GREATER MEKONG SUBREGION
CORE ENVIRONMENT PROGRAM

GMS Core Environment Program

Estimating Industrial Pollution in the Kingdom of Cambodia

Final Report

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Final Report

Produced by the GMS Environment Operations Center

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Abbreviations

ADB	Asian Development Bank
AIRS	Aerometric Information Retrieval System
ASM	Annual Survey of Manufactures
BOD	biological oxygen demand
CM	Census of Manufacturers
HHED	Human Health and Ecotoxicity Database
GDP	gross domestic product
GIS	geographic information system
IDP	Industrial Development Policy
IPPS	industrial Pollution Projection System
ISIC	International Standard Industrial Classification
LRD	Longitudinal Research Database
MIH	Ministry of Industry and Handicraft
MoE	Ministry of Environment
NSSF	National Social Security Fund
NO2	nitrogen dioxide
NPDES	National Pollutant Discharge Elimination System
PM10	particulate matters of size less than 10 microns
RGC	Royal Government of Cambodia
SEZs	Special Economic Zone and Specific Economic Zone
SO2	sulfur dioxide
TRI	Toxics Release Inventory
TSS	total suspended solids
UNIDO	United Nations Industrial Development Organization
USEPA	United States Environmental Protection Agency
VOC	volatile organic compounds

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Acknowledgments

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I. Summary

With the launching of its Industrial Development Policy (IDP) in 2015, Cambodia has clearly expressed its intent to boost the country's industrial development. While industrial development is expected to facilitate high economic growth and alleviate poverty, it may also add further pressure on the availability and quality of the Cambodia's natural resources and ecosystem services, and challenge environmental protection and pollution control authorities.

For Cambodia to be able to respond efficiently and effectively with industrial pollution regulations and law enforcement, it needs to be able to identify problematic manufacturing sectors and facilities, and tailor appropriate interventions. This is particularly important in a situation where agencies with authority to control industrial pollution in Cambodia face significant constraints in staff, budget and technology. Plant monitoring of air, water, and toxic emissions is at best done in a sporadic fashion, monitoring protocols and methods may not be applied consistently, monitoring equipment is often obsolete, data management and archiving procedures may not be strictly followed, and there is a lack of trained and empowered staff to actually perform site inspections and undertake data analysis for setting priority actions.

Such a situation is arguably not unique to Cambodia. It is generally recognized that environmental regulators in developing countries often lack vital information on where the main pollution hotspots are found, and which manufacturing sectors and specific enterprises are the main emitters in order to set priorities, strategies, and action plans for controlling industrial pollution. As a result, strategic level planning has very little relevant information on pollution that can inform and support priority setting for industrial pollution control, development of strategies, and improvement of policies and law enforcement.

As a response to this insufficiency of information, the former Infrastructure and Environment team of the Development Research Group of the World Bank has developed an Excel-based tool known as the Industrial Pollution Projection System (IPPS). This tool exploits the fact that industrial pollution is heavily affected by the scale of industrial activity and its sectoral composition. IPPS operates through sector estimates of pollution intensity (usually defined as pollution per unit of output or pollution per unit of employment).[1] Results from IPPS have been used in various countries where insufficient data on industrial pollution proved to be an impediment to setting up pollution control strategies and prioritization of activities.[2]

Section 1 presents a rapid overview of the setup for controlling industrial pollution in Cambodia. In Section 2, we briefly describe IPPS and discuss the challenges and limitations with the use of IPPS in Cambodia. With these limitations in mind, we present the characterization of industrial pollution in Cambodia using IPPS in Section 3. It is shown that a large percentage of industrial pollution is generated by a limited number of industrial sectors and by a limited number of industrial facilities within those sectors. It is also shown that a large share of industrial pollution originates from a very limited number of provinces. These results suggest that large overall reductions in the discharges of industrial pollution in Cambodia could be achieved by focusing resources to a relatively small number of industrial facilities and areas. Finally, Section 4 provides brief recommendations and concluding remarks.

[1] See Hettige et al. (1994) for details.

[2] For example, IPPS has been used to estimate industrial pollution in Brazil and Mexico (Dasgupta et al. 2000), Latvia (Laplante and Smits 1998), Nigeria (Etim 2012, and Odesanya 2012), Thailand (Laplante and Meisner 2001), and Viet Nam (Dore et al. 2008).

1. Industrial Development in Cambodia

Background

Cambodia's industrial sector has experienced significant growth in recent decades. Since 1993, the sector's share of gross domestic product (GDP) increased from approximately 12.5% to 24.1% in 2013. It experienced an average annual growth rate of approximately 12.4% over the period 1998–2013. Over the same period, the agriculture and service sectors grew at an average annual rate of 4.7% and 8.5%, respectively.

The industrial sector also represents an increasing share of employment in Cambodia: its share of the total labor force was approximately 5% in 1993. This share increased to 8.6% in 2008, to 19.9% in 2013, and to an estimated 24.3% in 2014 (Government of Cambodia 2015a). Such increases have been observed throughout the country and not only in major urban areas (Table 1).[3]

Table 1: Employed Population by Industrial Sector (%)

	Cambodia	Phnom Penh	Other Urban	Other Rural
	2009			
Agriculture	57.6	1.9	24.0	68.0
Industry	15.9	21.2	17.8	15.0
Services	26.5	76.9	58.3	17.0
	2014			
Agriculture	45.3	25.0	17.0	56.9
Industry	24.3	28.2	25.4	23.5
Services	36.4	69.3	57.6	19.6

Source: Government of Cambodia (2015a)

Despite this significant growth, the Cambodian industrial sector is generally considered weak with a narrow base (mostly concentrated in garment and food processing subsectors), limited value added, and low level of technology. Furthermore, it is generally recognized that a significant share of enterprises is not only small but also remains informal and lacks formal registration.

In March 2015, Cambodia's Council of Ministers adopted Cambodia's Industrial Development Policy (IDP) 2015–2025 (Government of Cambodia 2015b) to transform and modernise Cambodia's industrial structure from a labour-intensive industry to a skill-driven industry by 2025. For this purpose, Cambodia has set three targets: (1) to increase the industrial sector's share of GDP from an estimated 24.1% in 2013 to 30% in 2025, and that of the manufacturing sector from 15.5% to 20% in the same period; (2) to encourage a greater diversity of exports by promoting exports from sectors other than textile; and (3) to encourage the formal registration of most enterprises in the country.

While Cambodia possesses a rich environment resource, it simultaneously faces a number of critical issues including the (mostly) untreated discharge of domestic and industrial wastewater into surface water and increasing air pollution in urban areas. As noted by the Euronet Consortium, most manufacturing plants in Phnom Penh are located along the embankment of the Tonle Sap River and only a limited number of facilities have the capacity to treat industrial effluents before discharging in receiving sources (Euronet Consortium 2012). In a recent survey of pollution hot spots, the United Nations Industrial Development Organization

[3] All tables, figures and boxes are presented at the end of this report in the sequence of their presentation in text.

estimated that only 7% of surveyed industrial and manufacturing facilities had installed wastewater treatment facilities (Government of Cambodia and UNIDO 2012).

If rapid industrialization with similar characteristics were to be achieved in coming years, Cambodia's environment resource could be significantly and adversely impacted. It is in this context that a better understanding of industrial pollution in the country is necessary to provide pollution control authorities with information on how to better target their limited resources.

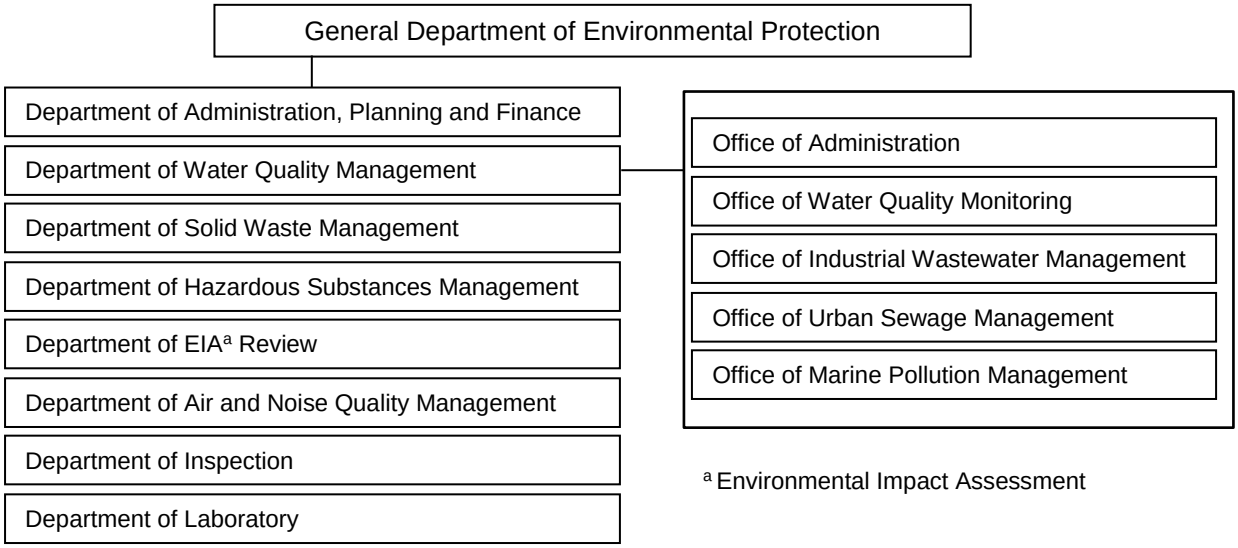
Pollution Control Mandate

Cambodia's Constitution provides the basic policy for the protection of the environment:

> The State shall protect the environment and the balance of natural resources and establish a precise plan for the management of land, water, airspace, wind, geology, ecological systems, mines, oil and gas, rocks and sand, gems, forests and forestry products, wildlife, fish and aquatic resources (Article 59).

