1996)*.

Some correlation studies of health and environmental pollution have been done in Jakarta by universities and/or the Ministry of Health, using medical records of health centers and/or hospitals *(ACHMADI, 1996)*.

Among air pollutants emitted by mobile sources in Jakarta are tetra ethyl lead (Pb) and carbon monoxide, both of which have potential adverse systemic health effects. These effects can be monitored practically and specifically. Therefore they can be utilised as indicators of the public health effects of air pollution in urban areas like Jakarta. But the impact of air pollution in Jakarta, influenced not only the human body directly but also to food and water indirectly. Studies of food contaminated by environmental pollutants, shows that many vegetables planted near busy roads contain lead (especially in low level socio-economic communities); the vegetables had a Pb content above the Tolerable Weekly Intake according to the WHO standard *(ACHMADI, 1996)*.

Achmadi in his study also analysed the risk differences among sub-groups of the population exposed to air pollutants in Jakarta.

Smoking adds to other sources of air pollution. Among the population under his study, only 19% of the *bajaj* (mini-taxi) drivers, 16% of the street vendors and 10% of the population in slum areas were not smokers. In other words, the majority may well be worsened by combined ambient air and tobacco pollutants. Tobacco smoking is an important source of CO as a pollutant, and usually makes the largest contribution to the CO body burden in those who smoke. The guideline for lead in air should be based on the concentration of lead in blood. A blood lead value of 0.02 µg/100mL may be regarded as the borderline for dividing the non adverse-effect from the lowest-adverse-effect level. In the population studied, average lead concentration of COHb among policeman have been reported to be 25 - 31.69% *(ACHMADI, 1996)*.

While the mean Pb for a control minimally exposed group was 0.0065 µg/mL, city slum dwellers, bajaj drivers and street vendors had averages of 0.0928, 0.0697 and 0.0290 respectively. There were no differences in COHb between urban and rural populations, but there were significant differences in Pb level. Urban populations tend to have higher average levels of Pb *(ACHMADI, 1996)*.

The level of Pb among slum area dwellers were so high (mean 0.0928 µg/100mL) maybe due to food contaminated by Pb from the air and other sources. The most important pathway by which atmospheric lead enters the food chain is thought to be direct food and foliage contamination. The contamination depends on the rate of fall out *(ACHMADI, 1996)*.

IV.3.2 Risk Analysis

By analysing the odds-ratios, the relative risk for air pollutant effects for each segment (group) of the urban population in Jakarta could be ascertain as follows *(ACHMADI, 1996)*:

1. The blood Pb level could be used as the indicator of the effect of air pollutant in the exposed group. For example, bajaj driver, slum area dwellers and street vendors combined had a relative risk 12.8 times the reference group i.e. minimally exposed people in the rural area. City dwellers in the study had risk based on the blood Pb 27.4 times that of the reference, and the bajaj driver group 15.4 times that of the reference. For the street vendors, relative risk was 4.4 times that of the reference. Perhaps these people lived in areas that are not heavily polluted.
2. The pollutants found in certain working conditions and environments in Indonesia (especially Jakarta) can also be reviewed.
   Among 70 workers of a lead acid battery recycling shop for example, 77.6% of the workers surveyed had blood lead above 0.0025 mg/100 mL. Heavy metals such as cobalt, iron, cadmium, mercury, Hg, molybdenum, and silver can adversely affect spermatogenesis and accessory sex organ function. Lead is known to be capable of

producing teratospermias, and probably plays a role in the increased incidence of stillbirths.

The total Hg blood levels of a community surveyed nearby oil drilling activities ranged from 0.33 – 7.83 µg/gr *(ppm)* compared to a community living where there are no oil drilling activities 0.24 – 3.49 µg/gr. Although these figures are considered acceptable, the accumulation of Hg in the population is threatening, since the vegetables being consumed by the populations in the area of activities, ranges from 12.5 - 50 *ppm*. The WHO limits is 30 *ppm*. Studies also document risk in workers exposed to mercury pollution in the gold workers and dentistry *(ACHMADI, 1996)*.

