A STUDY ON LAND-USE PLANNING BASED ON MOTOR TRUCK EXHAUST APPRAISAL MODEL IN SEOUL METROPOLITAN AREA

김 윤 선*

요 지

본 논문은 대도시권에 있어서, 날로 심각해지고 있는 자동차 배출가스(NOx)의 대기 오염문제를 효과적으로 해결하기 위하여 대기 오염량을 짧은 기간내에 분석, 평가가 가능한 『자동차 오염 배출량 평가시스템』을 구축하여, 서울 대도시권에 이를 적용시켰을때 서울특별시의 대기 오염량의 삭감 효과를 평가한다.

1. Introduction

Seoul city is indisputably, one of the biggest cities in the world. With an extremely high density of population and growing incomes, the concentration of motor vehicles in the city in recent years has assumed a dramatic increase. For example, about 40 percent of all the motor vehicles in korea and 63 percent of all passenger cars are concentrated in the city of Seoul[2]. This fact, coupled with the old nature of most of the vehicles plying the roads of the city and the flexibility associated with the regulations on motor truck exhaust has resulted in a serious debasing of atmospheric quality. Thus, the role of motor vehicles in causing air pollution problems in Seoul Metropolitan Area cannot be over-emphasized. But since land use activity is an important factor in traffic generation, any attempt at addressing air pollution problem in the metropolis should inevitably be viewed from the angle of land use and traffic generation activities. It would also demand a clearer examination and scrutiny of past policies and their future impacts as well as the anticipated growth levels of these traffic generation activities.

The intensity of the air pollution is Seoul city today calls for earnest and sustained effort towards the deveopment of feasible countermeasures that can abatement of eliminate this urban environmental problem. This is one of the major challenges facing researchers on environmental problems particularly in the rapidly urbanizing NIES and redressing this problem in Seoul city inevitably constitues the thrust of the study.

2. Framework of The Study

2.1 Study Area

The study area is characterized as Seoul District, Seoul Suburbs District and Seoul Fringe District depending on its measured distance from the CBD(Central Bussiness Disrict) of Seoul as shown in Figure 2-1. Seoul District takes up 17-Gu of the Seoul city covering a circumferential area of about 20 kilometers from the CBD of Seoul. Seoul Suburbs District covers the circumferential area lying between a distance of about 20㎞ and 40㎞. Seoul Fringe District which is the exterior region take up a circumferential area lying between a distance of about 40kilometers and 60kilometers from the CBD.

The study area is demarcated so that it represents a total of 38 zones with each zone representing a Gu, city or Gun. Seoul District takes up 17 zones, Seoul Suburbs District 12 zones and Seoul Fringe District,9 zones depending on the regional idiosyncrasy, traffic flow and so on, as shown in Figure 2-2.

*인천대학교 공과대학 산업안전공학과 조교수

◎本論文은 北海道大學 大學院 環境科學研究科 環境計則(交通公害)專功 學位論文要旨
접수 : 1989. 4. 22.