Cambodia's Ministry of Environment (MoE), established in 1993, has the main mandate for environmental protection in the country. It acts as a 'competent agency in the protection, prevention and control (of) all activities which potentially affect the quality of the environment.' The Ministry comprises five general departments, including a General Department of Environmental Protection, which itself comprises eight departments including the Department of Water Quality Management. This department has six offices, two of which are the Office of Water Quality Monitoring and the Office of Industrial Wastewater Management (Figure 1).

Figure 1: Organization of the General Department of Environmental Protection



With respect to environmental quality and industrial pollution control, MoE has the following functions:

- collecting relevant data and information about water quality at public water areas as well as pollution sources;
- preparing specific legislation for environmental protection;
- implementing the environmental legal instruments throughout the country; and

- issuing licenses or giving certificates of treated wastewater discharge to factories that complied with the national effluent water quality standard set by the ministry.

Following the establishment of MoE, the Law on Environmental Protection and Natural Resources Management was adopted in 1996. Said law requires MoE to establish an inventory list that will indicate (Article 12):

- the sources, types, and quantities of pollutants and wastes that are imported, generated, transported, recycled, treated, stored, disposed, or released into the airspace, water, land or on land surface; and

- the sources, types, and quantities of all toxic and hazardous substances that are imported, produced, transported, stored, used, generated, treated, recycled, disposed, or released into the airspace, water, land or on land surface.

Article 14 of the law further specifies that:

The MoE shall collaborate with concerned ministries to require the owners or those responsible of the factories, pollution sources, industrial zones or those zones that have natural resources development activities to:

- install or use monitoring equipment;

- provide samples; and

- prepare and keep files, and submit records and reports for examination.

As mandated in Article 13 of the Law, subsequent subdecrees were adopted in various years to govern environmental impact assessment (1999), solid waste management (1999), water pollution control (1999), and air and noise pollution (2000).

The Subdecree on Water Pollution Control defines standards for effluent discharge for any sources of pollution (Article 4) and specifies that the discharge for wastewater which is not consistent with the standards for effluence discharge is 'strictly prohibited' (Article 6). This Subdecree explicitly requires that the discharge of wastewater from any source of pollution listed in Annex 3 of the subdecree is subject to the granting of a discharge permit from MoE. Finally, Article 18 of the subdecree clearly specifies that the monitoring of the discharge of effluent from any source of pollution is the responsibility of MoE while the owner or person responsible for the pollution source 'holds the responsibility for installing an equipment of measurement of flow, concentration and amount of pollutant contained in his/her effluent and also keep the result for record keeping' (Article 23c). The Subdecree on Air Pollution Control and Noise Disturbance provides a similar approach for air pollution.

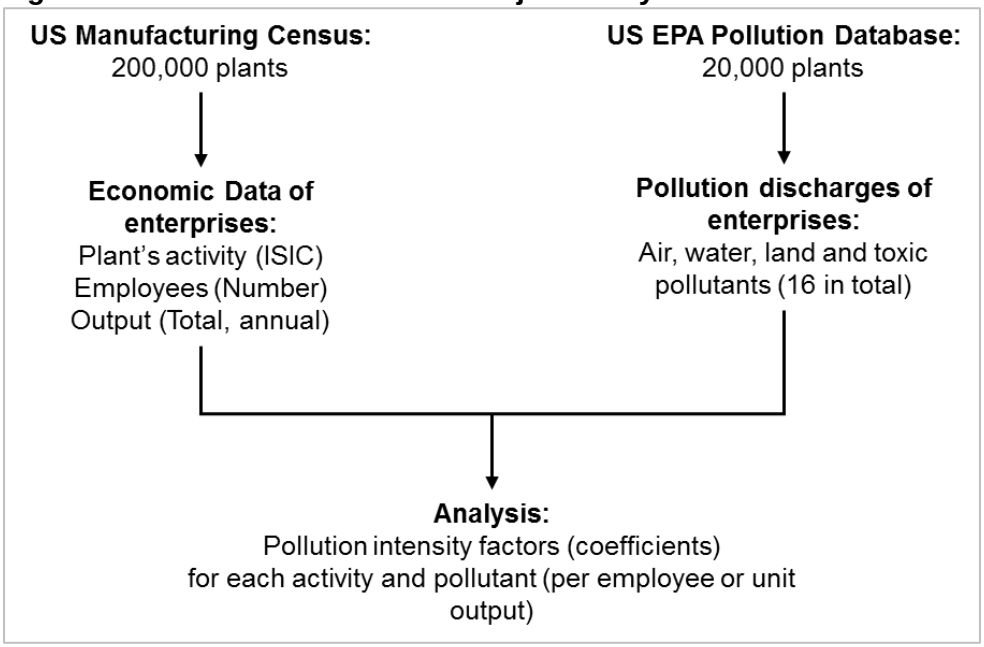
While the pollution control regulatory framework appears in place, it is generally—and openly—admitted that its effective implementation has been lacking and has suffered from limited national budget, inadequate human resources, and limited technological capacity. Shoka (2008) notes the irregular follow-up of the wastewater treatment process and its maintenance, and points out that a few cases of factories being fined despite a generally believed widespread compliance with regulatory standards.

2. The Industrial Pollution Projection System

Overview

The Industrial Pollution Projection System (IPPS) combines data from industrial activities, such as production and employment, with data on pollution emissions to calculate pollution intensity factors, thus representing the level of pollution emissions per unit of industrial activity.[4] As illustrated in Figure 2, pollution intensities have been calculated with data available from the United States Manufacturing Census and the United States Environmental Protection Agency (USEPA). The Manufacturing Census maintains the Longitudinal Research Database (LRD) that contains information from the Census of Manufactures (CM) and the Annual Survey of Manufactures (ASM). While the CM contains information on all manufacturing establishments in the United States, the ASM has detailed information on a subset of companies. Once an establishment has been selected to be part of the ASM, information is collected from the chosen company annually for a period of five years. The LRD contains detailed information on approximately 200,000 plants.

Figure 2: The Industrial Pollution Projection System



The USEPA maintains a number of databases on pollution emissions. These include the Toxics Release Inventory (TRI), the Aerometric Information Retrieval System (AIRS), the National Pollutant Discharge Elimination System (NPDES), and the Human Health and Ecotoxicity Database (HHED). The datasets are used in the calculation of pollution intensities.[5] After combining the LRD and EPA databases, it was possible to calculate pollution intensity factors for approximately 20,000 plants.

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[4] See Hettige et al. (1994) for details.

[5] The TRI contains information on annual emissions of more than 300 chemicals that are toxic to the environment. Manufacturing establishments that (i) employ 10 fulltime employees or more, and (ii) produce, import or process 25,000 pounds or more of any listed chemical must report the nature and quantity of the chemical produced, imported, or processed. In 1987, approximately 20,000 enterprises reported their release of such chemicals. The AIRS is the US national database for ambient air quality, air emissions and compliance data with the US Clean Air Act. The NPDES contains self-reported data from plants facing standards for water emissions. Finally, the HHED contains various indices of toxicological potency.

Box 1: The International Standard Industrial Classification

The International Standard Industrial Classification of All Economic Activities (ISIC) is a United Nations system for classifying economic data and is the international reference classification of productive activities. Its main purpose is to provide a set of activity categories that can be utilized for the collection and reporting of statistics according to such activities. It provides a comprehensive framework within which economic data can be collected and reported in a format that is designed for purposes of economic analysis, decisiontaking and policymaking. The classification structure represents a standard format to organize detailed information about the state of an economy according to economic principles and perceptions. These economic activities are subdivided in a hierarchical, four-level structure of mutually exclusive categories, facilitating data collection, presentation, and analysis at detailed levels of the economy in an internationally comparable and standardized way.

ISIC was first adopted in 1948 and has been subjected to four significant revisions, the latest (Revision 4) is dated 2008.

The ISIC is subdivided in a hierarchical, four-level structure. The categories at the highest level are called sections. The two-digit of the code identify the division, the third digit identifies the group, and the fourth digit identifies the class.

Section	C	Manufacturing
Division	13	Manufacture of Textiles
Group	139	Manufacture of Other Textiles
Class	1393	Manufacturer of Carpets and Rugs

Details on ISIC are provided at this site:
http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27

The USEPA contains emission information for a number of pollutants and chemical substances known to be harmful to both humans and the environment. IPPS coefficients are available for selected air pollutants—sulfur dioxide (SO_2), nitrogen dioxide (NO_2), volatile organic compounds (VOC), total suspended particulates (TSP), and particulate matter of size less than 10 microns (PM10)—and selected water pollutants including biological oxygen demand (BOD) and total suspended solids (TSS). IPPS also includes pollution intensities for over 240 priority chemicals and metals generally known to be toxic to humans and metals known to be bio-accumulative.

