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EFFECT OF TRUCK TRANSPORTATION POLICIES ON AIR POLLUTION IN BANGKOK

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1. Introduction

This paper was launched to examine the effects of truck transportation policies on air pollution in Bangkok. First, it focuses on characteristics of freight movement in Bangkok. Second, estimation of emission loads from present truck transportation was conducted by using developed empirical model. Freight data were collected from roadside questionnaire interview in fourteen freight-transaction places. Incorporate with air emission database of vehicle, number of vehicle registration and Geographic Information System, Vehicle Kilometer Traveled (VKT) and emission loads generated were calculated. Effects of each stage of truck policies, after the opening of public truck terminals, on air pollution were subsequently assessed. The results reveal that such policies could slightly decrease VKT of heavy-duty trucks but increase VKT of light-duty trucks. Consequently, it could reduce Nitrogen Oxide (NO_x) and Suspended Particulate Matter (SPM) but increase Carbon Monoxide (CO) and Hydrocarbon (HC). Besides, truck restriction from outer ring road is more effective in reducing NO_x and SPM than from inner ring road. Also, reduction of NO_x and SPM is in accordance with ratio of terminal usage.

2. Truck Policies Planned and Implemented in Bangkok

The government delegated Department of Land Transport (DLT) to set up and monitor truck policies in the kingdom. Both capital-intensive and management-intensive policies have been implemented. The latest progress is the completion of three public truck terminals in the north, west, and east of Bangkok, namely, Khlong Luang, Buddha Monthon, and Rom Klao, repectively. They are located outside the outer ring road area and accessible by highway no.1, no.338, and Bangkok-Chonburi motorway, respectively as shown in Figure 1.

Afterwards, four stages of truck restraint have been implemented. Outer and inner ring roads are referred for defining active zone. First, all trucks with 10 wheels and

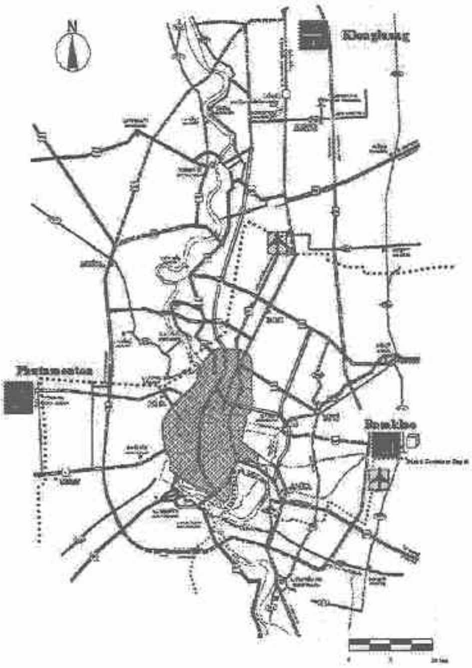

Figure 1 Location of Public Truck Terminals, Outer and Inner Ring Roads, and Truck Free Zone

Table-1 Truck Regulations after the Completion of Public Truck Terminal

Stage	Measure
1	Not allow ten-wheel truck and larger vehicles to park in the CBD area (45 square kilometer) for 24 hours immediately after three terminals are opened for service
2	Not allow ten-wheel truck and larger vehicles to park on the inner ring road and all of the streets located inside the inner ring road core (113 square kilometer) for 24 hours within three months after three terminals are opened for service.
3	Not allow ten-wheel truck and larger vehicles to enter the inner ring road core (113 square kilometer) during 5.00 – 22.00 hours within six months after three terminals are opened for service*.
4	Not allow ten-wheel truck and larger vehicles to enter and park inside the outer ring road core for 24 hours except some trucks that are allowed to enter the restricted area during 22.00 – 5.00 hours*.

more were not allowed to park inside 45-sq-km truck–free zone of Bangkok on 15 June 2000. Then, the zone has been expanded to inner ring road area (113-sq-km) since September 2000. These first two stages were accompanied by truck policy enforce earlier that was the prohibition of trucks from entering Bangkok during rush hours (6.00-9.00, 16.00-20.00 hours for four and six-wheeled trucks and 6.00-10.00, 15.00-21.00 hours for ten-wheeled and larger trucks). Finally, trucks with 10 wheels and more will totally be prohibited from entering the inner and outer ring road areas (24 hours) in the third and fourth stages, respectively. Some exclusive truck routes are also provided to enable trucks accessing to major ports and freight terminals located inside the restricted area. Such routes include all links between ports and expressway accesses.

transportation in Bangkok was firstly conducted. Study area of this paper covers fifty administrative areas in Bangkok. They are encoded to simplify origin-destination study.