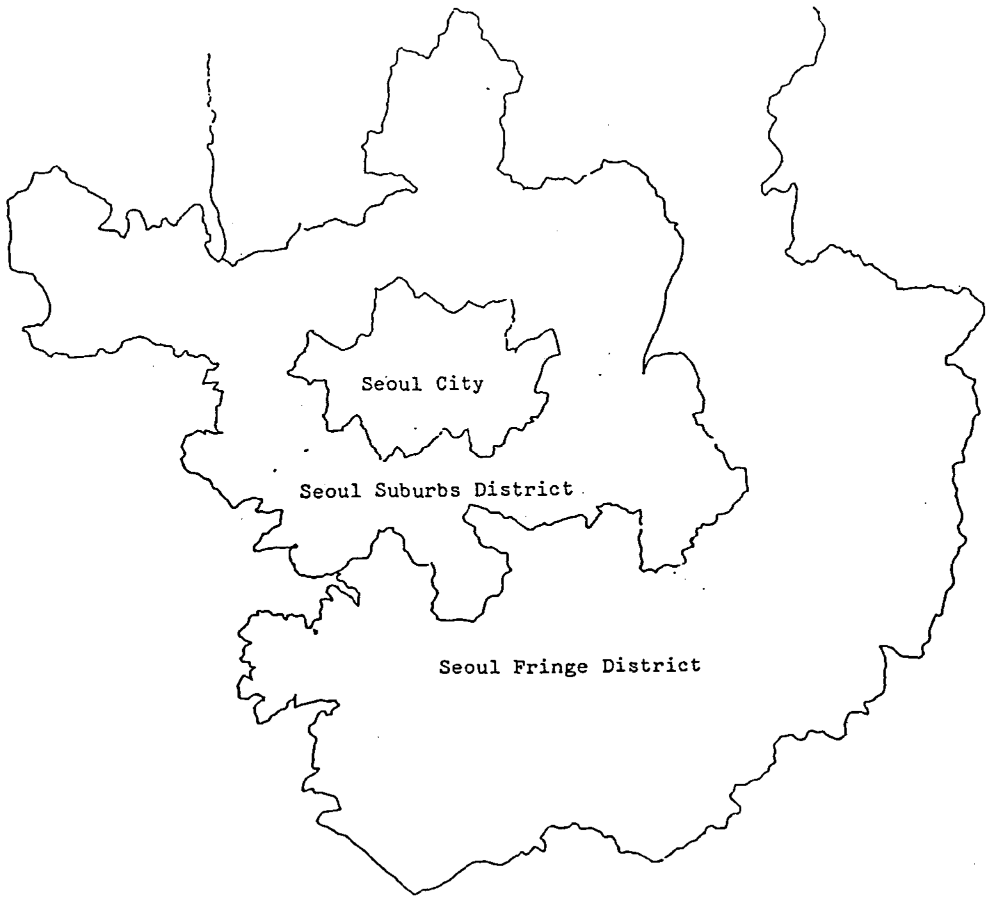

Figure 2-1. The Map of the 3 Designated Districts

2.2 Traffic Selection

The pursuance of a series of five year development plans, now in its fifth consecutive term has resulted in a marked improvement in the national living standards in Korea. A remarkable and visible result accompanying this economic improvement has been the drastic increase in vehiclar ownership and usuage. The number or motor vehicles operating within the country was 40,000 in 1965, rising to 126,000 in the 1970's, then to 527,700 in the 1980's and finally to 906,964 in 1984. Cars represented 63.7 percent of all motor vehicles under consideration while motor trucks made up 27.6 percent.

However, with regards to the amount of emission of nitrogen oxides (NOx) in Seoul city, 57.70% comes from motor vehicles. Furthermore, motor trucks which are few in number compared to cars contributed 51.81 percent[4]. Compared with similar studies for Tokyo, motor trucks contributed 66 percent and 74 percent in 1980 and 1985 respectively to all the nitrogen oxides (NOx) emitted into the atmosphere within the Tokyo Metropolitan Area[10]. Based on the above reasons, motor trucks were chosen as the proxy for the vehiclar type responsible for debasing atmospheric quality in Seoul city.

2.3 Exhaust Gas Selection

Of all the nitrogen oxides (NOx) emitted into the atmosphere in Seoul city, non-stationary vehicles accounted for 57.7 precent. Motor trucks represented 57 percent of this vehicles, while 43 percent were accounted for by the cars.

Diesel-powered motor vehicles which are normally associated with high emissions of nitrogen oxides as compared to the gasoline-fueled ones constitutes more than 50 percent of all registered motor vehicles in