For each of the air and water pollutants and the 240 toxic chemicals and metals, IPPS provides a lower bound, interquartile, and upper bound mean value for their pollution intensity factors. In this study, estimates of pollution load are based on the lower bound value, but more important are the ranking of industrial sectors in terms of pollution discharges and ranking of geographical areas. These rankings remain the same whether lower bound, interquartile or upper bound values are used.

Pollution intensity factors are calculated as the total amount of pollution discharge for a given pollutant divided by the manufacturing indicator (output value, value-added or employment).

In the case of an employment-based indicator, the factor is the number of kilograms of pollutant per unit of employment.

A difficulty in the calculation of pollution intensity factors is the variable used to capture the extent of manufacturing activity. While physical volume of output would be the ideal unit of measurement, industries and even establishments within an industry often use different units to report their volume of production. This limits comparison across industries. However, the values of output and plant-level employment do offer such common units of measurement—the ranking of industrial sectors is almost identical whether the value of output or employment is used.[6] In the United States, the choice of unit of measurement does not appear to impact the ranking of industrial sectors by pollution load. For the purpose of policymaking, it is this ranking that is most relevant.

The income elasticity of pollution per unit of output and the income elasticity of labor per unit of output are both negative and not significantly different from one another. This suggests that while developing economies generate more pollution per unit of output than developed economies, they employ more labor per unit of output in the same proportion. Therefore, this study uses pollution discharge per unit of labor as the pollution intensity factor.

Challenges in Implementing IPPS in Cambodia

IPPS relies on matching an industrial facility to a specific industrial sector for which pollution intensity factors are available. The standard approach of classifying economic activities is known as the International Standard Industrial Classification or ISIC (refer to Box 1). While most countries use ISIC codes to classify economic activities, it is common to observe in developing countries the use of hybrid systems combining ISIC with a national system of classification.

The implementation of IPPS in Cambodia experienced three challenges.

First, as pointed out in Cambodia's IDP, a large number of industrial and manufacturing facilities in Cambodia are operating in the informal sector, and lack licenses and permits from appropriate authorities, including that from the MoE and the Ministry of Industry and Handicraft (MIH). IDP notes 'the number of informal enterprises is extremely excessive.' The lack of registration allows enterprises to avoid rules and regulations, including the duty of paying taxes. In a recent survey of 373 enterprises conducted from February 2016 to June 2016, about 28% of interviewees have indicated the 'practices of the informal sector' as the biggest obstacle to the conduct of their (registered) business (World Bank 2016).

It is indeed a key target of IDP to encourage the formal registration of most small and medium enterprises in the country. For the purpose of applying the IPPS, enterprises lacking registration were not included in the enterprise datasets provided to the research team. Hence, while an objective of the current effort is to provide a more comprehensive understanding of industrial pollution in Cambodia, it must be noted that this understanding is limited to formally registered enterprises.

Second, while in the process of identifying appropriate enterprises datasets, it was found that multiple datasets of enterprises are maintained by various ministries, departments, and offices. These include, among others, the following organizations:

- General Department of Industry of MIH;

[6] Hettige et al (1994). For the US study, the rank correlation coefficient between intensity factors using the value of output and employment is 0.98, thus indicating an almost identical ranking.

- Department of Industrial Technique of MIH;
- **National Institute of Statistics of the Ministry of Planning;**
- Department of Environmental Impact Assessment of MoE;
- National Social Security Fund (NSSF); and
- Cambodia Chamber of Commerce.

The multiplicity of datasets with various degrees of comprehensiveness (none of them are fully comprehensive) and with various formats created a significant challenge to the study team. It was finally determined that the 2015 dataset provided by the NSSF was the most comprehensive set available for purposes of using the IPPS. A total of 1,744 small, medium and large manufacturing enterprises are included in the analysis.

It is relatively difficult to assess the comprehensiveness of the NSSF dataset.

In 2009, the National Institute of Statistics conducted the first nationwide survey (basically a listing) of establishments in Cambodia (Government of Cambodia 2009). The survey identified 376,761 enterprises across the country. The bulk of these enterprises (70%) are identified as micro-enterprises with one or two employees. The number of establishments with five or more persons engaged was 46,000 accounting for 12.3% while that with 10 or more persons engaged was 13,000 (3.5%); that with 100 or more persons engaged was 692 (0.2%); and that with 1,000 or more persons engaged was only 106.

The survey further identified that of the total number of enterprises, 22.5% (approximately 85,000 enterprises) belong to the manufacturing sector. If the same distribution according to size of firms noted above were to apply to these 85,000 enterprises, then there would approximately be 2,975 manufacturing enterprises with 10 to 100 employees, 170 manufacturing enterprises with more than 100 employees, and approximately 25 manufacturing enterprises with more than 1,000 employees. If the NSSF 2015 dataset mostly comprised enterprises with five employees or more, then the final dataset used for this research would include approximately 55% of manufacturing enterprises with more than five employees.

Alternatively, Table 2 reports the number of manufacturing enterprises recorded in the enterprise survey of 2011. The total number of enterprises with more than 11 employees is estimated to be 7,000 (representing 2.7% of all enterprises in the 2011 survey; 97.3% having 10 employees or less). If the NSSF 2015 were to include only larger enterprises, then the final dataset used for this report would represent approximately 25% of the reported number of manufacturing enterprises with 11 or more employees in 2011.

Table 2: Number of Enterprises in Cambodia (Enterprise Survey 2011)[a]

	Micro (1-10 employees)	**Small (11-50 employees)**	**Medium (51-100 employees)**	**Large (100+ employees)**
Number of enterprises	69,851	5,861	530	609
Share (%)	97.3	1.9	0.2	0.6

[a] Source: Government of Cambodia (2015b)

Hence, without a high degree of certainty, it may be asserted that the 1,744 enterprises included in the dataset for analysis represent a significant share of the reported number of manufacturing enterprises. In fact, there is reason to believe that the enterprises included in this dataset represent a significant share of medium and large enterprises, which could also explain why there are many communes with a sizeable population but no enterprise records (Map 1). First, the average number of employees in our dataset is 468 and the median is 130 (50% of the enterprises in the dataset have more than 130 employees). Second, as noted in Table 3, the recorded number of enterprises with 51 employees or more is 1,139 in the 2011 enterprise survey, while our dataset reports 1,141 enterprises with 51 or more employees.

Map 1: Distribution of Samples (Villages in Commune with Enterprise Data)

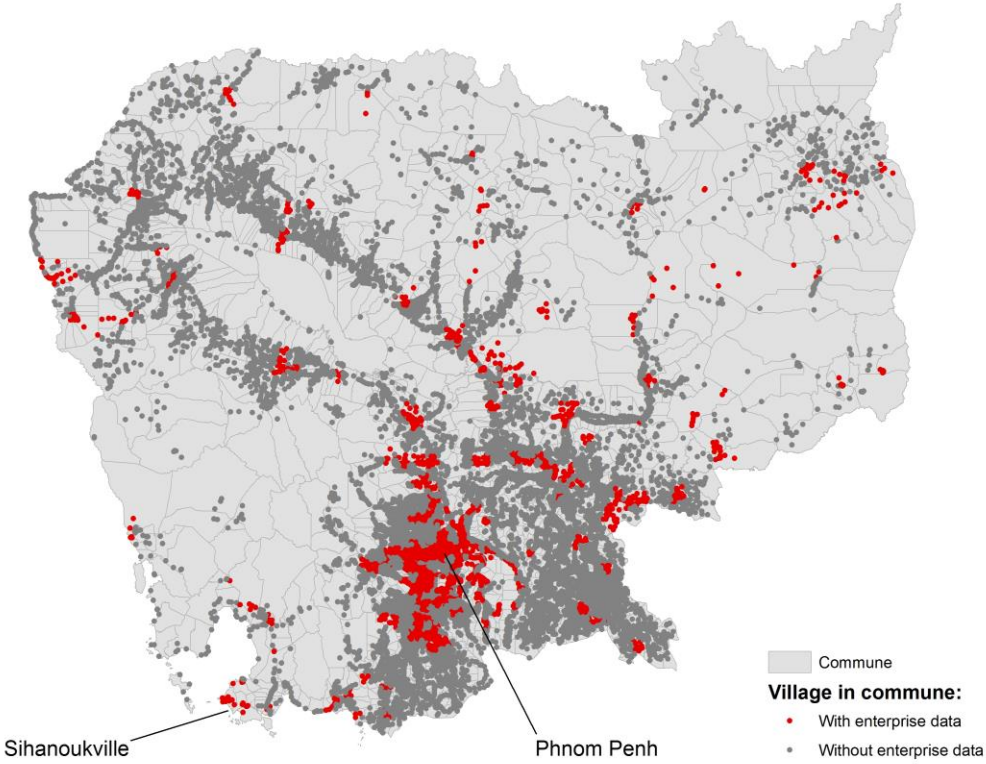


Table 3: Number of Enterprises in Cambodia: Enterprise Survey 2011 vis-à-vis this Report's Dataset

	Micro (1-10 empl)	Small (11-50 empl)	Medium (51-100 empl)	Large (100+empl)
Enterprise survey	69,851	5,861	530	609
This report's dataset	208	392	186	955

Finally, employee data provided in the database may not be accurate. The reporting of employee numbers by industrial activity may have been difficult in case of seasonal manufacturing. A number of employee data entries were either zero or left blank. It becomes impossible to validate the number of employees reported in the database hence these facilities were not included in the analysis.

