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Title	A Study on Measuring Repercussive Pollution Arising from Eastern Seaboard Development Program
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Citation	Environmental science, Hokkaido University : journal of the Graduate School of Environmental Science, Hokkaido University, Sapporo, 14(2), 1-12
Issue Date	1992-03-30
Doc URL	https://hdl.handle.net/2115/37268
Type	departmental bulletin paper
File Information	14(2)_1-12.pdf



Environ. Sci., Hokkaido University	14 (2)	1 ~ 12	Dec. 1991
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A Study on Measuring Repercussive Pollution Arising from the Eastern Seaboard Development Program

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Abstract

The repercussive pollution arising from the Eastern Seaboard Development Program are measured by the Input-Output Method.

The main results of the estimation of the direct and indirect repercussive pollutions of this study are as follows:

1. The total SOX in locational areas is the highest and more than twice as high than in Central region.
2. The highest COD Pollution occurs in locational areas.
3. Central region has the highest level of SS Pollution.
4. The total IWD in Central region is the highest.
5. The direct repercussive pollution impact in locational areas are SOX and COD while in Central region are SS and IWD.
6. Northeast region receives the lowest indirect repercussive pollution impact.
7. The indirect repercussive pollution impact in Bangkok are SOX, COD, SS and IWD.

Key words : Repercussive pollution, Direct and Indirect Repercussive Pollution Impact, Input-Output Model, Sulfur Oxide (SOX), Chemical Oxygen Demand (COD), Suspended Solid (SS), Industrial Waste Disposal (IWD), Eastern Seaboard Development Program.

1. INTRODUCTION.

Thai economy has changed tremendously from one based on agriculture to agro-industry and it is anticipated that Thailand will become a Newly Industrialized Country (NIC) by the end of the Seventh National Development Plan period (1992–1996). The majority of the population of the country seem to accept the policy of industrialization, but there appears to be much concern regarding the industrial pollution problems that can arise. Industrial development in any country will normally result in the development of technology and ultimately economic development but on the other hand, as a consequence, the country has to face environmental problems. Particularly, without proper preventive measures, pollution tragedy will be inevitable.

Pollution is the negative image of industrial development. Thailand has pollution

problems which have accumulated in the environment and in human bodies over a period of time causing public health problems. The origin of these problems is largely due to industrial activities. The Department of Biological Sanitation conducted a survey of the water quality of major rivers, Water samples were collected at the level 1 meter from the surface at water quality monitoring stations during August 1983 through August 1984. The summary of water quality in 1984 as contained in the report (see Figure 1), is as follows:

Chao Phrya River pollution was assessed as substandard. The major pollutants were organic matters and mercuric substances.

Ta Chin River in Nakornpatom province, Central region, was also identified to have substandard pollution. The major pollutant was organic matter.

Mae Klong River in Rajaburi province, Central region, was formerly polluted but after treatment the water quality was found to be within standard.

Pranburi River in Prachuabkirikhan province, Central region, was polluted with water quality below standard. The major pollutant was bacteria.

Bang Pakong River in Chachoengsao province, Central region, was polluted with water quality below standard. The major pollutant was mercury.

Petch River in Petchaburi province, Central region, was polluted with water quality below standard. The major pollutant was bacteria.

The major cause of pollution of the above-mentioned major rivers was the industrial development that increased production. The use of chemical substances as well as new production techniques which gave rise to more waste materials and pollutants to the environment.

The industrial pollution is on the rising trend, when it reaches the toxicity level it will eventually affect the health and even the life of the public.

2. THE STUDY OF THE REPERCUSSIVE POLLUTION ARISING FROM LARGE-SCALE INDUSTRY.

It is well known that pollution will always accompany industrial manufacturing activities. Therefore it is necessary to study the repercussive pollution arising from large-scale industry in order to allow for the government to plan protection.