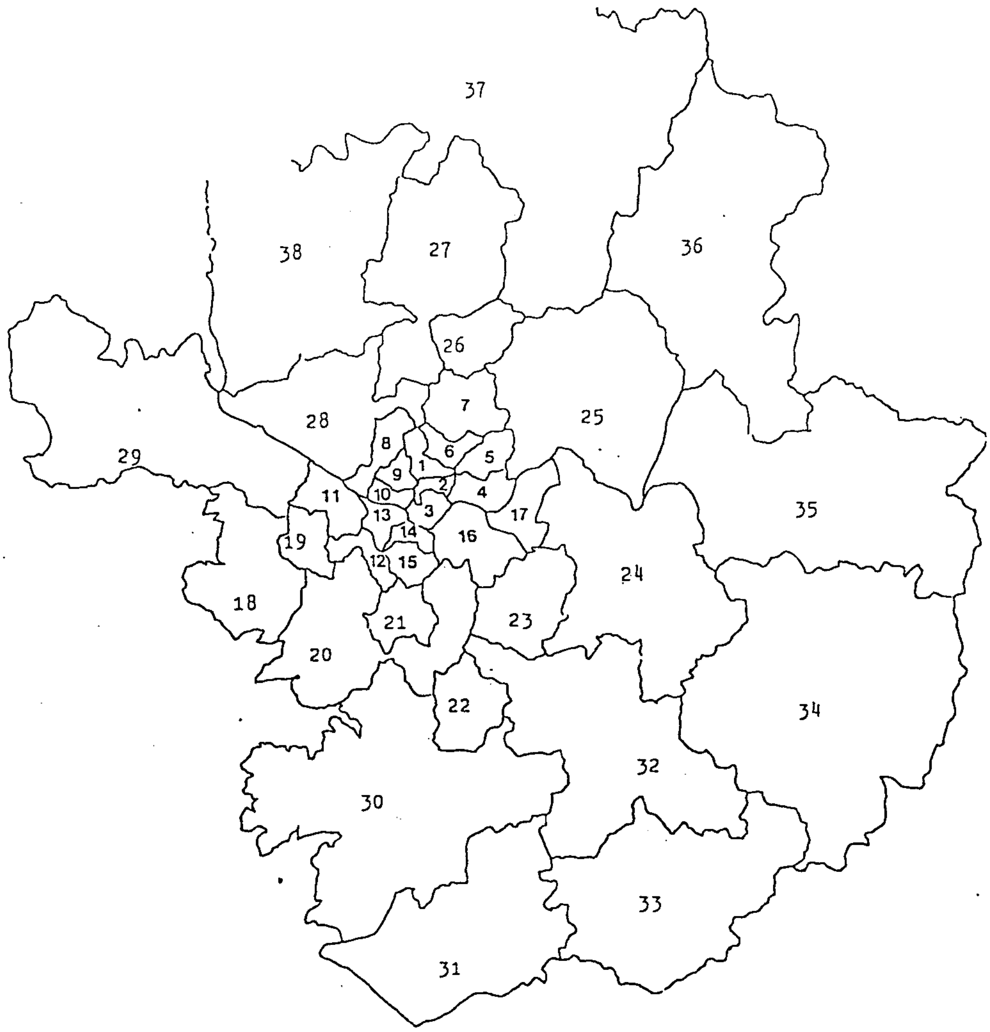

Figure 2-2. A Map of 38 Zonal Divisions

Korea.

By reason of this, pollution caused by nitrogen oxides emitted by motor trucks constitutes the subject matter for this study.

2.4 Study Methodology

The fundamental data frequently employed to estimated the exhaust volume emitted by motor trucks in an urban aea is the origin and destination table. However, the origin and destination table for motor trucks for Korea was not available. For the purpose of this study therefore, an origin and destination table was constructed using several secondary data[8] available from various Korean government agencies.

In addition, the origin and destination table of physical distribution volume in Seoul metropolitan area was available. An important setback of this table, however, was that the whole of the Seoul city area was designated as one zone. To remedy this situation, the annual average increasing rate of the volume of physical distribution in Seoul city was estimate from these sources, namely, the volume of the total physical distribution, the rate of distribution of internal-internal as well as internal-external physical distribution volume of goods within Seoul city.