As a result of these constraints and IPPS's own limitations, it is important to indicate that the estimates of industrial pollution presented in Section 3 should be used solely as a ranking device—of industrial sectors discharging air, water, or toxic pollutants (from more to less important), and of provinces by industrial discharge of air, water, and toxic pollutants.

The results presented in Section 3 should not be used to assess compliance by specific industrial facilities with national industrial regulations and standards. Similarly, if a system of industrial pollution fees is established in Cambodia in the future, the results presented in Section 3 should not be used to assess fees to be paid by individual enterprise. However, the results can and should be used to guide and focus the monitoring of industrial pollution in the Cambodia.

3. Results

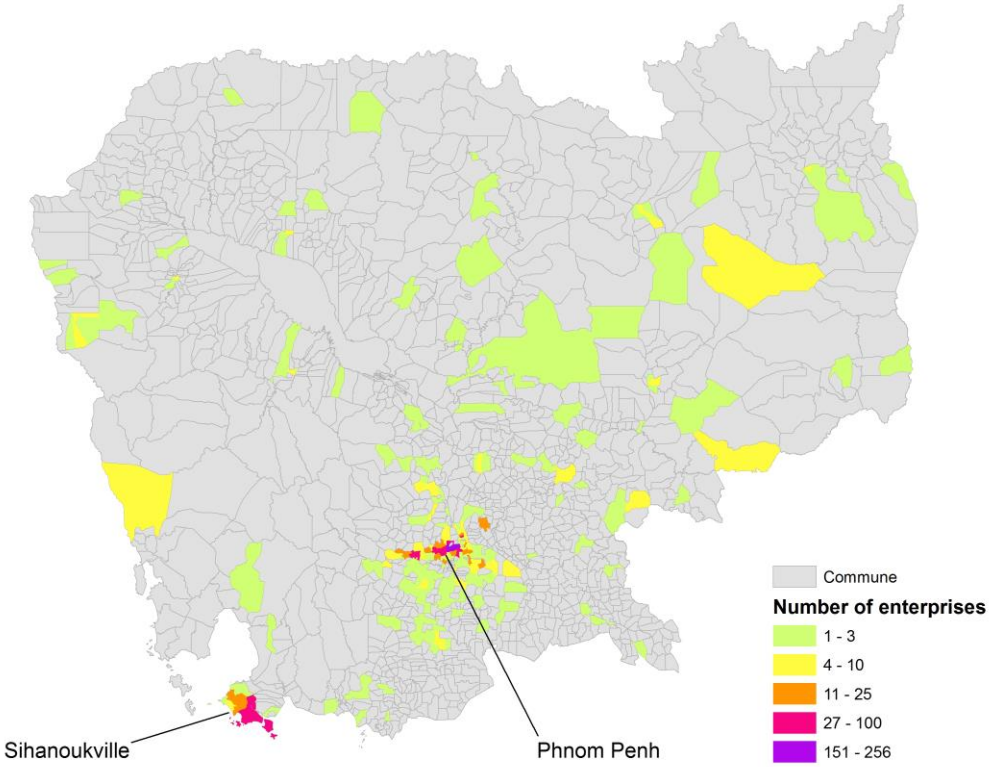
Industrial Activity and Distribution

The wearing apparel sector represents 35.8% of enterprises in our dataset and 61.2% of 816,000 employees. The spinning, weaving, and finishing textile sector, and the footwear sector are the next two most important sectors both in terms of number of enterprises and number of employees (refer to Table 7 in the Appendix). These three sectors together represent 57.7% and 85.5% of enterprises and of employees in our dataset. From the point of view of industrial pollution, the most important feature is the distribution of employment across industrial sectors.

Similarly, the distribution of enterprises is examined geographically (refer to Table 8 in the Appendix). Approximately 75.9% of enterprises are located in three provinces: Phnom Penh, Kandal, and Kampong Speu. Phnom Penh alone accounts for 61.2% of enterprises in the dataset. These three provinces represent 78.3% of employment in the manufacturing sector. Phnom Penh's share of industrial employment is estimated to be 54.9%, slightly lower than its share of enterprises. It is interesting to note that while Kampong Chang represents only 1.5% of industrial enterprises, it represents 4.0% of industrial employment.

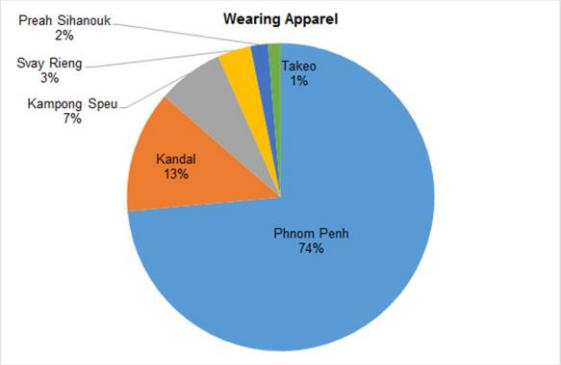
The geographical distribution of industrial activities can be examined in more detail as it may provide clues to the sources of pollution (Map 2).

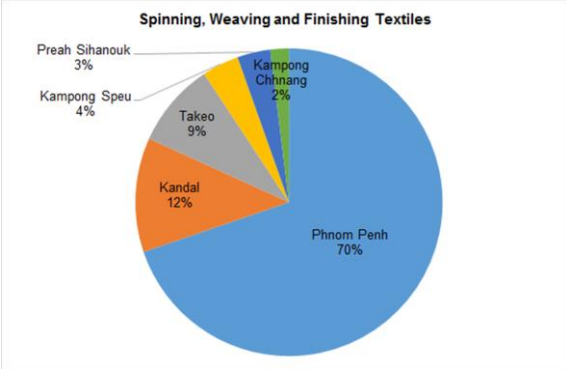
Map 2: Number of Enterprises in the Commune

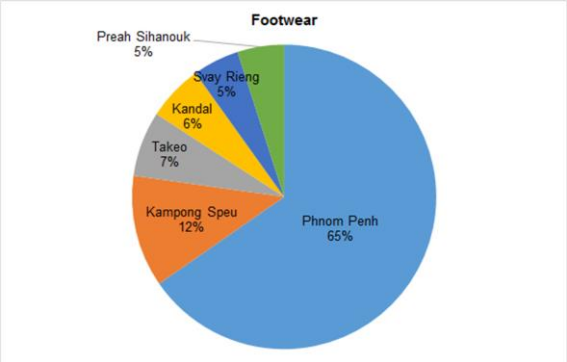


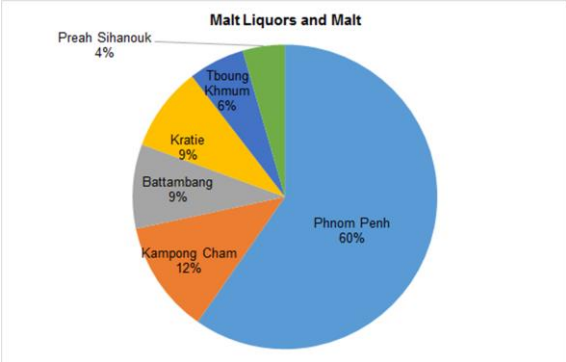
Phnom Penh accounts for the largest share of enterprises for most industrial sectors with the provinces of Kandal (for wearing apparel, spinning, weaving, and finishing textiles, and printing and publishing), Kampong Speu (for footwear), Kampong Cham (for malt liquors and malt), and Kampong Thom (for food products) trailing behind (Figure 3).

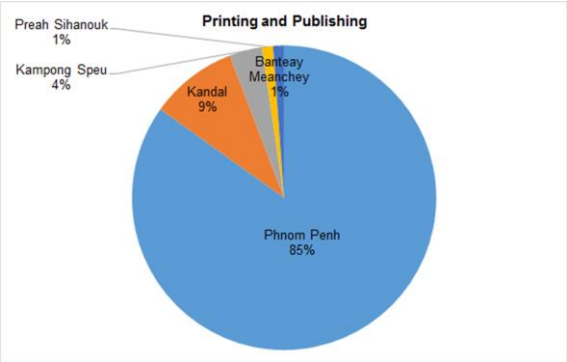
Figure 3: Distribution of Industrial Sectors by Most Significant Provinces

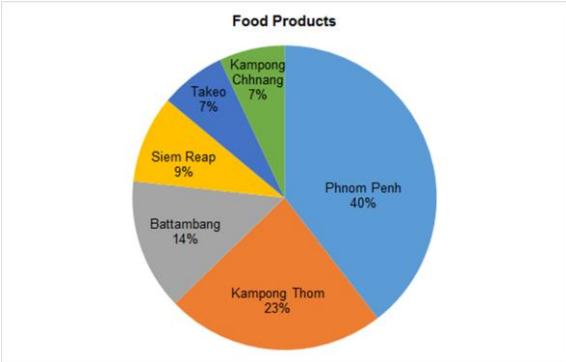












As shown in Figure 4, wearing apparel represents slightly more than 50% of industrial enterprises in many provinces, except for Preah Sihanouk where it represents only 26% of manufacturing enterprises. In many provinces, the spinning, weaving, and finishing textiles sector represents approximately 20% of enterprises. However, this sector represents approximately 50% of enterprises in Takeo.