Regarding the study of the repercussive pollution from industry, there are seven well known scholars i.e. Ayres, R.U. and Kneese, A.V. (1969); Victor, P.A. (1972); Cumberland, J.H.(1966); Daly, H.E. (1968); Isard, W.(1972) and Leontief, W.(1970) who studied the possibility of integrating economic and environment models. Ayres, Kneese and Victor made the Cassel general equilibrium model based on the Walras. Cumberland, Daly, Isard and Leontief each suggested that input-output models could be adapted to environmental sectors. Later Yamamura, E. (1979, 1980) and Iwasa, M., Yamamura, E. and Ota, M. (1985) studied the method for measuring the repercussive pollution based on the interregional input-output model, therefore, this research has adopted the method of measuring the repercussive pollution based on the input-output model, and measured the impact arising from the location of manufacturing industries in the Eastern Seaboard Industrial Complex.

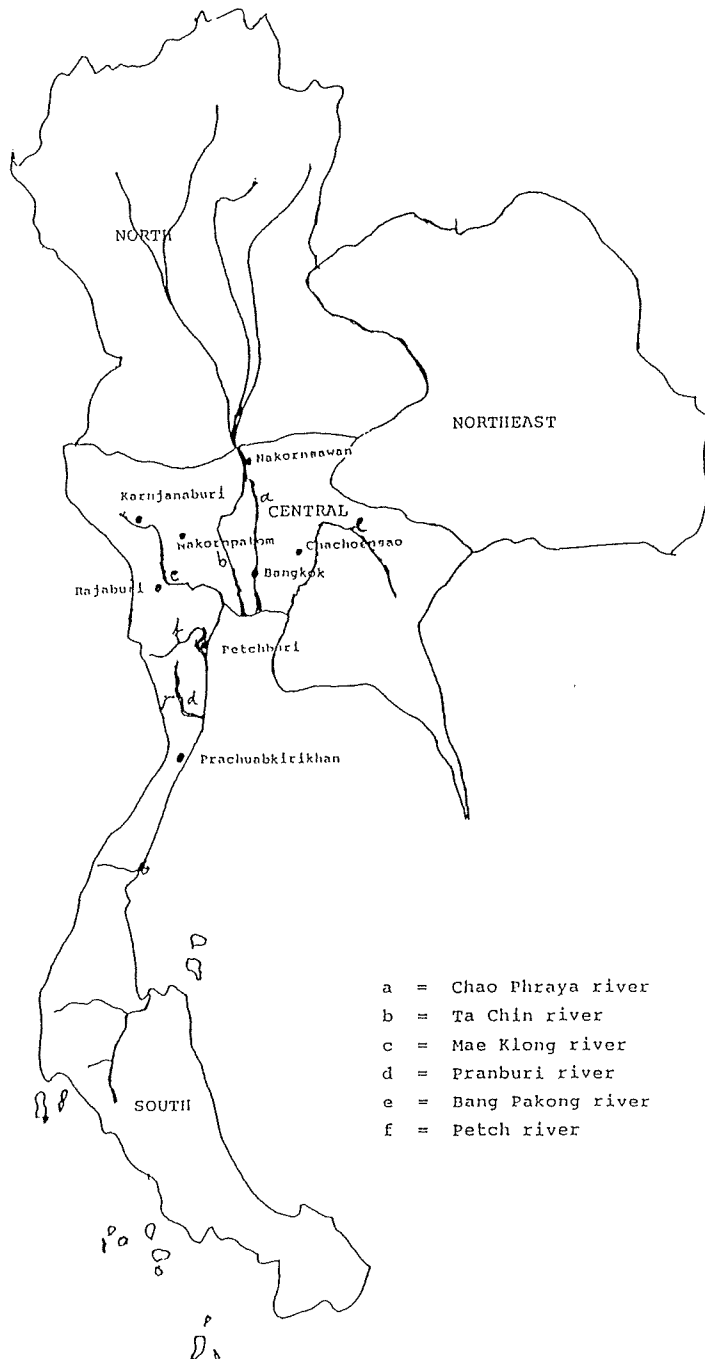


Figure 1 Location of the polluted rivers

3. THE METHOD FOR MEASURING THE REPERCUSSIVE POLLUTION.

The mathematical formation of the method for measuring the repercussive pollution arising from the location of manufacturing industries is the methodology of this study.