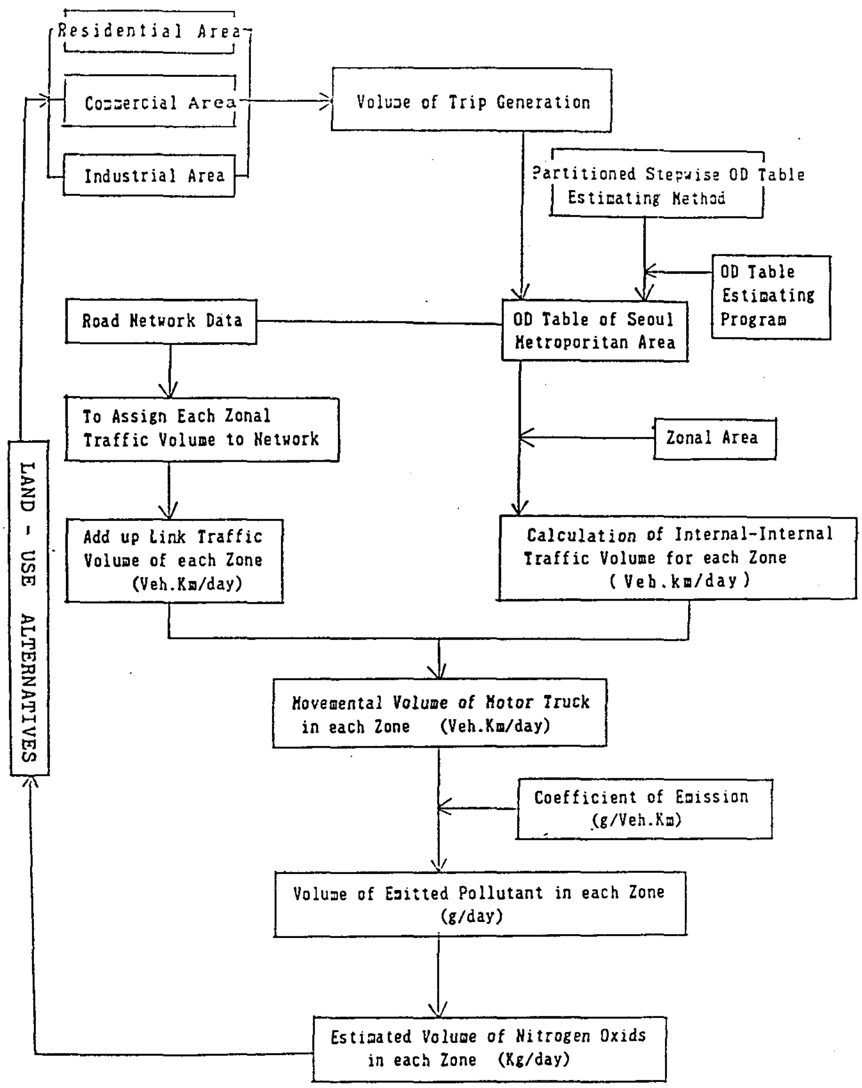

Figure 2-3. The Appraisal Model of Motor Truck Exhaust Gas

From this results, the volume represented the generation of physical distribution for both Seoul city and the Seoul Metropolitan area were estimated. By applying a redesigned OD Table estimating program to the above-generated volume of physical distribution generation data, the origin and destination volume for both Seoul city and the Seoul Metropolitan were derived.

Finally, the origin and destination table for motor trucks in the Seoul Metropolitan area was estimated using the data on the volume of physical distribution per vehicle which was obtained through a survey conducted at eight points within a cordon in Seoul city.

Road network data was assembled from [4] [6] and the zonal traffic volume assigned was derived from it. Finally, the link traffic (Veh.km/day) of each zone is added up from this assignment result. As the internal-internal traffic volume was not assigned to road network, we assume the radius of each zonal area to be the average trip length of internal-internal traffic volume and from this, the volume of motor truck movements within each zone (Veh.km/day) was estimated.

By multiplying the volume of motor truck movements within each zone by its coefficient of emission, the air pollution due to exhaust for each zone is derived. By comparing the results of this calculation for the

12 land use alternatives established earlier on in this study with the vaues obtained for not enforcing these alternatives, a framework for consideration for subsequent analysis was obtained.

3. Land Use Model

3.1 Environmental Judgement Criterion Value(EJCV)

When we apportioned a 10 percent and 30 percent respectively of all industrial land use activities within the Seoul city into the Seoul Suburbs District and the Seoul Fringe District, it is one of the objective of this study to investigate the sensitive degree of the abatement effectiveness of motor truck exhaust in Seoul city.