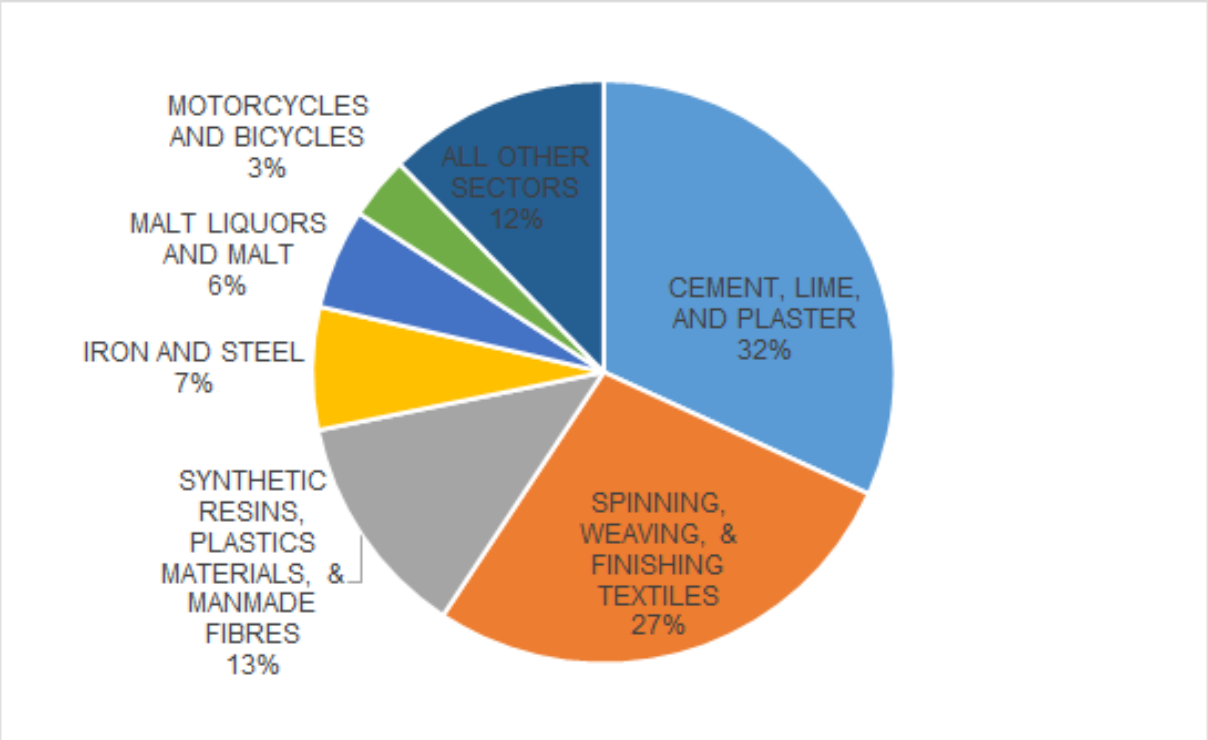
Figure 4: Share of Industrial Sectors in Selected Provinces

Industrial Pollution by Sector

Across all air pollutant emissions, the cement, lime, and plaster sector is the largest emitter (refer to Table 9 in the Appendix). It is also the largest emitter of SO_2, NO_2, PM10, and TSP. This sector represents approximately 0.2% of enterprises in the dataset and 0.1% of industrial employment, but contributes a majority of industrial air emissions in the country. The spinning, weaving and finishing textiles sector, and the synthetic resins, plastic materials, and manmade fibers sectors are the next largest emitters of air pollutants (Figure 5). Together, these three sectors account for 16.5% of enterprises (289 out of 1,744 establishments in the dataset) and 10.6% of employment (86,674 employees),in the dataset and approximately 72% of air pollution from the manufacturing sector. The cement, lime, and plaster sector accounts for approximately 88% of all PM10 emissions. The iron and steel sector is a significant emitter of

carbon monoxide (CO) and of PM10 while the motorcycles and bicycles sector is a large source of VOC.

Figure 5: Share of Air Pollutant Emissions by Sector



A key to prioritizing the control of air pollution in Cambodia is that a relatively small number of sectors and enterprises account for most of the air pollution in the country. Across all air pollutants, 16–18% of enterprises (or approximately 300 enterprises) in the dataset produce more than 70% of any given air pollutant (Table 4).

Table 4: Largest Industrial Sectors Emitting Air Pollutants

Top 3 sectors	% of enterprises	**% of air pollutants emitted by top three sectors**						
		Total	SO2	NO2	CO	VOC	PM10	TSP
Cement, lime, plaster Spinning, weaving Synthetic resins	16.5	71.8	72.5	80.6				
Iron and steel Spinning, weaving Synthetic resins	18.6				70.5			
Motorcycles and bicycles Spinning, weaving Synthetic resins	16.9					76.9		
Cement, lime, plaster Spinning, weaving Iron and steel	18.0						95.5	
Cement, lime, plaster Spinning, weaving Nonmetallic mineral products	17.6							75.3

With regard to conventional water pollution, a similar scenario is repeated. The iron and steel sector comprises only 40 enterprises in the dataset (2.3% of all enterprises) but discharges 71.6% of total suspended solids and 68.8% of water pollutants (Figure 6). Looking at the three sectors discharging the most water pollutants—the iron and steel, sporting and athletic goods,

and drugs and medicines sectors, which account for 2.9% of enterprises in the dataset—account for approximately 85% of industrial discharges of TSS (Table 5). The spinning, weaving, and finishing textiles, footwear, and sugar factories and refineries—which account for 21.9% of enterprises—discharge 64.9% of BOD wastes.

Figure 6: Share of Water Pollutant Discharges by Sector

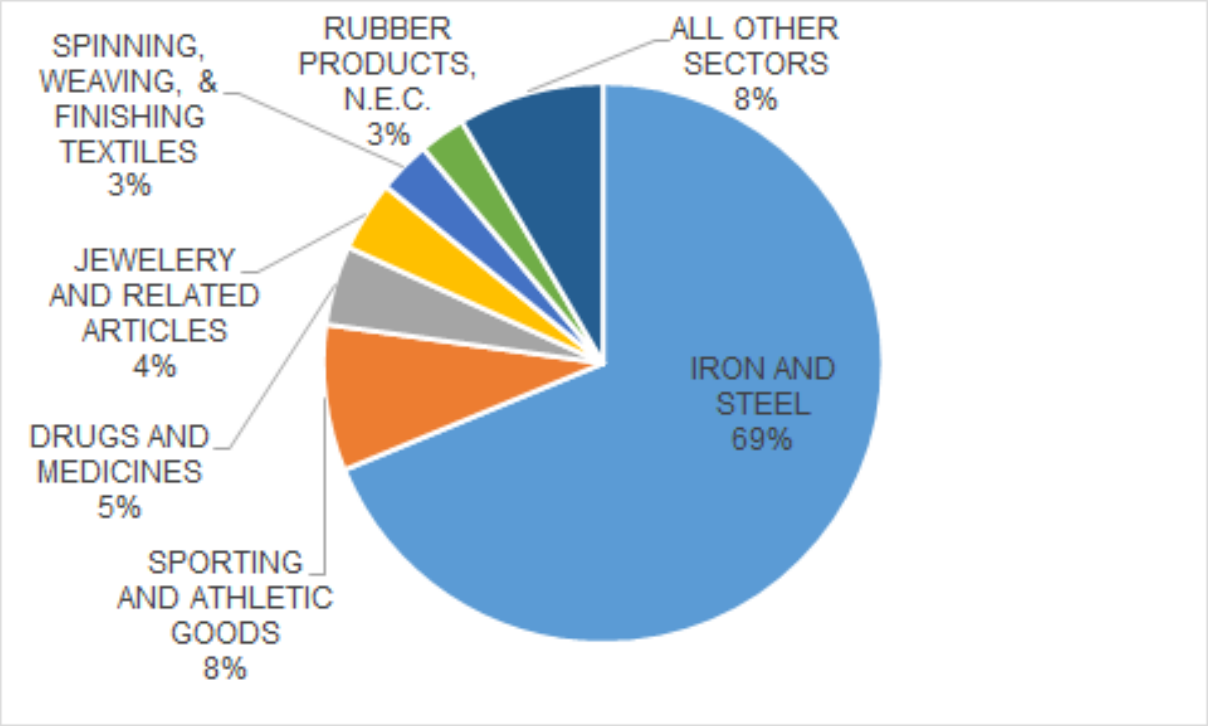


Table 5: Largest Industrial Sectors Discharging Water Pollutants

Top three sectors	% of enterprises	Total	BOD	TSS
Iron and steel Sporting and athletic goods Drugs and medicines	2.9	81.8		85.2
Spinning, weaving Footwear Sugar factories and refineries	21.9		64.9	