The following conditions should be considered to formulate the method for measuring the repercussive pollution:

- (1) The necessity to measure the repercussive pollution by industries and scales.
- (2) The differences of the impact of repercussive pollutions arising from the location of manufacturing industries.
- (3) The impact of pollutions both from the direct repercussive effects and the indirect repercussive effects.
- (4) The indirect repercussive pollution both from the locational region and other regions.

The definition of the notations of the partitioned matrices are as follows :

A : input coefficients matrix by regions.

I : identity matrix.

S : matrix having the values of inputs from other industries to locational industries along the main diagonal (the diagonal running from the upper left to the lower right) and zero elsewhere.

D : matrix having the values of input of locational industry along with the column and zero elsewhere.

R : emission factors.

X represents the matrix of the total repercussive pollution and satisfies the following equations.

$$\begin{aligned} X &= D * R + A \cdot S * R + A^2 \cdot S * R + \\ &= D * R + [I + A + \dots] A \cdot S * R \\ &= D * R + [I - A]^{-1} \cdot A \cdot S * R \end{aligned}$$

where, $D * R$ is the direct repercussive pollution and $[I - A]^{-1} \cdot A \cdot S * R$ is the indirect one.

The repercussive pollutions have been allocated into 5 regions namely: Central, Bangkok, Northeast, North and South. The direct repercussive pollutions will be the impact experienced in Central region where the locational industries located ; and the indirect repercussive pollutions will be the impact in other regions. The study will be based on pollutions emission by industries.

4. THE ESTIMATE OF THE REPERCUSSIVE POLLUTION ARISING FROM THE INDUSTRIAL LOCATIONS IN THE EASTERN SEABOARD INDUSTRIAL COMPLEX.

During the Fifth National Plan (1982-1986), in 1982 the Eastern Seaboard Development Program (ESDP) was announced to be a large-scale industrial complex. Due to the National Policy of industrial location distribution to regions and the recent discovery and development of natural gas deposit in the Gulf of Thailand, the ESDP is established in two

provinces of Central region i.e. Map Ta Phut, Rayong province and Laem Chabang, Chonburi province.

In this study, Thailand is classified into 5 regions i.e. Bangkok, Central, Northeast, North and South (see Table 1). The ESDP is located in Central region as well as Bangkok. The types of industry are classified into 21 Sectors (see Table 2) and the types of industry in ESDP are presented in Table 3, according to the classification in Table 3 (see Table 3).

The Eastern Seaboard Development Program is not merely the growth of an existing industrial situation but rather a fundamental change in the economic complex of Central region.

The main locational industries are the international competitive industries; heavy and petrochemical industries, polluting industries located at Map Ta Phut ; and export processing and light industries, non-polluting industries located at Laem Chabang.

The ESDP is expected to become prosperous according to the result of an earlier research (Sunee Mallikamarl, 1990). The Output of locational industries in the year 1995 will become very high as well as the Employment Opportunities (see Table 4).

The repercussive pollutions are measured into 4 emission sectors i.e. Sulfur Oxide (SOX), Chemical Oxygen Demand (COD), Suspended Solid (SS) and Industrial Waste Disposal (IWD).

The main research results are as follows : -

- 1) From the fact presented in Table 5, the direct repercussive pollution of SOX in

Table 1 The Classification of 5 Regions of Thailand.