The above figures indicate that some heavy metals have potential for effects on the reproductive system. Yet studies of clinical outcomes on the reproductive system have not been done. But studies of contaminant pathways and bioindicators reveal above acceptable values *(ACHMADI, 1996)*.

From the above description, we can conclude, that the current levels of air pollution in Jakarta, already have the potential for public health impact. Of particular concern and surveillance value are atmospheric particulate matter, sulfur dioxide, nitrous oxide, carbon monoxide and heavy metals (lead, cadmium and mercury). Control strategies for air pollution and public health programs for high risk groups are needed.

V MANAGEMENT OF AIR POLLUTION IN JAKARTA

There are several moves being campaigned and run in reducing the air pollution in Jakarta, such as "Blue Sky Program", "1 Million Trees Campaign" and "1 Million Parks Campaign". Following that, several new city parks were being built. The Medan Merdeka Park in the Monas area for example, was upgraded with a budget of billions of rupiahs[4] (Rupiah is Indonesia's currency). The local government of the Jakarta Metropolitan area plans to build 6,500 ha of park land to compare the 650 km²/65,000 ha of the city of Jakarta, which means a tenth of the city size *(KOMPAS, 1997)*.

But up till now only 50% is being realized (around 3,250 ha). The ideal image is 9,750 ha opened green land in Jakarta, specifying in 3,250 city forests and 6,500 ha city parks. But

[4] Since the economic crisis in 1997, the value of Rupiah is getting worse.
At February 12, 2001, 1 EUR ≈ Rp. 8650,-

in reality only 4,000 ha opened green land (873 ha city forests and 3,250 ha city parks) are to be seen *(KOMPAS, 1997).*

Along both side of the Mookervaart river and along the south side of the Daan Mogot Street, West Jakarta, to the Tangerang district, a primary park was being built in October 1997. The Governors of Jakarta Metropolitan area has also invited the owners and managers of the skyscrapers along-side Thamrin Street, talking them in to participating in an effort to create a much more beautiful and fresh air Thamrin district. They were asked to bring down their gates and broader the sidewalks to 7-8 m. Billions of rupiahs would be brought-in to accomplish this task. If it works out, this 1.6 km long sidewalk along-side the Thamrin is going to be the one of the most beautiful district in Jakarta, and of course also reducing the air pollution in this area *(KOMPAS, 1997).*

V.1 Blue Sky Program

In accomplishing the "Blue Sky Program", the air pollution control is focused on the pollution sources from vehicles and industries, because both of them has the largest contribution to air pollution in Jakarta Metropolitan area. The two have a different classification in its source movement, so in implementing the pollution control, one must use different methods. The Blue Sky Program consists of *(BAPEDAL, 1999)*:

- Air pollution control over the vehicles (mobile pollutant sources), and
- Air pollution control over the industrial activity (immobile pollutant sources).

The successful application of the Blue Sky Program for immobile pollutant sources (industries) is measured by *(BAPEDAL, 1999)*:

- the improvement of the ambient air quality
- emission reduction

The successful application of the Blue Sky Program for mobile pollutant sources (vehicles) is measured by *(BAPEDAL, 1999)*:

- the gas energy policy for motor vehicles, mostly for taxis and public transportation
- socialization of the use of non-lead benzene, such as ambient air quality improvement in

highways, tests for private or official cars, and the role of the community in maintaining and driving their cars in the right way.

As part of the program to campaign a clean pollution-free air in Jakarta, BAPEDAL supported by *Swisscontact* and the Police Department has just completed the 3rd Emission Reduction Week Program, which began on April 14, and ended on May 14, 2000. The 3rd Emission Reduction Week Program this time was participated by 117 auto-repair services in Jakarta. A total of 7,942 benzene- and diesel-engined motor vehicles from 23 vehicle brands were tested in an auto-repair garage of one of the participants (see Figure 13) *(N.N., 2000).*

Figure 13: Emission Control for Motor Vehicle *(N.N., 2000)*

The result of the Blue Sky Program concerning mobile sources are *(BAPEDAL, 1999)*:

- Lead-free benzene. It was the statement of the President of the Republic of Indonesia that mentioned, that benzene containing lead will at least by the end of year 1999 not be produced anymore. The marketing of lead-free benzene was started in August 1995 with the name Super-TT. The usage of Super-TT in the cars can: create a clean air, minimize the maintenance costs, improving the performance of the engine and economize the fuel-usage *(N.N., 2000)*.
  BAPEDAL will soon also establish a few rules: the State-Ministers Decision concerning the Emission-Quality Standard of new cars and motorcycles. Besides that, on May 18, 1997, a lead-free low octane benzene was marketed (RON 86), Petro 2T, especially for motorcycles in Jakarta.