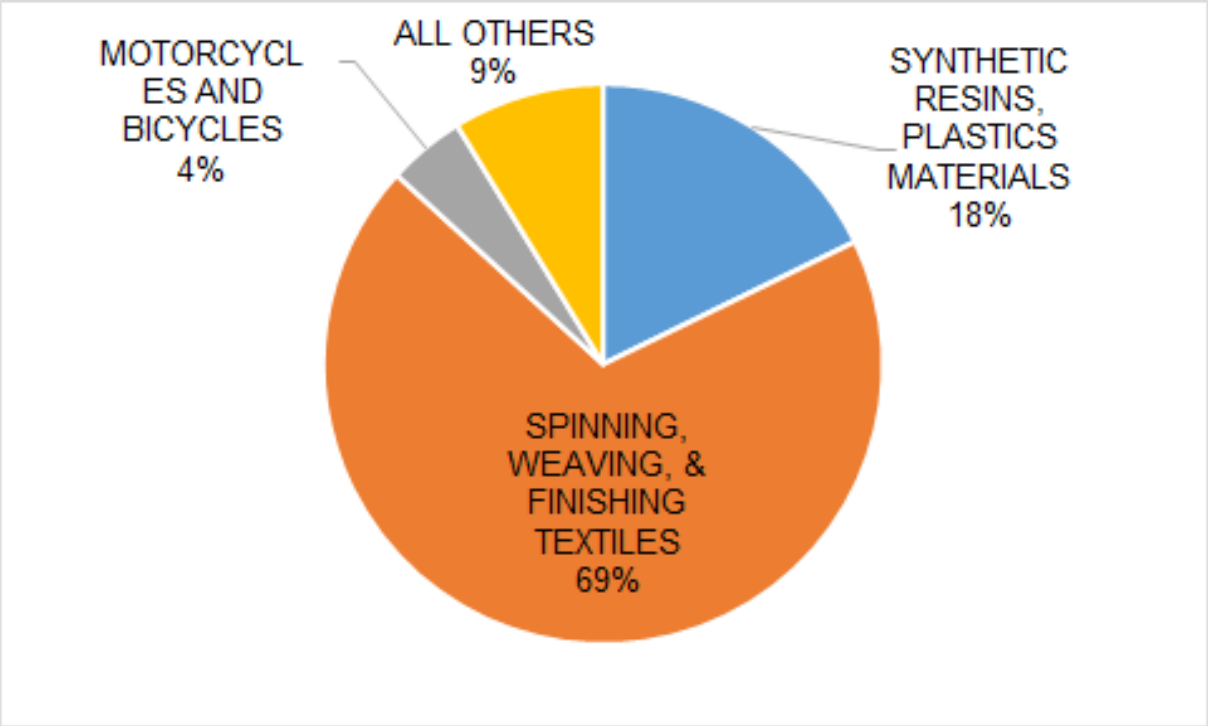
Refer to Appendix Table 10 for the distribution of toxic metal discharges by industrial sector. Except for toxic metal discharges in water—for which 3.7% of enterprises or 65 enterprises from iron and steel, synthetic resins and plastic materials, and motorcycles and bicycles account for 75.3% of discharges—the discharges of toxic metal would appear slightly less concentrated as seen in Table 6: 18.6% of enterprises discharges or approximately 65% of toxic metal discharges.

Table 6: Largest Industrial Sectors Discharging Toxic Metal Pollutants

		% of toxic metal pollutants of top three sectors			
Top three sectors	% of enterprises	Total	Air	Land	Water
Iron and steel Spinning, weaving Synthetic resins	18.6	65.4		65.2	
Iron and steel Spinning, weaving Electrical industrial machinery	17.9		73.3		
Iron and steel Synthetic resins Motorcycles and bicycles	3.7				75.4

Approximately 396 enterprises (22.7% of enterprises from synthetic resins and plastic materials, spinning, weaving and finishing textiles, and footwear sectors) account for approximately 62.8% of toxic discharges (refer to Appendix Table 11). With respect to toxic discharges to water, 16.9% of enterprises account for more than 90% of discharges. The spinning, weaving, and finishing textiles sector alone account for 69% of toxic discharges to water (Figure 7)

Figure 7: Share of Toxic Discharges to Water by Sector



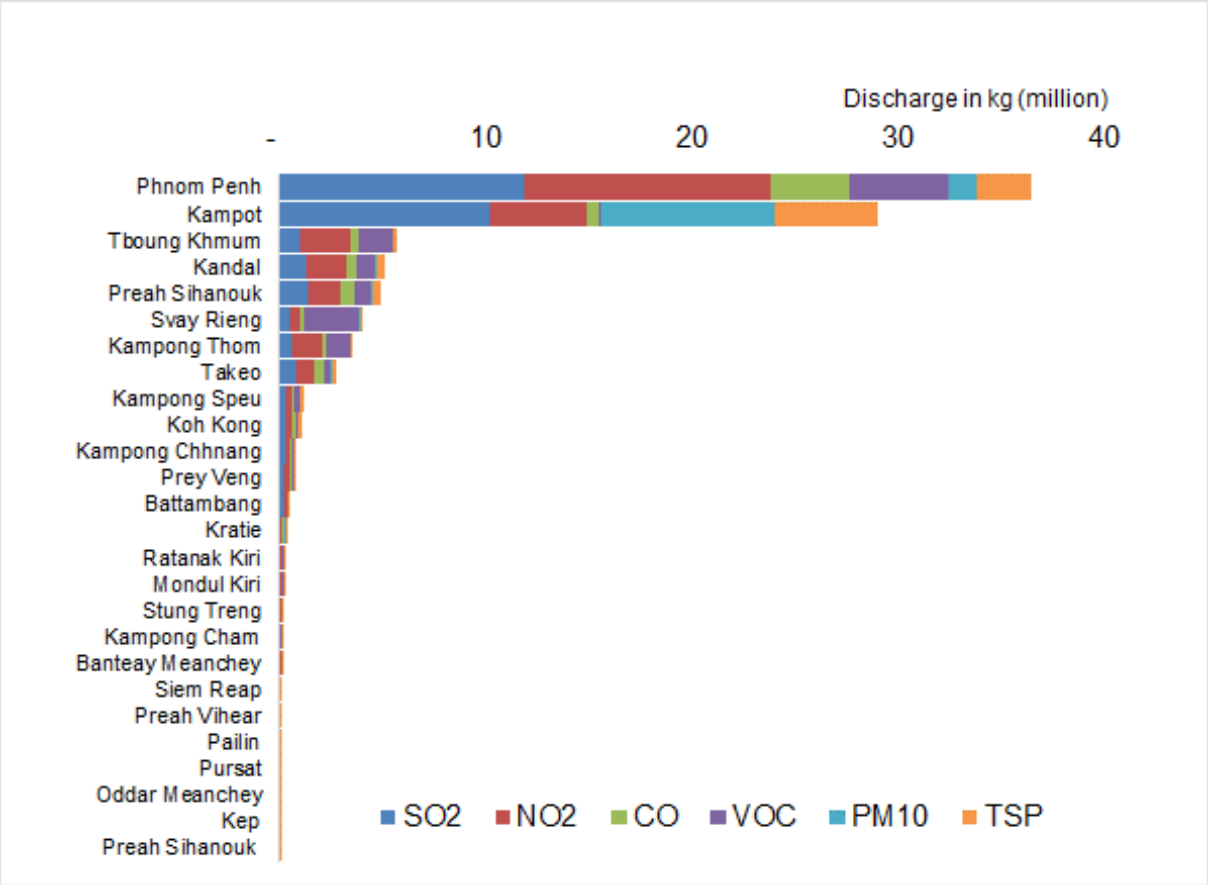
The results clearly indicate that the industrial discharges of air, water, and toxic pollutants in Cambodia originate from a limited number of industrial sectors representing approximately less than 20% of enterprises in the dataset.

Industrial Pollution by Geography

It has been shown (Appendix Table 8) that industrial employment in Cambodia is concentrated in Phnom Penh (54.9% of industrial employment in the dataset), Kandal (15.1%), and Kampong Speu (8.3%) in this order. These three provinces account for more than 78% of industrial employment. If pollution intensities (as measured by per unit of labor) were similar across industrial sectors, one would estimate a similar distribution of pollution discharges. However, this does not reflect the outcome of the estimates below.

Examining air pollution first, it is found that Phnom Penh accounts for 37.5% of total air pollutant emissions (Appendix Table 12). It also accounts for only 12.9% of PM10 emissions and for 28.0% of TSP emissions. On the other hand, the province of Kampot, which accounts for only 0.3% of industrial employment, represents 29.8% of total air pollutant emissions, 51.3% of TSP emissions, and 82.6% of PM10 emissions. These two provinces account for the bulk of air pollutant emissions in the country (Figure 8). Kampot's ranking as a significant source of TSP and PM10 is the outcome of types of enterprises located in the province, namely cement enterprises.