Region	Changwat (Province) 73 Changwats	
Bangkok	Capital city.	
Central (24)	Mid-Central	: Nontaburi, Patumtani, Ayuthya, Saraburi, Lopburi, Singburi, Angthong, Chainat.
	Central East	: Chonburi, Rayong, Chachoengsao, Chantaburi, Trat, Nakornnayok, Prachinburi, Samut-Prakarn.
	Central West	: Supanburi, Nakornpatom, Rajaburi, Petchaburi, Prachuabkhirikan, Kanjanaburi, Samut-Songkram, Samut-Sakorn.
Northeast (17)	Karasin, Khonkaen, Chaiyapoom, Nakornpanom, Buriram, Nakornrajsima, Mahasarakam, Mukdaharn, Yasothorn, Roied, Loey, Srisaket, Sakolnakorn, Surin, Nongkai, Udonthani, Ubonrajathani.	
North (17)	Nakornsawan, Kampangetch, Tak, Pitsanulok, Prae, Petchaboon, Nan, Lampang, Lampoon, Sukhothai, Utaradit, Uthaitani, Payao, Pichit, Chiangmai, Chiangrai, Maehongsorn.	
South (14)	Chumporn, Krabi, Trang, Songkhla, Satoon, Yala, Naratiwas, Pattani, Pang-nga, Nakornsri thamraj, Patalung, Phuket, Ranong, Surajtani.	

locational areas is about as twice high compared to the Central region due to the amount of SOX emission from the manufacturing activities of Petroleum (10), Basic Chemical (11) and Non-Metal Products (8). The indirect repercussive pollution in Northeast region is of the lowest impact due to the fact that the number of factories located in Northeast region is the least compared with other regions (see Table 5).

Table 2 Classification of Industry.

Number	Sector
1	Agriculture, Livestock, Forestry and Fishery.
2	Mining.
3	Food Processing, Beverage and Tobacco.
4	Textile.
5	Leather Products, Rubber and Rubber Products.
6	Wood Products.
7	Paper and Paper Products.
8	Non-Metal Products.
9	Light Industries.
10	Petroleum.
11	Basic Chemical.
12	Basic Metal.
13	Fabricated Metal.
14	Machinery.
15	Electrical Machinery.
16	Transport Equipment.
17	Electricity.
18	Construction.
19	Trade.
20	Transport and Communication.
21	Banking and Finance, Public Administration and Business Services.

Table 3 Type of Industries in ESDP

Number.	Sector.	Locations.
3	Food, Beverage and Tobacco	Laem Chabang
4	Textile	Laem Chabang
5	Leather Products, Rubber and Rubber Products	Laem Chabang Map Ta Phut
8	Non-Metal Products	Laem Chabang
10	Petroleum	Laem Chabang Map Ta Phut
11	Basic Chemical	Laem Chabang Map Ta Phut
13	Fabricated Metal	Laem Chabang
15	Electrical Machinery	Laem Chabang
16	Transport Equipment	Laem Chabang

Table 4 The Output and Employment Opportunities in the year 1995.

Sectors	Output	Employee
<i>Map Ta Phut</i>		
Leather, Rubber and Rubber Products	336,741.78	340
Petroleum	80,268,569.32	4,205
Basic Chemical	1,378,035.80	1,150
Total MTP	81,988,346.90	5,695
<i>Laem Chabang</i>		
Food, Beverage and Tobacco	350,764.21	373
Textile	181,045.44	576
Non-Metal Product	605,361.11	683
Leather, Rubber and Rubber Products	783,419.83	587
Petroleum	8,501,174.15	350
Basic Chemical	907,107.04	385
Fabricated Metal	71,483.04	120
Electric Machinery	2,300,047.20	2,825
Transport Equipment	2,782,368.45	3,358
Total LB	16,482,770.49	9,257
Total all	98,466,117.39	14,952

Estimated Output: million baht based on 1985 currency year. (approx. 25 baht = 1 US Dollar).

Source: Office of the Eastern Seaboard Development Committee.

2) As presented in Table 6, the direct repercussive pollution of COD in locational areas is the highest owing to the fact that Petroleum manufacturing activity (10) which consumes a large volume of water is located there. Central region also has a high level due to the Electricity production activity (7). The indirect repercussive pollution in Northeast region produces the lowest impact because of the least number of factories among other regions (see Table 6).