Table 2 Number of Survey Location for Each Classification

	Location		Scale		
	Outer Ring	Inner Ring	Large	Medium	Small
1	IN	IN	0	4	2
2	IN	IN	0	1	0
3	IN	OUT	1	0	3
4	OUT	OUT	0	1	0
5	OUT	OUT	0	0	2
Total			14		

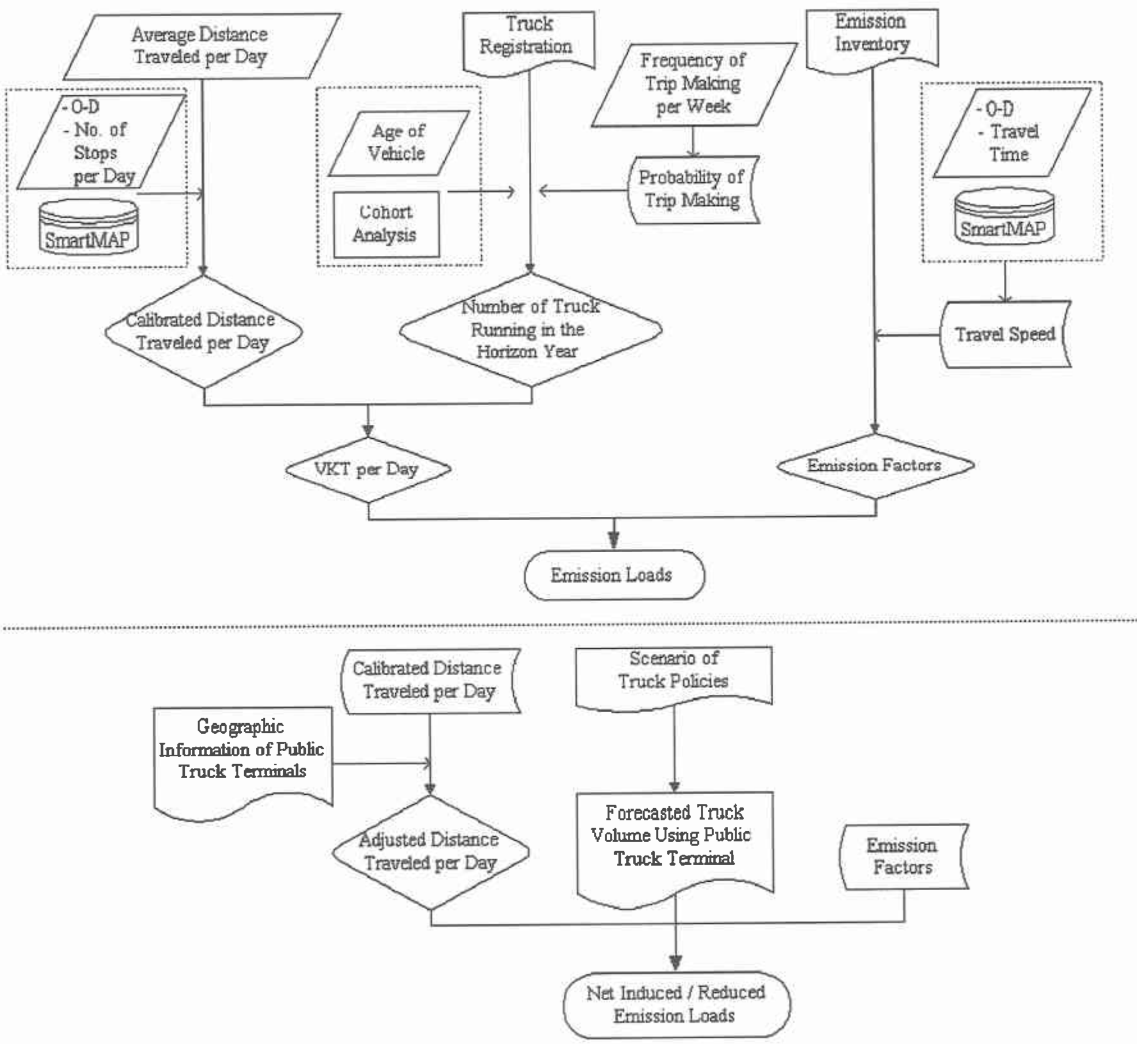

Figure 2 Analytical Process of the Estimation of Emission Loads from Truck Transportation Before (above) and After (below) the Implementation of Truck Policies

3. Data Collection

To determine the effect of public truck terminal on the change of environment and traffic conditions, the analysis of the existing emission loads from truck-based freight

Survey locations are selected based on variety of scales, positions, and market types (Table-2).After defining the survey locations, questionnaire is designed. Twelve questions about general information, freight transportation data, and freight transportation problems are incorporated. General information includes business types as retailer, wholesaler, factory, farm and garden, freight forwarder and others; commodity types as vegetable, clothes and leathers, (fresh food), fruits, processed foods, manufacturing products, meat and fish, flowers, rice, sugar and flour, and others; vehicle types as pick-up, four-wheeled, six-wheeled, ten-wheeled trucks, and van. Freight transportation data include distance traveled per day and per week, freight origins and destinations, number of stops per day, age of vehicle, trip frequency in a week, gas refueling, load factor, loading and unloading time, and travel time. One thousand and two hundred (1200) questionnaires are distributed and collected from truck users at fourteen survey locations, during 1 November 1999 and 31 December 1999 corresponding to peak period of each location. Then, they are screened. Finally, nine hundred and ten (910) valid questionnaires are qualified for analysis.

Statistics of truck registration from the year 1981 to 1998 and emission factors of light-duty diesel trucks (LDDT) and heavy-duty diesel vehicles (HDDV) are obtained from department of land transport (DLT) and pollution control department (PCD), respectively. Forecasted truck volume using public truck terminals is collected from JICA. In addition, geographic information of Bangkok from SmartMAP™ (GIS-based program) is incorporated to calibrate vehicle kilometer travel (VKT) data.

