# Air Pollution in Ho Chi Minh City, Vietnam

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ABSTRACT

In HoChiMinh city, industrial and transportation activities are the main air pollution sources. Results of surveying and measuring at thousands of industrial installations show that main air pollution industries as: fuel burning, refining and laminating steel, building materials, chemicals...Besides, transportation activities also emit a large amount of air pollution because of fuel consumption of hundreds of cars and about 2 millions motorcycle all types. Report introduces present air pollution condition in HoChiMinh city includes: air pollution loads of some major industries and concentration of air pollution in ambient air, workplace and roadside. Report also suggests some synthesized measures to improve that condition.

## I. INTRODUCTION

HoChiMinh city is the largest city in Viet Nam, is one of center of politics, economic, science of all the country. The city is 0.6% of country area and 6.4% of population, but it concentrates 25% industrial producing capacity and 40% industrial output of whole country. Kinds of existing vehicles at Ho Chi Minh City are about 40% of country. Industrial and traffic activities are more and more developing. It makes increase environmental pollution, in which air pollution effect considerably to people’s life quality. Thus, it is necessary to attach special importance to both the economic development and environmental protection to sustainabledevelopment.

# II. method and material

To asses present air pollution condition in HoChiMinh, author uses main method following:

* Surveying and collecting data of industrial pollution sources.
* Surveying and collecting data of transportation activities.
* Estimating emission loads of air pollution by method using emission factors.
* Surveying and collecting data of air pollution at stations.
* Analysing, data processing and compare with permissible concentration

**III. breif of activities of industry and transportation in HOCHIMINH CITY**

**3.1. Industrial activity:**

### **3.1.1 Scale and distribution of industry in Ho Chi Minh City:**

According incomplete statistic by the end 2000, Ho Chi Minh city had over 750 factories and enterprises and over 25,000 small-scale industry installations. Factories in HoChiMinh city formerly are distributed in small industrial groups and small-scale industry installations are placed all over district in city.

Nowadays, with rapid development of industry, HoChiMinh city has 10 concentrated industrial zones. At present and in future city has tendency to move many enterprises from urban area to concentrated industrial zones.

### **3.1.2 Production processing and environmental protection**

Most of industry enterprises in HoChiMinh city, especially small-scale industry, have common characteristics as following:

1. Most of factories are old, operation time are over 20 years.
2. Backward and in synchronous equipment are.
3. Technology is not high
4. Materials, fuel is not good, and much consumption.

From above characteristics, bad situation for environment is that:

1. A large quantity of waste pollutes environmental pollution.
2. There are many factories without system to control and treatment wastewater and emission.
3. Many enterprises are placed in crowded residential area.

At present, although there are some air treatment systems installed and operated in new factories as well as some old factories, air pollution from industrial production is still a noticeable problem.

### **3.2. Traffic activity**

Road system in HoChiMinh city consists of 943 roads with 1,275km length. Number of engine vehicles, according to statistic in 2001 is about 2,000,000 motorbikes and 250,000 cars all kinds, in which many motorbikes and other means used 15 years, even few of them from 1950s. Traffic density at main crossroads in HoChiMinh city is very high, traffic-jams regularly happen at main point, increase remarkable air pollution level.

## IV. AIR POLLUTION IN HOCHIMINH CITY

#### 4.1. Main pollution sources

### **4.1.1.Iindustrial production source**

Major sources polluting in industry production in HoChiMinh city are Thermo-electricity, cement, steel laminating and refining, weaving and dying, food processing, chemical. Table 1 presents air pollutants loads of some industry in HoChiMinh city.

Table 1.Major air pollutants’ load of some industry in HoChiMinh city (T/year)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Industry | Pollutants | | | | | | |
| SO2 | NO2 | CO | SPM | CxHy | SO3 | VOC |
| Thermo-electricity | 48,082 | 14,042 | 563 | 1,341 | 428 | 791 |  |
| Steel laminating and refining | 897 | 131 | 3,104 | 3,417 |  |  |  |
| Acid manufacturing | 420 | 35,7 | 1.4 | 3.25 |  | 9.1 |  |
| Cement | 5,589 | 854 | 23 | 558 | 23 | 71 |  |
| Weaving and dying | 1,128 | 172,4 | 4.8 | 71.6 | 0.72 |  |  |
| Food processing | 1,120 | 257 | 15 | 52.5 | 10.8 | 15.3 |  |
| Wood processing | 39,5 |  |  | 442 |  |  | 19.7 |

### **4.1.2 Traffic pollution sources**

Traffic activities by land in HoChiMinh city is major air polluting sources in urban. Pollutants’ quantity generated from land traffic are large ratio in total pollutants’ quantity in cities: CO is about 90%, Hydrocarbon about 60%, NOx about 50%. Existing engine vehicles use lead petrol so air pollutants from traffic also remain Pb, moreover remarkable SPM from burning product and from road.