3) Based on the fact presented in Table 7, the direct repercussive pollution of SS in Central region is higher than in locational areas due to Mining (2) and the Electricity production activities (17) which have high levels of SS. Locational areas also has a high level of SS due to the Petroleum manufacturing activity (10). The indirect repercussive pollution to the Northeast region has the lowest impact which is similar to SOX and COD (see Table 7).

4) According to the facts presented in Table 8, the direct repercussive pollution of IWD in Central region is higher than in locational areas due to the Electricity production activity (17) while locational areas do not have Electricity Sector located. The indirect repercussive pollution in Northeast has the lowest impact which is similar to SOX, COD and SS (see Table 8).

5) As indicated in Table 9 and Figure 1, the total repercussive pollutions of SOX and

Table 5 Repercussive SOX by Regions and Industrial Sectors.

SECTOR	DIRECT		INDIRECT			
	LOCATION	CENTRAL	BANGKOK	NORTHEAST	NORTH	SOUTH
1		10,030	1,243	2,293	2,894	2,558
2		1,744,347	0	59,125	27,021	306,508
3	13,408	5,922	7,111	179	367	179
4	11,899	8,318	7,115	2,180	4,365	1,622
5	48,251	7,889	5,220	178	301	168
6		4	0	0	0	0
7		33,964	32,132	1,327	2,266	1,289
8	210,237	8,878	2,961	660	944	438
9		8	8	0	0	0
10	13,754,249	30,847	185,288	7,720	13,086	7,614
11	585,810	40,174	16,540	691	1,177	676
12		14,258	7,545	303	529	303
13	37	36	8	0	0	0
14		88	159	5	12	5
15	23,696	603	441	13	27	27
16	58	0	3	0	0	0
17		5,064,846	949,434	21,252	407,245	50,725
18		5	19	0	0	0
19		16	7	0	0	0
20		39,647	75,901	3,366	3,492	4,459
21		25,124	1	0	0	0
TOTAL	14,647,645	7,035,004	1,291,136	99,292	463,726	376,571

Table 6 Repercussive COD by Regions and Industrial Sectors.

SECTOR	DIRECT		INDIRECT			
	LOCATION	CENTRAL	BANGKOK	NORTHEAST	NORTH	SOUTH
1	0	37,461	6,047	13,517	17,055	15,081
2	0	0	0	0	0	0
3	132,215	58,461	70,073	1,858	3,724	1,814
4	18,957	13,258	11,200	3,477	6,969	2,503
5	99,399	16,258	9,287	368	617	354
6	0	32	44	0	0	0
7	0	217,869	206,123	8,550	14,499	8,313
8	96	2	0	0	0	0
9	0	170	251	0	3	0
10	3,459,622	7,754	46,593	1,930	3,277	1,883
11	37,096	43,752	18,010	745	1,260	724
12	0	5,296	2,844	110	192	111
13	4,315	5,022	1,704	61	115	61
14	0	203	312	10	18	10
15	36	1	0	0	0	0
16	10,211	175	1,184	30	64	30
17	0	2,547,306	477,480	10,661	204,793	25,499
18	0	0	3	0	0	0
19	0	3,072	2,059	77	532	455
20	0	33,019	63,176	2,804	2,899	3,698
21	0	11,115	7,951	315	523	435
TOTAL	3,761,947	3,000,226	924,341	44,513	256,540	60,971

Table 7 Repercussive SS by Regions and Industrial Sectors.