The transfer-policy of land use is divided into 6 cases (case 1-6) of the equal apportionment and 6 cases (case 7-12) of the selective apportionment.

In case of adopting the selective apportionment, particularly, the establishment of Environmental Judgement Criterion Value as the estimated value of exhaust density of each zone is needed. Therefore, the Environmental Judgement Criterion Value was designed as follows.

Let 1 denote Seoul city and let 2 denote the Seoul Suburbs District and let 3 denote the Seoul Fringe District. Let i1 denote the number of zones of Seoul city and let i2 denote the number of zones of the Seoul Suburbs District and let i3 denote the number of zones of the Seoul Fringe District. Let $\lambda i1$ denote the exhaust volume of each zone of Seoul city and let $\lambda i2$ denote the exhaust volume of each zone of the Seoul Suburbs District and let $\lambda i3$ denote the exhaust volume of each zone of the Seoul Fringe District.

Let $\Phi i1$ denote the area of each zone of Seoul city and let $\Phi i2$ denote the area of each zone of the Seoul Suburbs District and let $\Phi i3$ denote the area of each zone of the Seoul Fringe District. Then the exhaust density of each zone is denoted as follows :

$$dij=\frac{\lambda ij}{\Phi ij} \quad [kg/km^2] \cdots\cdots (3,\ 1)$$

Then the Environmental Judgement Criterion Value(EJCV) can be represented as follows :

$$\begin{aligned} EJCV &= \frac{\Sigma_j \Sigma_i\ dij}{\Sigma\ ij} \\ &= \frac{\Sigma_i di1+\Sigma_i di2+\Sigma_i di3}{i1+i2+i3} \\ &\fallingdotseq 7.3 \quad [kg/km^2] \cdots\cdots (3,\ 2) \end{aligned}$$

This EJCV is used for judgement the environmental level of each zone and is made 12 land use indexes by it. That is, this value becomes the value of judgement criterion for transfer apportionment.

3.2 Apportionment Land Use Model

The method to apportion the industrial area extracted from Seoul city is sorted out into three cases as : the apportionment to the Seoul Suburbs District, the apportionment to the Seoul Fringe District and apportionment to the Suburbs and the Fringe on 50 percent to 50 percent basis. Furthermore, there are two methods as the equal apportionment and the selective apportionment, and there are two methods like the extraction ratio of 10 percent and 30 percent.

Then, we established twelve land use models (3 x 2 x 2). However, we will present only two representative cases as follows.

1) Land Use Model Using Equal Apportionment to the Suburbs and the Fringe on 50% to 50% Basis

This apportionment method means to extract the industrial area equally from 17 zones of the Seoul city and to apportion it equally to the Seoul Suburbs District and the Seoul Fringe District on 50 percent to 50 percent basis.

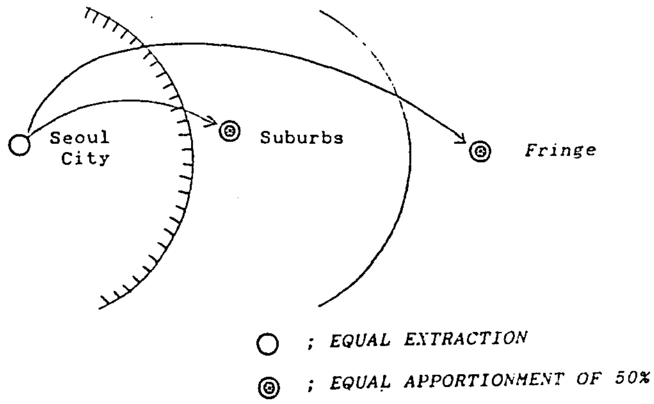

Figure 3-1. Diagram Presenting Equal Apportionment to the Suburbs and the Fringe on 50% to 50% Basis

The sum of the industrial area to extract from the Seoul city was represented as $\rho \sum_{i=1}^{17} \phi ij$. We apportion it equally to the Seoul Suburbs District and Seoul Fringe District an 50 percent to 50 percent basis.