### **4.2 Air pollution level in Ho Chi Minh City**

**4.2.1 Air pollutants’ concentration in workplace**

Air pollution level in workplace at factories, especially factories are arranged polluting type mentioned above, is considerable. Measuring results in many years show that pollution level at some factories be one of metallurgy, wood processing, rubber, cement, chemical industry… Concentration of some pollutants are rather high, some are higher than allowable concentration. Table 1, present some results to illustrate for this remark.

Table 2: Pollutants concentration in workshop environment at some enterprises

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| TT | Name | Pollutants’ concentration (mg/m3) | | | | | Noise  Level (dB) |
| SPM | SO2 | NO2 | CO | Others |
| 1  2  3  4  5  6  7  8 | Ha Tien cement factory  Tan Binh steel factory  Nha Be steel factory  Phi Hung aluminum Co.  Thu Duc Cashew nuts processing mill  Posvina tole factory  Satimex wood factories  Tarubchimex Rubber factory | 18.3  7.2  16  6.0  0.51  1.25  9.7  0.5 | 4.2  0.55  0.04 | 0.82  0.25  0.49  0.07  0.04  0.05  0.08 | 38.5  12  40  11  1.0 | 0.198 1  100 2 | 120  86  82  89  87  95  62 |
|  | Allowable concentration (AC) | 6.0 | 20 | - | 40 |  | 90 |

*Above results gathered from many sources in many years*

*Note:* 1 : Phenol concentration (AC: 0,01); 2: HCl concentration (AC: 10)

**4.2.2. Air pollution at Road side**

Monitoring results in many continuous years at positions: Hang Xanh roundabout, Dien Bien Phu – Dinh Tien Hoang crossroad, Phu Lam roundabout shows that SPM is always higher 2-6 times than allowable concentration, concentration of other pollutants sometimes are more than allowable concentrations. Result of 2001 at monitoring sites is present in figures following page.

Figure 1. SPM Concentration at road-side monitoring sites – 2001

Figure 2. Concentration of NO2 at road-side monitoring sites – 2001

**4.2.3 Air pollutants’ concentration in ambient air**

Figure 3. Concentration of Lead at road-side monitoring sites in 2001 and 3 month beginning of 2002

In HoChiMinh city, there are many factories , enterprises emitting air pollutants, but their scales are not large, so affect to industrial production and air environment are not noticeable. Air polluting sources effect mainly to labor environment as well as surrounding zones but not effect to throughout city. Traffic activities also effect heavily at roadside along main streets. The following figures present some pollutants’ change of ambient air in HoChiMinh city, in 2001.

Figure 4. SPM in ambient air - 2001

Figure 5. NO2 concentration in ambient air – 2001

**V. SOME MEASURES TO MINIMIZE AIR POLLUTION IN HOCHIMINH CITY**



Figure 1. SPM Concentration at road-side monitoring sites – 2001

Figure 2. Concentration of NO2 at road-side monitoring sites – 2001

**5.1 For industrial activity:**

- For management: strengthening management measures following current regulation such as making report of environmental impact assessment, periodical and unpredictable inspection of implement standard of air quality TCVN. It is necessary to come to issue quota of air emission for enterprises.

- For project: continue to develop concentrated industrial zones (IZ). Minimize invest out of IZ. Cary out step-by-step and resolutely moving polluting enterprises out of inner city.

- For technology and industry: enterprises actively minimize pollution level by measures: cleaner production, treatments in stack to ensure that air emission must be reach TCVN before emitted.

**5.2 For traffic activity:**

1. Management measure: it is necessary to have a company, which has enough strong to task controlling of traffic pollution. With present structure, this task is distributed for many units, so its effective is not high.
2. Project and building investing measure: especially road network. Nowadays, this work is not good, its result is growth level of road network is slower than of urbanization, population and vehicles.
3. Control vehicles increasing: strengthen and improve public means of transportation to get modern
4. Using clean fuel: using other clean fuel as electric, gas, hydro, solar energy.
5. Improve motorbike technology in order to reduce air emission from vehicles and using simple measures to reduce fuel vaporization
6. Control emission by investigating of air in stack, and machinery technology. This measure has carried out but to weak and operation not good.