SECTOR	DIRECT		INDIRECT			
	LOCATION	CENTRAL	BANGKOK	NORTHEAST	NORTH	SOUTH
1	0	14,994	1,533	3,431	4,335	3,830
2	0	7,342,411	0	251,151	113,770	1,297,815
3	104,311	46,123	55,361	1,464	2,936	1,464
4	15,080	10,546	12,027	2,854	5,550	2,164
5	105,292	17,221	9,839	394	663	378
6	0	7	0	0	0	0
7	0	180,756	171,048	7,093	12,045	6,893
8	265,973	11,233	3,744	836	1,119	556
9	0	163	243	0	4	0
10	2,419,151	5,419	32,579	1,264	2,291	1,332
11	398,143	27,351	11,253	1,554	791	455
12	0	17,505	9,440	381	660	381
13	2,042	2,372	813	26	51	26
14	0	698	1,242	48	83	47
15	319	8	2	0	0	0
16	776	9	78	1	3	1
17	0	4,371,725	819,503	18,342	351,453	43,782
18	0	5,265	11,794	0	0	0
19	0	3,822	2,566	99	663	173
20	0	57,713	110,483	4,903	5,075	6,488
21	0	42,286	30,280	1,230	2,022	1,679
TOTAL	3,311,087	12,157,627	1,283,828	295,071	503,514	1,367,464

Table 8 Repercussive IWD by Regions and Industrial Sectors.

SECTOR	DIRECT		INDIRECT			
	LOCATION	CENTRAL	BANGKOK	NORTHEAST	NORTH	SOUTH
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	8,374	3,698	4,418	109	436	145
4	2,675	1,868	1,590	481	973	338
5	2,035	328	178	4	8	3
6	0	225	123	1	4	1
7	0	653	605	21	37	20
8	26,801	1,160	460	71	102	45
9	0	49	68	0	0	0
10	12,515	23	156	4	8	4
11	314	16	3	0	0	0
12	0	1,825	968	33	62	42
13	612	704	230	6	30	8
14	0	206	365	13	22	12
15	15,115	384	276	7	16	16
16	10,072	173	1,145	29	72	29
17	0	258,532	48,412	1,013	20,775	2,564
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
TOTAL	78,513	269,844	58,997	1,792	22,545	3,227

COD have the highest impact in locational areas while SS and IWD have the highest impact in Central region. Though Central region does not have the highest SOX and COD impact, it still has high levels. (see Table 9 and Figure 2).

6) From the research result, Northeast region has the lowest indirect repercussive SOX, COD, SS and IWD impact due to the least number of factories located there when compared with other regions.

7) From the facts presented in Table 10 and Figure 2, the total repercussive pollutions of SOX, COD, SS and IWD are the highest indirect repercussive impact in Bangkok when compared with other regions even though Bangkok is only a province and not a region such as others but Bangkok is the closest city to the locational industrial area which contains all of the infrastructure facilities (see Table 10 and Figure 3).

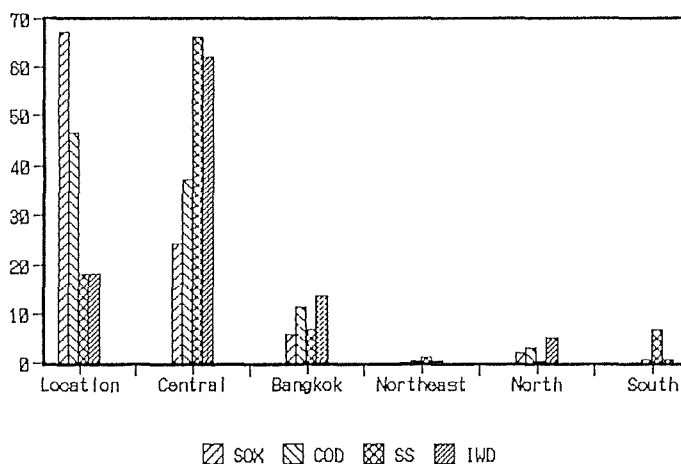


Figure 2 Distribution Percentage of Total Repercussive Pollution by Region.