The calculations of vehicle kilometer traveled (VKT) can be conducted by two approaches; average daily traffic (ADT) and distance traveled analysis. Distance traveled analysis is selected for this study because of the lack of traffic data of overall road networks. For travel time study, interview survey technique is selected because of limitation in time and budget for data collection. The process of data analysis is shown in Figure 2.

4. Characteristic of the Movement of the Trucks

From questionnaire survey, retailer is a major business of this study (52.2 %) followed by wholesaler (37.1 %) and factory (3.7 %). Major commodities are vegetable (17.3 %), clothes and leathers (16.9 %), and mix fresh foods (16.9 %), respectively. Pick-up truck is a major vehicle (93.8 %) followed by six-wheeled truck (4.2 %) and van (1.3 %). Most trucks consign goods from factory, wholesaler, and warehouse (or truck terminal) to vender, fresh market, and retail or grocery shop. Each commodity type has individual pattern of distribution channel. Trucks carrying manufacturing products are found that they have highest load factor (88.3 %) followed by ones carrying fruits (85.9 %), and clothes and leathers (82.8 %). Trucks from factories have highest load factor (88.4 %) followed by from warehouses or truck terminals (88.1 %) and wholesalers (86.8 %). Peak hour of truck traveling to and from fresh market is 5.00 – 8.00 hours. For processed food and clothes markets as well as private truck terminal, peak period is 10.00 – 12.00 hours

5. Effect of the Emission Loads after Implement of Public Truck Terminal in Bangkok

The effect of public truck terminal implementation on air pollution in Bangkok is considered. Estimation of number of truck trips using three public truck terminals in the year 2000 by JICA is adopted for calculation of induced emission load. To simulate the truck ban measures adopted after the opening of public truck terminal as mentioned in Section 2, Freight Transportation Plans and Policies in Bangkok. Five scenarios are considered in JICA research as follows:

Table -3 Net Induction of VKT per Day, NO_x, CO, HC and SPM (Kilograms per Day) According to Different Scenarios of Truck Policies Implemented after the Opening of Public Truck Terminals

Source: JICA(1992)			Distance Traveled(km/day)		Induced VKT per Day (x 10^3)		Induced Emission Loads (kg/day)			
Scenario	No. of Truck Using Terminals									
	1.6T	10.5T	1.6T	10.5T	1.6T	10.5T	NO_x	CO	HC	SPM
Case 1	3,596	548	83.7	- 63.1	300.9	-34.6	-295	189	88	-15
Case 2-a	16,211	2,470	84.9	- 63.1	1,376.7	-155.9	-1,301	883	412	-65
Case 2-b	19,367	2,951	84.9	- 63.1	1,644.0	-186.3	-1,556	1,053	492	-77
Case 3-a	27,258	4,154	83.5	- 63.1	2,277.0	-262.2	-2,243	1,426	665	-118
Case 3-b	33,176	5,055	83.5	- 63.1	2,771.3	-319.1	-2,730	1,735	809	-144

Case 1 is the existing condition with 2.8% use ratio.

Case 2-a is 24-hour heavy truck restriction of inner area with 2.8 % use ratio.

Case 2-b is 24-hour heavy truck restriction of inner area with 100 % use ratio.

Case 3-a is 24-hour heavy truck restriction of outer area with 2.8 % use ratio.

Case 3-b is 24-hour heavy truck restriction of outer area with 100 % use ratio.

The estimation of number of truck trips using three public truck terminals in the year 2000 is shown in Table 3. Four commodity types are incorporated in JICA study including processed food, clothes and leathers, manufacturing products and miscellaneous goods. Therefore, the trucks carrying these goods in this study are taken into concern. After the implementation of truck terminals, heavy trucks running inside Bangkok area will be reduced. However, the number of delivery trucks (LDDT) to carry goods from truck terminal to the destination inside Bangkok will be increased as a trade-off. In addition, distance traveled of LDDT will be unavoidably increased due to longer distance between the public truck terminals and other administrative area. Distance traveled per day is readjusted as shown in Table 3.

The north, west, and east public truck terminal are located in Don Muang, Thavee Watthana and Ladkrabang area, respectively. From the distance matrix, the distance ratio is calculated by dividing the average distance between Don Muang, Thavee Watthana, and Ladkrabang and the other administrative area by the average distance among overall administrative area. The induction (or reduction) of vehicle kilometer traveled (VKT) and emission loads after the implementation of public truck terminals in Bangkok are presented in Tables 3, respectively.

After the implementation of public truck terminals, the vehicle kilometer traveled (VKT) of LDDT are largely increased while the VKT of HDDV are slightly decreased. The results yield the conclusion that implementation of truck terminal could help reduce emission loads of NO_x and SPM in Bangkok Metropolitan Area but emission loads of CO and HC become higher due to the induced vehicle kilometers traveled of delivery truck. The 24-hour truck restriction from outer ring road core is more effective in reducing NO_x and SPM emissions than from inner ring road. The percent reduced of emissions depends on the percentage of truck terminal usage.

6. Conclusion

Heavy truck is the major source of Nitrogen Oxide (NO_x) and Suspended Particulate Matter (SPM). As shown in Table 1, NO_x from heavy truck (HDDV) is approximately two times of light truck (LDDT) in spite that VKT of LDDT is approximately seven times of HDDV. This results in the reduction of NO_x and SPM when truck restriction policies are enforced at the third and fourth stage, as shown in Table 3. The percentage of NO_x reduction reaches up to 8.2 times when implementing the final stage of truck policies and all truck terminals provide service at their capacities. However, the unexpected outcome of truck policy implementation is the increasing of Carbon Monoxide (CO) and Hydrocarbon (HC) from the higher number of delivery trucks (1.6 tons) that come to pick-up the equivalent loads of one line-haul truck (10.5 tons).

The results of this study are expected to be a beneficial case study for the policy-makers to perceive the effects behind the implementation of truck policies and prepare to cope with the upcoming consequences, for instances, induced number of delivery trucks and cooperation of truck transportation companies.

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