# VI. CONCLUSION

1. Major air polluting sources in HCMC are industrial and traffic activities.
2. Ambient air quality is rather clean and stable in many years. Air of some factories and their surrounding areas is polluted, especially industries as: cement , metallurgy, fuel combustion industry, with specific parameters: SPM, SO2, NO2. Air environment at main crossroads and traffic circles is polluted by mainly SPM, noise level. Other parameters as NO2, lead also considerable level.
3. To minimize air pollution level in HoChiMinh city, must apply synchronously different synthetic methods

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**Improvement to VMT Estimation for Air Quality Analysis**

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**ABSTRACT**

Emission estimation model MOBILE6 incorporates several traffic-related input data including a comprehensive set of VMT related variables, which are essential to the accuracy of the generated emission factors from MOBILE6. The default values of VMT related variables are derived based on the analysis of the US nationwide data years ago, which clearly deviate from the local-specific values. Since VMT related variables have significant effects on MOBILE6, the local-specific values should be used to generate more accurate emission factors. At present, however, there exist methodologies that can generate local VMT information directly. On the basis of review of the current practices and methodologies, this paper intends to develop a practical improvement to the VMT & mix estimation methodologies. The link volume estimation is modelled as the function of both the traffic count data and the link attributes. The model coefficients can be easily calibrated from the real-world data. A case study in southwest Houston is illustrated to show the estimation process and the effectiveness of the proposed approach. Impact analysis shows that the emission factors generated by local improved VMT estimation are closer to the ideal one, and better than both the nationwide default and the Traffic Count Method.

**Keywords:** Vehicle Miles Travelled, Air Quality Analysis, Emission Factors, Volume Estimation.

1.0 INTRODUCTION

US Environmental Protection Agency (EPA) requires that on-road mobile source emissions such as carbon monoxide (CO), volatile organic compounds (VOCs), oxides of nitrogen (NOx), particular matter (PM), etc. do not exceed the motor vehicle emission budgets estimated in the Rate of Progress (ROP) and Attainment Demonstration State Implementation Plan (SIP). The only model that was approved by EPA for use by all US states except California for the conformity determination analysis is MOBILE6, one of its primary inputs to which is the mobile source emission related travel indicator - Vehicle Miles Travelled (VMT) & mix [1].

VMT is a unit to measure vehicle travel made by a vehicle, such as an automobile, van, pickup truck, or motorcycle. Each mile travelled is counted as one vehicle mile regardless of the number of persons in the vehicle. VMT mix specifies the fraction of total highway VMT that is accumulated by each of the different vehicle types.

VMT & mix have significant effects on the emission estimation model MOBILE. Emission analysis is very sensitive to VMT & mix. For example for MOBILE5 (the previous version of MOBILE6) at high temperature, a 2.8% change in HDGV mix causes about a 10% change in the CO rate and a 4.8% change in HDGV mix leads to about a 10% shift in the VOC rate [2].

There are many changes on VMT related functions in MOBILE6, which are different from the old versions. The VMT related functions include VMT FRACTIONS, VMT BY FACILITY, VMT BY HOUR, SPEED VMT, and VMT mix.

While the national default VMT information in MOBILE6 is provided for each of the above functions, the variations in roadway network characteristics between different areas are big enough to justify the use of locally developed VMT distributions [3].

A review of existing theoretical achievements [2, 3, 4, 5, 6, 7] has identified that most of the models are focusing on the estimates of VMT mix for the old version MOBILE5, with no consideration about facility types and speed variations. Some of the existing approaches (e.g., the fuel consumption based finance method, the policy procedure, etc.) are not link-based, which means that it is difficult to use them directly for the estimation of VMT by facility, by hour and by speed, as required in MOBILE6.

Although the EPA guidance [3] is for getting the nationwide default value, its basic approaches and some of the procedures are good enough for developing the estimation of the local specific VMT related variables. In the practice, the two methodologies (Traffic Count Method and Travel Demand Method) used in the EPA guidance are also being used in many states. However the existing Traffic Count Method does not consider the link attributes, which simply applies the traffic count volume to the other links. Also, the estimations of VMT related variables in the EPA guidance are only for getting the national wide defaults. It is not for getting the local estimation.

Bhat and Nair proposed and implemented a fractional split model, which is link based and is easy to provide VMT mix for MOBILE5 [8]. However, it does not consider any of the information from the traffic counts data, and it does not meet the requirements by MOBILE6, where more detailed VMT information is needed.

Since no local VMT estimation methodology exists that can meet the requirements of MOBILE6 directly, efforts can be made by taking the advantages of some of the existing methodologies. The objective of this research is therefore to propose improvement to the current VMT estimation methodologies. The methodology will address new requirements to VMT related variables in MOBILE6.