Here, The areas $\acute{\Phi}i2$ and $\acute{\Phi}i3$ to be apportioned to each zone can be represented as follows :

$$\acute{\Phi}i2=\frac{\rho}{2i(2)} \sum_{i=1}^{17} \phi ij \fallingdotseq 0.060km^2$$

$$\acute{\Phi}i3=\frac{\rho}{2i(3)} \sum_{i=1}^{17} \phi ij \fallingdotseq 0.080km^2 \quad \cdots\cdots (3,\ 3)$$

2) Land Use Model Using Selective Apportionment to the Suburbs and the Fringe on 50% to 50% Basis

This apportionment method means to extract the industrial area from zones of Seoul city being over the Environmental Judgement Criterion Value and to apportion it selectively to 8 zones of the Seoul Suburbs District and to 5 zones of the Seoul Fringe District as shown in Fringe 3-2.

When we apportion 10 percent or 30 percent of the industrial area of Seoul city, we do not apportion it to the zones which satisfy the following two conditions :

1. di2>EJCV, di3>EJCV
2. Development Reservation District

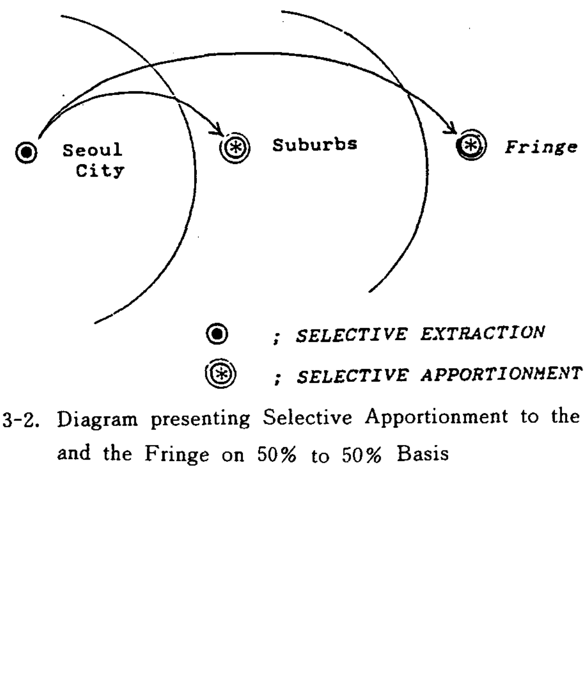

Figure 3-2. Diagram presenting Selective Apportionment to the Suburbs and the Fringe on 50% to 50% Basis

Furthermore, the ratio to apportion to the regions i[2], i[3] of remainder can be represented as follows :

$$\gamma i2=\frac{EJCV-di2}{\Sigma_i(EJCV-di2)} \quad (3,\ 4)$$

$$\gamma i3=\frac{EJCV-di3}{\Sigma_i(EJCV-di3)} \quad (3,\ 5)$$

Thus, the areas $\acute{\Phi}i2$ and $\acute{\Phi}i3$ to be apportioned are obtained as follows :

$$\acute{\Phi}i2=\frac{EJCV-di2}{2\Sigma_i(EJCV-di2)}\ \rho\sum_{i=1}^{17}\ \phi i1 \quad (3,\ 6)$$

$$\acute{\Phi}i3=\frac{EJCV-di3}{2\Sigma_i(EJCV-di3)}\ \rho\sum_{i=1}^{17}\ \phi i1 \quad (3,\ 7)$$

4. Analysis and Consideration

Apportioning 10 percent of the industrial area from Seoul city to the Suburbs, we can obtain the abatement effectiveness percent using equal apportionment and of 1.18 percent using selective apportionment.

That is, when we apportioned 10 percent of the industrial area from Seoul city to the Suburbs, the abatement effectiveness using equal apportionment and using selective apportionment did not show much difference.

However, apportioning 10% of the industrial area from Seoul city to the Fringe, we can obtain the abatement effectiveness of 1.92 percent using equal apportionment and of 0.81 percent using selective apportionment. Also, apportioning 10 percent of the industrial area from Seoul city to the Suburbs and the Fringe on 50 percent to 50 percent, we can obtain the abatement effectiveness of 2.13 percent using equal apportionment and of 1.14 percent using selective apportionment.