- The use of air pollution control equipment. A catalic converter will be installed in every new cars; - new cars with carburator systems: installed with passive catalic converter.
  - new cars with injection systems: installed with 3-way catalytic converter (active)

V.2 1 Million Trees Campaign

Jakarta's badly polluted air caused from the excessive gas from motor vehicles may be reduced by planting certain plants that are proved useful in reducing air pollution. That was the idea of "1 Million Trees Campaign". Research shows, there are 5 species of woody plants and 5 species of shrubs aside from several other grass suitable for air pollution reduction *(KOMPAS, 1997)*.

Researches on several pollution-suitable plants were run not only in the labor of the Research and Development Center of the Public Affairs Department, but also in field studies in Bogor, Bandung and Jakarta. Five trees that were proved to be able to reduce air pollution are *Felicium decipiens*, *Swietenia mahagoni*, *Canarium commune*, *Syzygium polyanthum* and *Elaeocarpus grandiforus*. And shrubs suitable for that are *Codiaeum variegiatum*, *Werkisiana*, *Mussaenda sp.*, *Ixora javanica* and *Hibiscus rosa-sinensis*. In the laboratory, these shrubs have proved to reduce air pollution from 47-69% *(KOMPAS, 1997)*.

Besides those plants, several grass species may also reduce air pollution. The average height of trees being examined in field studies were 9.83 – 12.35 m. Aside from reducing air pollution, these trees can also beautify the environment along the streets *(KOMPAS, 1997)*.

V.3 1 Million Parks Campaign

The growth rate of the citizen of Jakarta Metropolitan area according to the official authority reaches 1,000 person/days, what makes the available land more and more scarce. Almost any empty space left is used, even riverbanks *(KOMPAS, 1997)*.

With the Million Parks Campaign, plenty of unmanaged spaces used by illegal dwellers, were officially organized and turned into parks. This move was quite difficult in its realization, because the authority had to face the illegal dweller hanging around government property *(KOMPAS, 1997)*.

Data from the Park officials of West Jakarta shows that even within lots of delays, this project kept going on. The amount of parks being built kept growing from time to time. Data from 1995 showed that existing parks numbered 55 locations, covering a 10.64 hectare area; green boulevards along roadsides 131 covering 64.78 ha, green boulevards in the city 28 with 6.63 ha. Two years after, in 1997, the amount of parks grew to 94 locations covering an area of 12 hectare area; green boulevards along roadsides 150 covering 66 ha, green boulevards in the city 35 with 8.5 ha *(KOMPAS, 1997).*

One of the park that being renovated is Medan Merdeka Park. This park is located near the Merdeka Palace or the President Palace. The gardening of this park is hoped to be finished at the end of 2001. The budget still needed until the end of this project is estimated around 30 billions rupiahs. It is said that the budget used to create the Medan Merdeka Park since budget year 1994/1995 to 2000 has reached a sum of 70 billions rupiahs. But till now, it is not yet finished and will be carried on in the budget year 2001. The greening designing including woody plants/protective plants has reached a number of 1,800 trees from the planned 4,886 trees, whereas 404,360 m² shrubs and grass has been planted from the planned 463,000 m² *(SUARA PEMBARUAN, 2000).*

V.4 Improving the Bus Management System

The cities which depend mainly on road transportation like Jakarta Metropolitan area are experiencing social and economic difficulties resulting from increased population and an increase in the use of motor cars. There have been, for instance, increases travel time and frequent traffic accidents due to chronic road congestion, as well as environmental problems such as noise, vibration and air pollution, and increased energy consumption. These problems will only be further aggravated with increasing urban transportation demand so long as urban transportation continues to rely on road transportation *(GUNADI, 2000).*