2.0 PROPOSED IMPROVEMENT

**The improved methodology strives to set up the relationships between link volume and the count data as well as their link attributes. The disaggregating of volume in hour of day and speed will follow the EPA Traffic Count Method since it is a useful and the only method that can disaggregate volume according to the requirements by MOBILE6.**

**The important improvement to the estimation of VMT related variables is the estimation of link traffic volume. Suppose  is the volume for vehicle type t at count station , where ,  is the total number of count stations on road type y. y is the road type, t is the vehicle type.**

On link , volume for vehicle type *t* with road type y can be estimated from any of the count station  located on the same road type (i.e. type y):

** (1)**

**where,  is the unknown coefficient to be calibrated from simulation results;  is the total number of link attribute types to be included in the estimation process;  is the j-th link attributes.**

To calibrate the coefficients , Equation (1) can be transferred into the following form:

 (2)

Let, , and , then the following simpler form can be obtained:

 (3)

The calibrated coefficient matrix  in Equation (3) can then be obtained by a multivariate regression analysis using any standard routine.

After the calibration process, the volume on link  for vehicle type  can be estimated based on the count data from link :

 (4)

Since there are  count stations, a total of  estimated values for the same link volume can be obtained. The final estimated volume  can then be estimated as an average of all these  estimations:

** (5)**

In Equation (1), the link attributes that may be included in the estimation process can be link width, link length, link speed, land use types, urbanized types, etc. All of these link attributes should be quantified beforehand for the convenience of calibration and calculation. The more link attributes that are related to VMT information, the more precision can be obtained during the estimation process.

**After obtaining the estimated traffic volume for all the links, the link volume should be disaggregated according to the hours of day so that hourly VMT can be obtained. By applying the BPR curve, the speed VMT can be estimated as well.**

These disaggregating processes of the methodology are conceptually straightforward, although their calculations might be relatively complex. To obtain the hourly VMT, the distribution of link-level volumes by hour of day should be prepared by using the user-provided distribution. If the user does not provide this kind of information, or the user can only provide this kind of distribution for some particular links (e.g. only for some freeway, or some arterial road), the default temporal distribution can be applied to the links, where local distributions are missing. By multiplying the link distance with the hourly volume, the hourly link VMT can then be obtained directly.

After obtained the hourly distributions of VMT by speed for all kinds of facilities, it is easy to get the other VMT related variables required in MOBILE6. Therefore VMT BY FACILITY; VMT MIX; VMT by HOUR and VMT BY SPEED can all be generated.

The improved approach to estimate VMT related variables for MOBILE6 can be summarized into the following six steps:

Step 1: Estimate the volume at the links where no traffic counts are collected;

Step 2: Distribute link-level volumes by hour of day using user-provided or default temporal distributions (usually from count data sets);

Step 3: Calculate hourly VMT by multiplying link distance by hourly volume;

Step 4: Calculate the v/c ratio using either link-specific capacities or lookup tables;

Step 5: Apply the BPR curve, using link-specific free flow speeds or lookup tables, to arrive at hourly congested speeds; and

Step 6: Obtain all VMT related variables required by MOBILE6.

The above procedures are similar to that for Traffic Count Method except the important new features in Step 1, where the link traffic volume is estimated by Equation (1) instead of the simple extension of the count volume from the station.

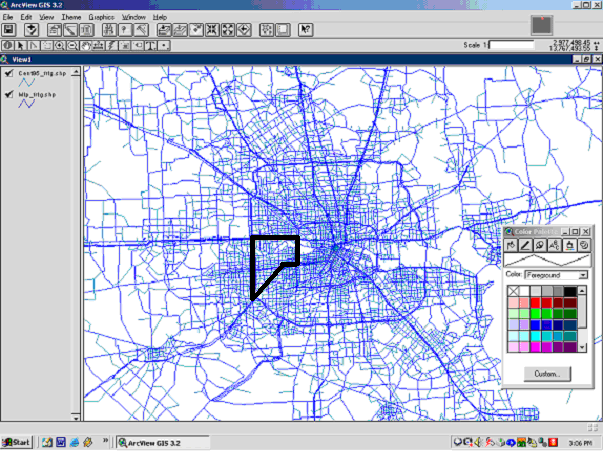
3.0 CASE STUDY

To illustrate the proposed improvement, a case study was conducted in the southwest Houston, Texas. The selected sub-network contains 276 links with 34 freeway links, 110 arterial links and 132 local street links. While there is no ramp information available, which is also the truth for most of the local situations, the final ramp VMT can be a portion of the estimated freeway VMT. The EPA guidance suggests this portion as 0.8% [3, 6].