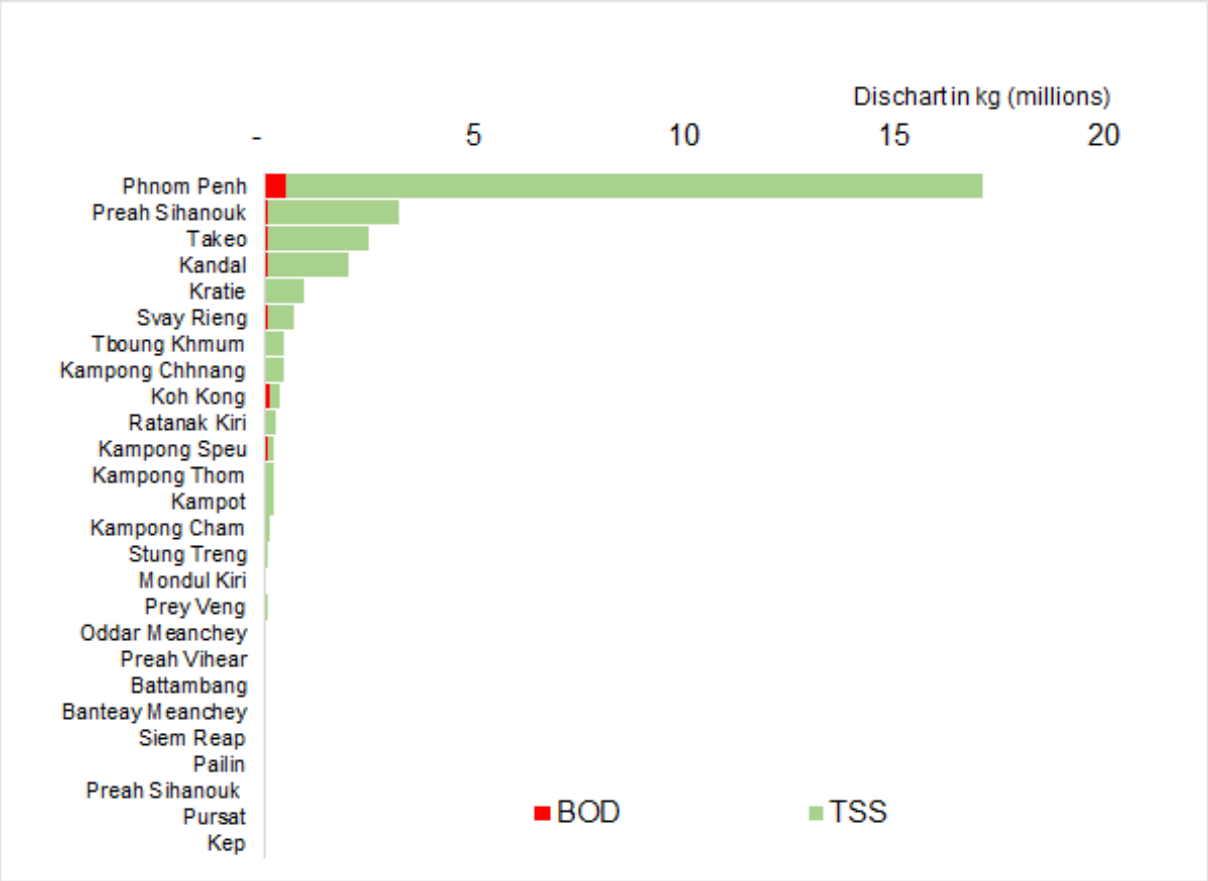
Figure 8: Provincial Shares of Industrial Air Pollutants



The geographical distribution of industrial water pollutants is significantly different with Phnom Penh accounting for 59.2% of total discharges of water pollutants, 44.7% of BOD discharges, and 59.8% of TSS discharges (Appendix Table 13). Following Phnom Penh are Preah

Sihanouk, Takeo, and Kandal provinces with the largest amount of water pollutants accounting for approximately 85% of total discharges of water pollutants (Figure 9).

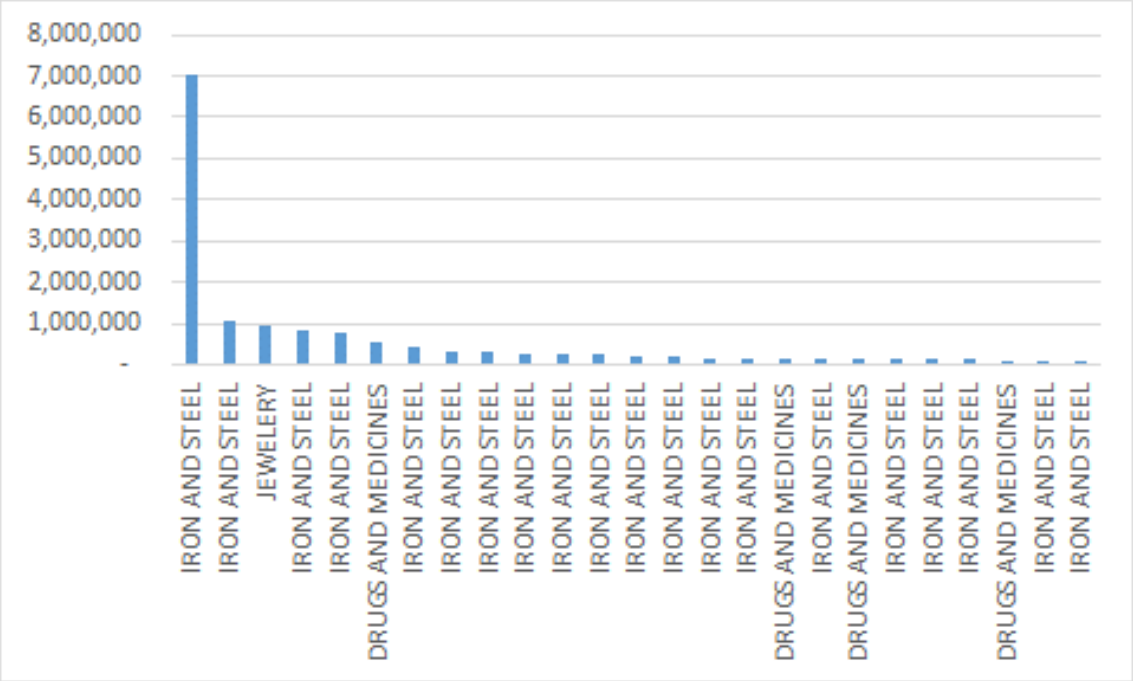
Figure 9: Provincial Shares of Industrial Water Pollutants



It is interesting to examine in greater detail the results from selected provinces beginning with Phnom Penh. Dataset includes 1,068 industrial establishments in Phnom Penh, considered a large number of enterprises to target. In order to prioritize pollution control effort, authorities may need to examine the distribution of water pollutant discharges by sector and by individual enterprises in Phnom Penh itself.

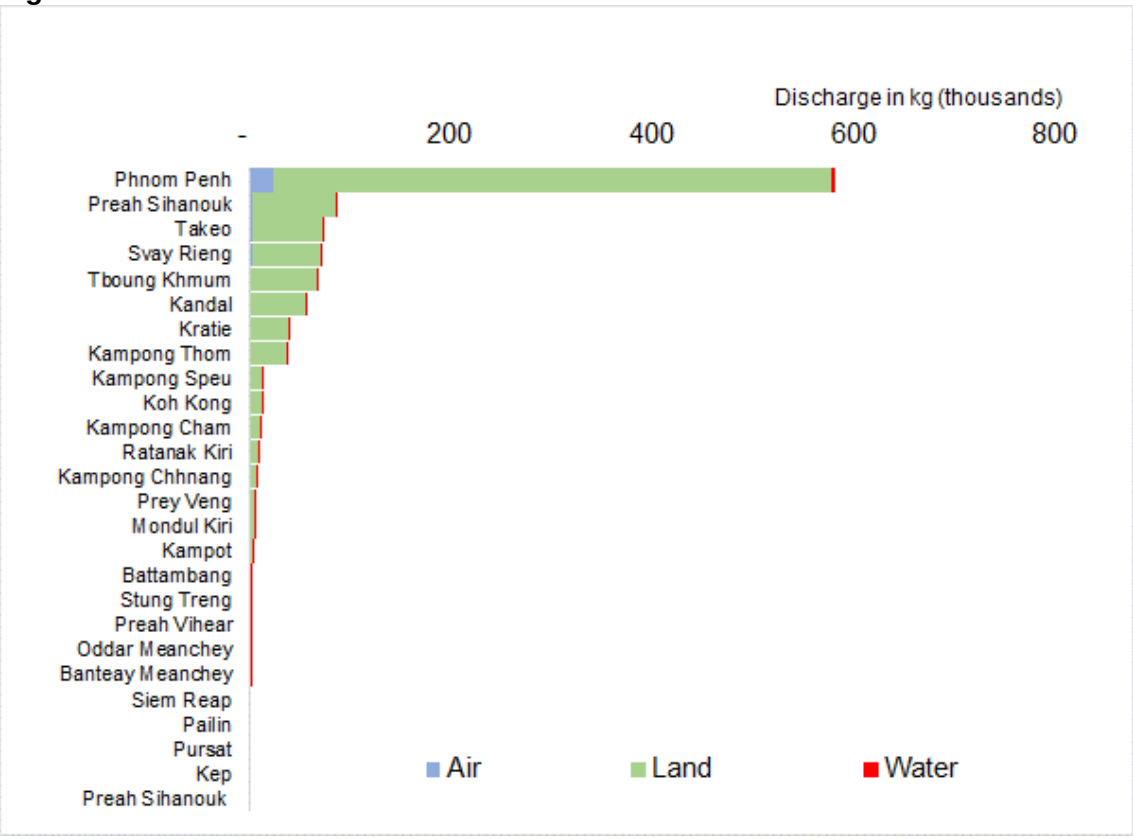
Out of 1,068 industrial enterprises in Phnom Penh, the largest 25 dischargers of TSS account for approximately 92% of total discharges in Phnom Penh. In fact, the three largest dischargers of TSS in Phnom Penh account for approximately 55% of TSS discharges in the province. As shown in Figure 10, the distribution of TSS discharges is heavily skewed toward a very limited number of enterprises. Of the 25 enterprises with the largest TSS discharges, 20 enterprises come from the iron and steel sector, four from the drugs and medicines sector, and one from the jewelry sector. The single largest enterprise discharging TSS in Phnom Penh accounts for 42.4% of TSS discharges in the province.