The concern arises from recognition that increasing car dependence in most cities represents a major environmental threat and increase inequities between those with access to cars and those without it. It is therefore important to seek out efficient and effective ways to improve the quality of the natural environment and the inequity problems through the shaping of future urban public transport *(GUNADI, 2000).*

Public transportation in Jakarta is mainly dependent on bus operation. However, punctual bus operation is hindered by serious traffic congestion on operation routes and bus terminals in recent years, and this has reduced transportation capacity. The low transportation capacity of the existing public transport can be mainly attributed to longer headways, inadequate bus feeder services caused by poor access, a lack of punctuality and poor reliability, comfort and lack of information on public transport routes and schedules *(GUNADI, 2000)*.

In brief, the low performance of the public transport system particularly the bus system in Jakarta is caused by the public transport system becoming less and less attractive as an urban transport mode. The lack of public transport provision has caused increased dependence on private cars, inefficient use of resources, deterioration of environment and created social equity problems which lead to unsustainable life patterns. Therefore, the need is to reduce private car dependence through improvement of public transport management *(GUNADI, 2000)*.

This Bus Management System improvement is suitable with the agenda 21 that has been established by the central government of Indonesia. Agenda 21 mentioned that:

> *"...Transportation strategies should reduce the need for motor vehicles by favouring high occupancy of public transport and providing safe bicycle- and footpaths..." (GUNADI, 2000)*

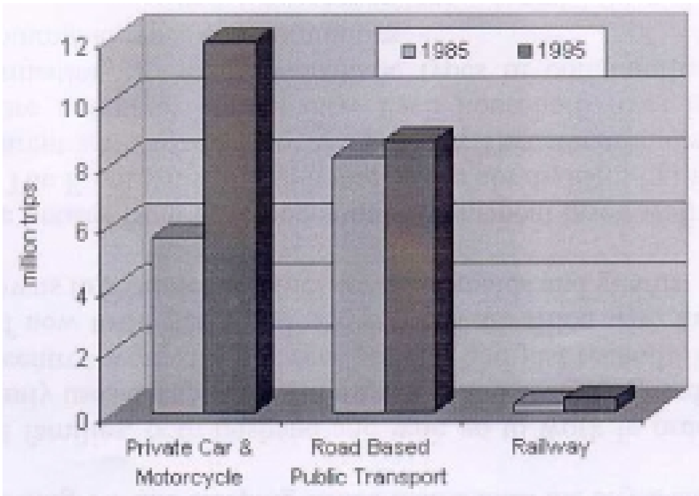
In term of its function, a well-established public transport system can make a positive contribution to economic efficiency, environmental sustainability and social equity by *(GUNADI, 2000)*:

- Overcoming growing traffic congestion that leads to a less efficient city economy
- Meeting the need to maintain and expand transport infrastructure with limited funds
- Protecting the community and the environment from the adverse impacts of transport, such as declining air quality and urban amenity
- Dealing with the growing relative isolation of people without access to cars

Public transport operates with a larger capacity of passengers and provides significant total trip reductions compared with the same trips made by automobile. Reduction of total trips contribute in reducing consumption of fuel and reduce air pollution which leads to a more efficient use of scarce resources and reduced threats to life and health. As mentioned in the World Bank Report, the cost of health damage from air pollution in Jakarta is estimated at about US$ 219.9 millions per year *(GUNADI, 2000)*.

Based on a survey from JICA in 1985, 14 million-transport trips are made daily in the Jakarta Metropolitan area. About 63% of trips were made by public transport (8.2% million by bus system and 0.2 million by railway). In 1995, in the Jakarta Metropolitan area, with the population close to 20 million inhabitants, there were some 21 million-transport trips made daily. A majority or 11.9 million, were made by cars (6.8 millions) and motorcycles (5.1 millions). Public buses accounted for only 4.7 million trips, other road vehicles 4 million and railways 0.4 million (see Figure 14).