## 3.1 Information Collected

Information needed for illustration of the improved methodology include the link traffic count data and the link attributes information. The link traffic count data were collected from the 1996 traffic map for Harris County from TxDOT, while the link attributes information were based on the descriptions embedded in the GIS network data regarding the 1996 Houston GIS data from Houston – Galveston Area Council.

The 1996 traffic map for Harris County was prepared by the Transportation Planning and Programming Division of Texas Department of Transportation, in cooperation with the US Department of Transportation, Federal Highway Administration. All counts on the map were 24 hour axle counts divided by 2. They were generally made between the dates of September 9, 1996 and December 16, 1996 with the exception of a few ties in counts between bordering counties from other TxDOT districts.



Note:  illustrates the area for case study

**Figure 1 GIS Network for Houston Area in the Format of ArcView.**

The 1996 Houston GIS network data were stored in the format of ArcView. It contains both the network itself and its corresponding network information. Fig. 1 shows the GIS network of whole Houston area in the format of ArcView, where different facility types can be displayed in different colors. In the database, there is the information for the link attributes, such as: number of lanes, link width, link length, mean speed, night speed limit, and land use type, etc. This information can be used directly for the calibration and estimation.

## 3.2 Link Volume and VMT Estimation

The link volume estimation started from the calibration of Equation (1) or (3). Based on the information available, a total of 4 link attributes were selected in this case study, namely link length, mean speed, night speed limit, and land use type. The selection of link attributes in other areas may not follow this. However, the selected ones should be sensitive to the link volume as well as the resulting VMT estimation. According to the information collected, there are 6 land use types, which were quantified into digits 1 to 6 for the convenience of later calibration. Except the land use type, all the other link attributes have already been quantified when the data were archived.

Among the total 276 links, 12 freeway links, 15 arterial links and 15 local street links were assigned the count data. This means that it is supposed that the volumes in these 42 links were treated as real data while the rest 234 links were left blank, which might be estimated by the proposed methodology.

The calibrations of coefficients were conducted among the “known” count data, i.e. the 42 links where count data were available. Following the regular regression process, the calibrated coefficients in the Equation (1) or (3) were calculated. Owing to the different relationships existed inside, the calibrated coefficients for freeway, arterial, and local streets are different.

The estimation of traffic volume can be realized based on Equations (4) and (5). Equation (5) is necessary since there were more than one link with traffic count data for each of the three facility types. The average to the different estimations on the same link was final estimated link volume.

The link VMT could then be obtained by multiplying the estimated link volume with its corresponding link length. By aggregating the total VMT subjected to the same type of facility, the total VMT for this facility would easily be obtained.

To validate the proposed improvement, a total of 4 scenarios were conducted to compare the estimation results. Scenario 1 calculated the real VMT on all links, which is treated as an ideal one. Scenario 2 estimated the VMT on each links based on the EPA Traffic Count Method. The reason why this method was selected is that this is a good method and has been recognized by EPA and public. Scenario 3 used the proposed improvement to estimate link VMT. In Scenario 3, link VMT was estimated by the calibrated coefficients and link volume estimation equations. Considering the fact that in some local areas, the traffic count data are not available for some facility types such as local street, Scenario 4 was set up. Scenario 4 imaged that only freeway count data were available and only coefficients for freeway link volume estimation were calibrated. The link volumes for other facility types must also use the calibrated coefficients for freeway.

Table 2 lists the total VMT estimates by all facility types based on different scenarios in southwest Houston area. In Table 2, the four scenarios were marked as “Ideal”, “TCM”, “Improved (I)” and “Improved (A)” for better understanding the meanings. It is shown that the estimates of Total VMT based on both Scenario 3 and 4 (i.e. both use improved methods) were closer to the ideal one than the estimates on Scenario 2 (TCM method).

To better compare the results on the 4 scenarios, the relative errors of the estimates on each scenario (except scenario 1) were calculated and listed on Fig. 2. In Fig. 2, it is obvious that TCM resulted in the largest relative errors among all the scenarios, especially for freeway, ramp and total VMT.



Note: Improved (I) means that the improved model calibrated each facility type independently;

Improved (A) means that the calibrated model for freeway was used to links of all facility types

**Figure 2 Comparison of Relative Errors (%) of Total VMT Estimation by Facility Types Based on Different Methods in Southwest Houston Area.**

Based on the above estimation, the VMT fractions on all facility types were calculated. Again, the VMT fractions on facility types by improved two methods were closer to the ideal one.