Table 9 Distribution Percentage of Total Repercussive Pollution by Region

Region	Emission Sectors			
	SOX	COD	SS	IWD
Location	67.26	46.74	17.98	18.05
Central	24.3	37.28	66.02	62.04
Bangkok	5.93	11.48	6.97	13.57
Northeast	0.18	0.55	1.36	0.41
North	2.00	3.19	0.62	5.18
South	0.32	0.76	7.05	0.74

Table 10 Distribution Percentage of Total Repercussive Pollution by Region (omitted Location)

Region	Emission Sectors			
	SOX	COD	SS	IWD
Central	74.27	69.99	80.49	75.71
Bangkok	18.11	21.56	8.50	16.55
Northeast	0.56	1.04	1.66	0.50
North	6.13	5.98	0.75	6.33
South	1.98	1.42	8.59	0.91

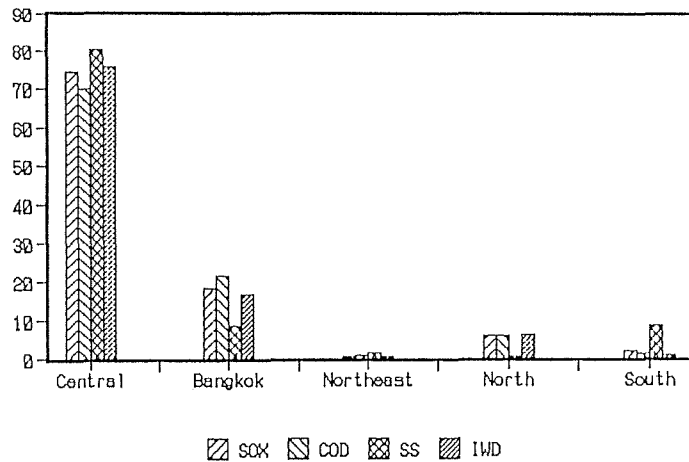


Figure 3 Distribution Percentage of Total Repercussive Pollution by Region.
(omitted Location)

5. CONCLUSION.

An attempt has been made to measure the repercussive pollutions arising from the Eastern Seaboard Development Program. The Input-Output Method has been used to estimate the direct and indirect repercussive pollutions arising from industries located in Eastern Seaboard Industrial Complex.

The result of the research indicates that the total direct repercussive pollutions in locational areas has the highest impact and Central region has the second highest impact. The indirect repercussive pollutions impact in other regions were not as high as expected. Northeast region has the lowest impact.

It is noticeable that the Northeast region, actually, has least number of factories located there compared with other regions. It can be said that where there is no industry there is no industrial pollution, on the other hand, the Northeast region has the problem of poverty and that is one of the reasons why Northeast people migrate to Bangkok and other regions to seek employment opportunities. It is anticipated that the Eastern Seaboard Development area will be a region where the Northeast people will migrate to besides Bangkok.

However, regarding industrial pollution problems, SOX, and COD are the serious direct repercussive pollution problems which mean air pollution and water pollution. These pollution impacts have effected life, health and property of the people in the industrialized countries. Japan is the worst example which represented the impact of industrial pollution in the past. The Yokkaichi Asthmatic Bronchitis disease and Kawasaki Asthmatic disease from air pollution; the Minamata disease and Itai-Itai disease from water pollution created a multitude of problems to the Japanese people and the government which have taken more than ten years and consumed a huge amount of money to find a solution. Such experiences should be a good lesson for Thai government

to study for planning the protection of the environment against industrial pollution especially in the area of Eastern Seaboard Industrial Complex. Thai government should be aware that the economic development will not give only favorable results. Unfavorable outcome will result and will affect all concerned including the government, the government officials, the industrialists and the people. It is accepted that environmental pollution comes with industrial development.

Without appropriate measures, the environment will be destroyed and rehabilitation may be impossible. At the same time the people living around the factories will accumulate in their bodies toxic substances created by industrial activities.

ACKNOWLEDGMENTS

This study has been supported by The Japan Society for the Promotion of Science (JSPS), Ronpaku Program, which the authors hereby acknowledge with thanks.

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