Figure 14: Growth of Vehicle Trips ***(GUNADI, 2000)***



In the ten-year period from 1985 to 1995, the relative proportion of trips using public transport was lower due to as increase in the use of private motor vehicles *(GUNADI, 2000)*.

There are basically three type of buses in Jakarta: the City Bus, a large bus with 50 (single deck) to 85 (double decker) seating capacity; the Mini Bus, a medium size bus with 30 seating capacity and Mikrolet, a small bus with about 9 seats capacity. There are a total of 13,000 buses in Jakarta consisting of 23% City Buses, 29% Mini Buses and 48% Mikrolet *(GUNADI, 2000)*.

Improving the system of bus management for Jakarta in the year to come become responsible of all sectors, the Local Government of Jakarta, the private sector and the community. The recommendations would be as follow *(GUNADI, 2000)*:

- The Local Government of Jakarta should determine the level of standards, fare and operational procedures which most appropriate and acceptable to their community.
- Determination of an appropriate and agreement of fares structure and fares policy should be achieved through public meeting which involve the government with different

institutions, the private sector and the community, in order to provide an integrated fare and ticketing system in competitive operating environment.

- Bus operator should improve their services and provides service equally to all society due to increased fares. Developing access feedback from users, such as access for complaint to customer services is important to monitor bus system performance.
- Both the government and the private companies should participate in publishing guidebooks not only as guidance for bus users in order to increase services, but also as a promotion for them.

VI CONCLUSION

"Blue sky, clean air, healthy environment" has long since been an obsession of the people of Jakarta Metropolitan city. Jakarta wishes to be a metropole ranking next to the other megacities in the world with its prosperous citizen, by implementing "clean air project" and "blue sky project". The air pollution in Jakarta is rated very bad after Mexico City and some cities in China and India. What cause the air pollution are mobile objects (transportation/vehicles) as the primary cause and immobile objects comes next (factories/industries, construction and households).

From available data, the vehicle transportation sector, which amounts to 3.8 million, takes part in 70% of the air pollution process, whereas factories and industries adds up to 18%. The rest is caused by constructions and households. What can be done among other is the need to create a certain energy source that does not pollute the environment such as the law to use environment-friendly fuel for new cars, like BBG (gas fuel) or lead free benzene *(DJAUHARI, 2000)*.

Based on observations in some locations, mostly in industry quarters (like Tanjung Priok in north Jakarta) and areas with high transportation rates (like Sudirman-Thamrin Street in central Jakarta), the air quality is deteriorating from year to year. That is why the local government of Jakarta Metropolitan Area began campaigning "clean air project" a couple years ago as one of an environmental maintenance program. Along with the "blue sky project", an inventarization has been conducted in order to collect data of immobile polluters, to improve the Pollutant Standard Index and the noise grade in the capital city, and to compile an emission standard index of immobile and mobile pollutant sources in the Jakarta

Metropolitan area. Recently, a direct move has been done by the BAPEDAL of the Jakarta city government by ordering a gas emission test for private car owners *(DJAUHARI, 2000)*.

Some alternatives in putting a stop to air pollution in order to improve the air quality in Jakarta Metropolitan area such as “clean air program”, “blue sky project”, the car emission-test, lead-free benzene and also the gas fuel campaign must be maintained. All this is meant to increase the quality of the in Jakarta Metropolitan area, so the community of Jakarta and its next generation may live healthily and may be spared from the dangers of air pollution.

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Appendix A

The Map of Indonesia

Source: The University of Texas at Austin (UT Library Online), 1997

Appendix B:

Mie-1, Mie-2, DIAL and Central Data Processing System

Mie-1 installed in the campus of the University of Indonesia in Depok *(PINANDITO et al., 1998)*

Mie-1 installed in the LIPI Oceanic Research Institute in Ancol *(PINANDITO et al., 1998)*

DIAL installed on the top of the LIPI Headquarters Building at Gatot Subroto Street
(PINANDITO et al., 1998)

Central Data Processing System installed in the LIPI Headquarters Building at Gatot Subroto Street
(PINANDITO et al., 1998)