After estimating the link volume and VMT by facility type, the next parts just followed the steps in the section on “Implementation Procedure,” which is similar to the process of Traffic Count Method. After disaggregating facility VMT into hours and speed distribution, all the MOBILE6 required parameters were obtained.

## 3.3 Impact on Emission Estimation

The final estimated local VMT related variables were input into MOBILE6 so that the impacts on emission estimations could be obtained. Table 1 lists the estimates for three emission factors VOC, CO and NOx based on different scenarios. Fig. 3 illustrates the relative errors for the different methods. From both Table 1 and Fig. 3 it is shown that the proposed improvements have better estimation on the emission factors. They are better than both the nationwide default one and TCM estimation. It is interesting to note that all the three emission factors for the both improved methods are smaller than the real one although all the relative errors are relatively small comparing with the other two methods. For default values, CO and NOx are much smaller than the real one, while VOC is bigger. For TCM, CO and NOx are much bigger than real ones while VOC is much smaller.

**Table 1 Emission Factors Estimates Based on Different Methods of VMT Estimation in Southwest Houston Areas**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Ideal | TCM | Improved (I) | Improved (A) |
| VOC | 0.467 | 0.448 | 0.459 | 0.454 |
| CO | 5.259 | 5.459 | 5.304 | 5.309 |
| NOx | 0.904 | 0.963 | 0.927 | 0.927 |



**Figure 3 Relative Errors (%) for Estimates of Emission Factors Based on Different Scenarios.**

5.0 CONCLUSION

In this research, the improvements to the VMT estimation were proposed which considered both the link attributes and the traffic count information. The proposed model for volume estimation is easy to be calibrated. Case study and model calibration in southwest Houston show that the improved approach is better than both the EPA Traffic Count Method and the nationwide MOBILE6 defaults in terms of the estimation of both VMT and emission factors. In order to apply the improved approach to the real-world networks, more calibrations and validations under various environments are necessary, which will be the next step of this research.

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**A Study on the Association of Particulate Air Pollutants and Respiratory Diseases in Metro Manila**

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**ABSTRACT**

In the Philippines, the most common air pollutant being monitored in 11 stations is total suspended particulates (TSP). This study was intended to look into the health implications of ambient air quality in Metro Manila with a view looking at various policy implications to improve the existing environmental and health monitoring systems in the country. The study obtained the Environmental Management Bureau’s monitoring data for TSP from 1995 to 2001 and the morbidity and mortality data from 1995 to 2000 from reports and survey of selected hospitals and health centers. Using GIS software, data gathered from hospital survey and air quality data were combined with other attributes such as demographic, socio-economic profile, and road networks. In the analysis of the TSP concentration versus mortality and morbidity data, there appears to be a close association between TSP data and respiratory disease data from 1995-1997 when the average TSP concentration reached the “unhealthy” level (> 230 μg/m3). Motor vehicles were suggested to be the main source of particulates. It was recommended to establish disease surveillance sentinels alongside air quality monitoring stations for better protection of public health and to improve testing of smoke belching vehicles.

**Keywords**: TSP, monitoring, respiratory diseases, GIS, Metro Manila

1. **INTRODUCTION**

This study was intended to look into the health implications of ambient air quality in Metro Manila. Monitoring data of Total Suspended Particulates (TSP) were taken from the Environmental Management Bureau-National Capital Region (EMB-NCR). Data from 1995 - 2001 were raw data from the 11 monitoring stations, which were taken by EMB-NCR every six days while summary results from 1987 up to 1994 were given in maximum, minimum, and annual average concentrations. Morbidity and mortality data from 1995 to 2000 were obtained from the Department of Health (DOH) Center for Health Development –National Capital Region and in selected hospitals and barangay health centers.

# 2.0 LITERATURE REVIEW

Global initiatives on the investigation of the health effects of environmental pollution especially indoor and outdoor air pollution found solid evidence to prove significant correlation between respiratory diseases and air pollutants.

There were eight major studies on air pollution conducted in Metro Manila in the last 10 years. However, only two out of eight studies are related to health effects of air pollution. There are also past and ongoing activities related to air pollution and air quality monitoring specifically on PM10 sampling and analysis, source apportionment, particle size fractionation and elemental analysis, air quality modeling, GIS applications, database development, as well as formal and continuing education at the Philippine Nuclear Research Insititute, Ateneo de Manila University and the University of the Philippines, Manila and Diliman. However, it was obvious in these past studies that health effects of air pollution were not given enough attention.