That is, if we apportion 10 percent of the industrial area to the Suburbs, to the Fringe, or to both on 50 percent to 50 percent, equal apportionment showed the abatement effectiveness of about twice as much as selective apportionment excepting the Fringe District.

Apportioning 30 percent of the industrial area from Seoul city to the Suburbs, we can obtain the abatement effectiveness of 4.04 percent using equal apportionment and of 2.67 percent using selective apportionment.

Again, apportioning 30 percent of the industrial area from Seoul city to the Fringe, we can obtain the abatement effectiveness of 6.05 percent using equal apportionment and of 4.25 percent using selective apportionment. Furthermore, apportioning 30 percent of the industrial area from Seoul city to the Suburbs and the Fringe on 50 percent to 50 percent, we can obtain the abatement effectiveness of 5.12 percent using equal apportionment and of 3.74 percent using selective apportionment.

That is, if we apportion 30 percent of the industrial area to the Suburbs, to the Fringe, or to both on 50 percent to 50 percent, equal apportionment showed the abatement effectiveness of about one and a half times as much as selective apportionment.

Table 1. Abatement Effectiveness of the Amount of Motor Truck Exhaust in Seoul City using Apportionment of 10% or 30%

Unit : kg/km²/day

LOCATION / PERCENTAGE RELOCATED	TO SOBURBS		TO FRINGE		TO BOTH ON 50% TO 50%	
	EQUAL	SELECTIVE	EQUAL	SELECTIVE	EQUAL	SELECTIVE
10%	11.09 (-1.16)	11.09 (-1.16)	11.00 (-1.96)	11.13 (-0.80)	10.98 (-2.14)	11.09 (-1.16)
30%	10.58 (-5.70)	10.92 (-2.67)	10.49 (-6.51)	10.74 (-4.28)	10.64 (-5.17)	10.80 (-3.74)

5. Conclusion

A summary of the results are as follows :

1) In this study, an appraisal model for measuring the abatement effectiveness of air pollutant (NOx) due to motor truck exhaust in Seoul city was built and it became clear that it is functionally operative.

2) Using the traditional four-step travel demand forecasting process well-known as the standard technique for estimating link traffic volume, we have to choose whether we build the computer program serving each step's purpose or buy the computer program software after paying an enormous amount.

However, if we use the appraisal model of motor truck exhaust built in this study, we can obtain that simulation results easily by only one personal computer and thus, it does not cost a great deal.

Therefore, it seems to us that the appraisal model of motor truck exhaust is a suitable model for developing countries and most especially for the Newly Industrializing Economics(NIES).

References

1. Bruton M. J(1970) : An Introduction to Transportation Planning, Hutchinson Education Ltd, pp. 3-5.
2. Byung Hwan Cho (1982) : Implementation of Regulatory Control, Principles, Policies and Practises, Environmental Agency, pp. 121-145.
3. Environmental Agency (1984) : Environmental Preservation, pp. 234-255.
4. Institute of Korean Scientific Technology (1986) : A study on Smoke Control Technology of Diesel Vehicles (1), pp. 238-309.
5. Institute of Korean Scientific Technology (1979) : A study on the Investigation of Physical Distribution and Administrative Improvement Scheme for Motor Trucks.
6. Korean Transportation Department (1983) : A Study on Traffic Improvement for Seoul City (1). (2). (3).
7. Michio Hashimoto (1979) : Air Pollution Countermeasures Art, Journal of Environmental Protection Control, Vol. 14 No. 1 pp. 2-7.
8. Shuzo Nishioka and Yuichi Moriguchi (1985) : Analysis of Air Pollution and Physical Distribution, Environmental Research Quality Environmental, No. 54, pp. 97-110.
9. Takeshi Kurokawa (1974) : An Investigation into Physical Distribution within an Urban Area, Urban Planning, No. 78.
10. Tokyo Prefecture (1982) : Repot for Pollution Countermeasures of Mobil Sources (Nitrogen Oxides), pp. 189-191.
11. Vehicle Emission Control Division of Air Pollution Research (1983) : A Survey on Vehicle Driving Pattern in Urban Area, National Environmental Protection Institute, pp. 5-6.