Several findings had already established the relationship of air pollution on health, specifically on particulate matter. However, the effect of TSP on mortality has not been confirmed since conflicting results were found. It appears that TSP, as an indicator is not as sensitive as PM10 or PM2.5, which are the inhalable particles that can go directly to the lungs. And since 70% of a person’s time is spent mostly indoor, indoor air quality has a more pronounced effect on health than ambient air.

# 3.0 EXISTING CONDITIONS AND METHODOLOGY

**3.1 Ambient Air Quality Information**

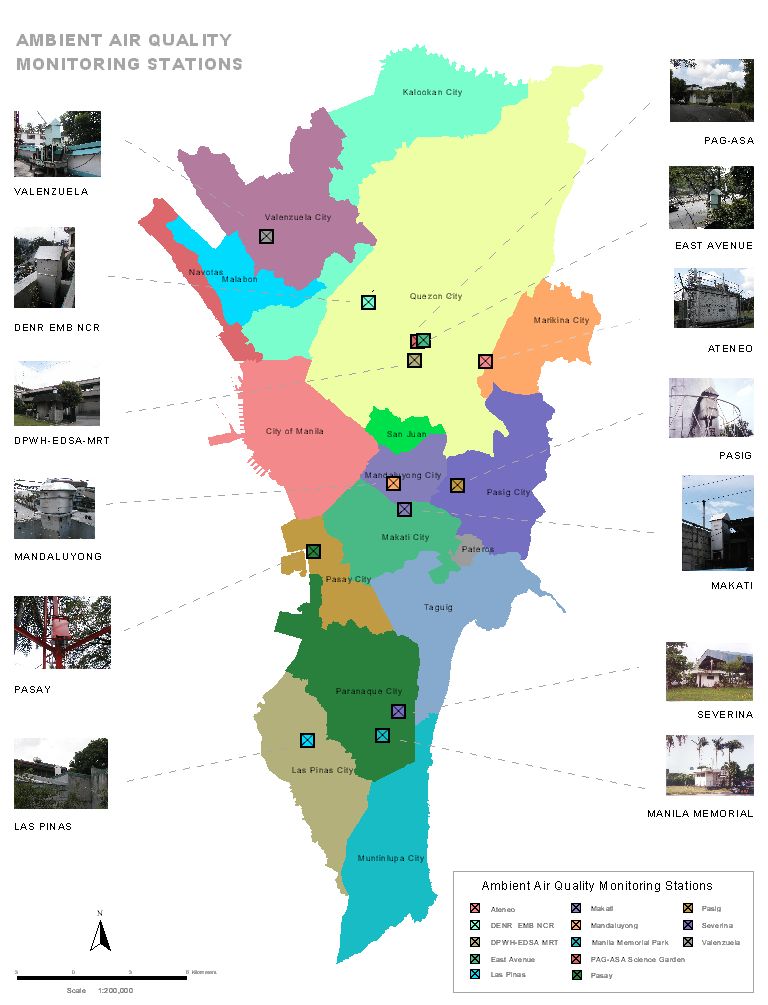
In the Philippines, the most common air pollutant that is being monitored is total suspended particulates (TSP). The EMB-NCR currently maintains 11 ambient air quality monitoring stations throughout Metro Manila as shown in Figure 1. The regular schedule is to obtain 24-hour average TSP samples every six days on a rotation basis. The stations are capable of monitoring TSP using high volume samplers. Samples are analyzed using gravimetric method. Because of the sporadic development in Metro Manila, land uses surrounding the ambient air-monitoring stations are a mixture of residential, commercial, institutional, and industrial areas. The data collected by EMB-NCR were reported in annual reports as minimum, maximum, and average data. This study had to obtain the raw data, which were processed and encoded in a database format.

### **3.2 Health Information System**

The health information system in the Philippines is not well established and the centralized database within the national Department of Health is not updated regularly. The Department of Health of each local government is tasked with collecting health statistics, which are submitted, to the central office. However, the records are spotty with occurrence of under-reporting. Hence, the study did a primary survey of 17 representative hospitals and request for specific cases of related diseases such as Pulmonary Tuberculosis, Acute Respiratory Infection, Cardiovascular Diseases, Bronchial Asthma, COPD, Pneumonia, Bronchitis, Allergic Rhinitis, Emphysema, Cough, Phlegm, Wheezing, Cancer of the Lungs, Ischemic Heart Disease, Pulmunary Heart Disease, Congenital Anomaly, Other Related Ailments.

The hospital surveyed were East Ave. Gen Hospital, E. delos Santos Memorial Hospital, St. Luke’s Hospital, United Doctors’ Medical Center, National Children’s Hospital, Philippine General Hospital, Ospital ng Maynila, Manila Medical Center, San Lazaro Hospital, Makati Medical Center, Makati General Hospital, Rizal Medical Center, Cardinal Santos Hospital, Medical City, Manila Central University Hospital, and Caloocan Gen. Hospital, which are all located within polluted areas.

# 3.3 GIS Database

Data gathered during hospital survey and air quality data from different monitoring stations were incorporated into the GIS software together with other related data such as demographic, socio-economic profile, and road networks. As there was no dispersion modeling in this project, correlation of the data was determined using GIS overlays. To establish relationships between the data layers, simple queries and processing of the data were done and information is presented as thematic maps. Using Surfer, the TSP geometric mean concentrations from 1996 to 2001 were plotted in contour maps as shown in Figure 2. The highest concentration of TSP was formed in Quezon City in 1997 and 2000 where mounds or peaks were observed with light intensities for high concentrations. Figure 1 Ambient Air Quality Monitoring Stations in Metro Manila

1. **FINDINGS AND DISCUSSION**

**4.1 Air quality and health**

In general, there has been no significant change in the levels of TSP from 1988 to 1994. However, from 1997 until 2000, the trend in TSP levels in Metro Manila has been decreasing. Notably, there is an increasing trend in the TSP levels in 2001. In the analysis of the TSP concentration and mortality and morbidity data in Figure 3, there appears to be a close association between TSP data and morbidity data from 1995-1997 when the average TSP concentration reached the “unhealthy” level, which is greater than 230 μg/m3. TSP does not appear to be sensitive to mortality data as there can be various reasons attributable to death. At the start of 1994, TSP concentration increased to unhealthy level until it gradually decreased to the “fair” level in 1998. Motor vehicles were suspected to contribute to the elevated TSP due to the high traffic density near the air monitoring stations.

Mortality data has been consistently stable through the years whereas morbidity seems to have been affected by TSP levels especially from 1995-1997. However, with limited information, it is difficult to conclude whether TSP concentration has any direct or indirect effect on morbidity and mortality rate. More epidemiological analysis has to be done and the air quality data has to be validated.

* 1. **Confounders**

# In the Philippines, as in other countries, there is too much emphasis on ambient air monitoring. Being a tropical country, there is no combustion of coal for heating or cooking as experienced in other countries. Instead, air pollution mainly comes from motor vehicles, stationary sources (industry and power plants), and smoke (tobacco and backyard burning). The following confounders were identified that could have affected the air quality in Metro Manila (NCR) or may have contributed to the diseases surveyed in the study:

1. Mt. Pinatubo eruptions since 1992
2. Tobacco smoking
3. Construction boom
4. Indoor air pollution
5. Motor vehicles run by dieasel
6. Tricycles and 2-stroke engines
7. Garbage crisis in 2000
8. Other infectious diseases epidemics

#### 5. CONCLUSIONS AND RECOMMENDATIONS

It is rather difficult to conclude whether there is an association between TSP and health in general. However, in our findings, morbidity has showed a tendency to be linked with elevated concentrations of TSP perhaps due to acute symptoms manifested early on due to air pollution. Mortality does not appear to have any clear correlation with TSP. The following recommendations are proposed for future consideration:

1. Establishment of disease surveillance points

The collection and processing of health statistics was included in the devolution of powers to the local government units. Hence, there is no centralized collection by the national Department of Health as in the past. To avoid duplication of efforts within cities and towns, several disease surveillance points (DSP) can be established to serve as public health monitoring sentinels to form national DSP system. A DSP can represent, say 10,000 population, collecting mortality and morbidity data identifying various causes. Hospitals and health centers can feed into the DSP information system. External support is necessary to initiate the DSP system with a view to making it sustainable after several years and regular funds have been allocated from government or NGOs.

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Note: Intensity of TSP concentration increases as the color lightens.

Figure 2. TSP Geometric Mean Contour Maps

Figure 3 Average TSP Concentration, Morbidity and Mortality Data for the National Capital Region

B. Study on the effects of indoor air pollution

Indoor air quality is necessary in establishing the relationship between air pollution and public health. An average person spends 70-80% of his/her day indoors whether at home, school, office, factory and entertainment hence the exposure to outdoor air is much less than indoor air. The tendency to attribute respiratory diseases to outdoor air pollution may not be valid considering that most of the studies regarding air pollution in the Philippines is focused on ambient air quality.

C. Strict implementation of laws and regulations

In order to improve the air quality in Metro Manila, there should be a determined public advocacy for political and regulatory action from all citizens and sectors. The policymakers and regulatory agencies should implement stricter air pollution standards particularly for rapidly growing cities and to enforce anti-smoke belching inspections and campaigns.

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