Figure 10: The 25 Largest Enterprises Discharging TSS in Phnom Penh



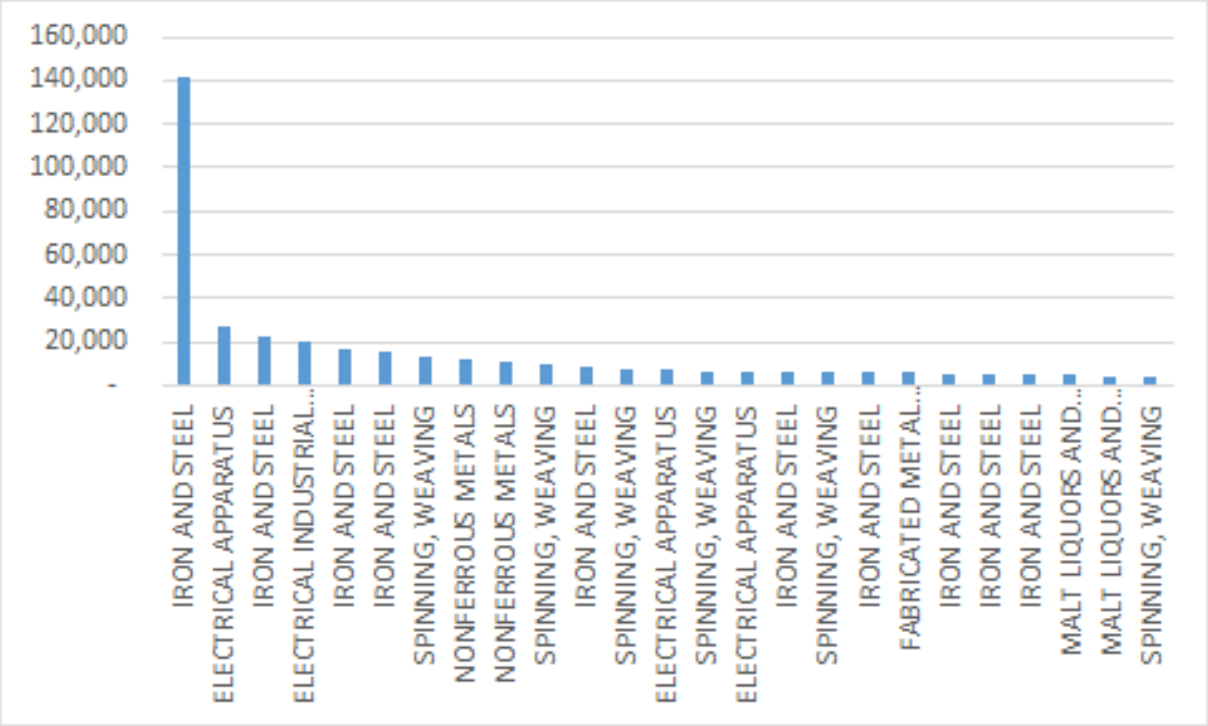
A relatively similar situation arises with respect to the discharge of toxic metal pollution with Phnom Penh accounting for approximately 53.2% of these discharges. The next largest provinces discharging toxic metal pollution are Preah Sihanouk, Takeo, Svay Rieng, Tboung Khmum, and Kandal (Figure 11). These six provinces account for 86.0% of all industrial toxic metal discharges in the country (Appendix Table 14).

Figure 11: Provincial Shares of Industrial Toxic Metal Pollutants



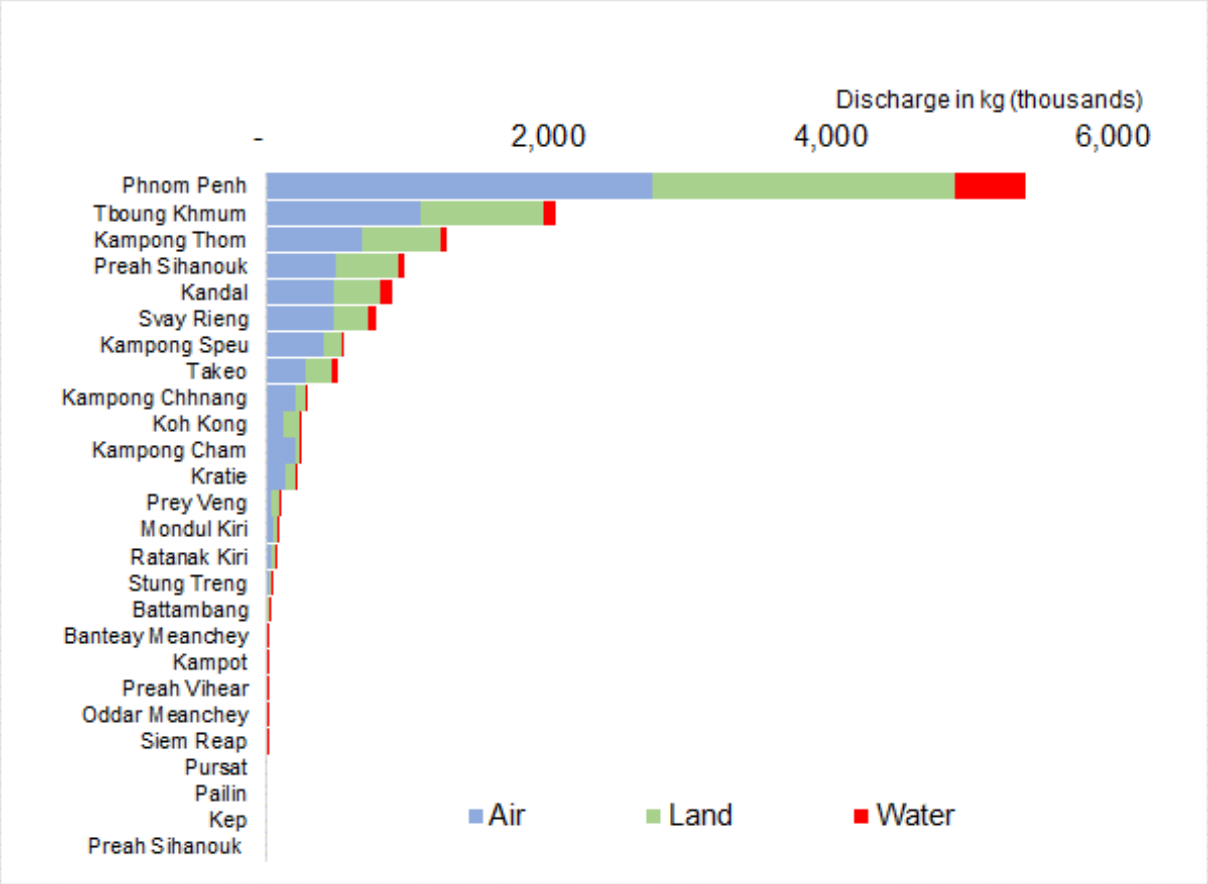
Given the prominence of Phnom Penh, it is interesting to examine the results in greater detail from this province. The three largest enterprises discharging toxic metal pollution account for 32.8% of total discharges in Phnom Penh. The 10 and 25 largest enterprises account for 50.0% and 66.2% of these discharges, respectively. Of the 25 largest enterprises discharging toxic metal in the province, 10 come fro the iron and steel sector (Figure 12). In fact, the single largest enterprise discharging toxic metal is an iron and steel enterprise which accounts for 24.4% of total discharges in Phnom Penh.

Figure 12: The 25 Largest Enterprises Discharging Toxic Metal Pollutants in Phnom Penh



Finally, we examine the discharges of toxic pollutants. While Phnom Penh accounts for the largest share with 38.9% of discharges at the national level, the significance is less prominent when compared with toxic metal, air, and water pollutants. Tboung Khmum, Kampong Thom, Preah Sihanouk, Kandal, and Svay Rieng also significant add to the discharge of toxic pollutants in the country (Appendix Table 15, Figure 13).

Figure 13: Provincial Shares of Industrial Toxic Pollutants



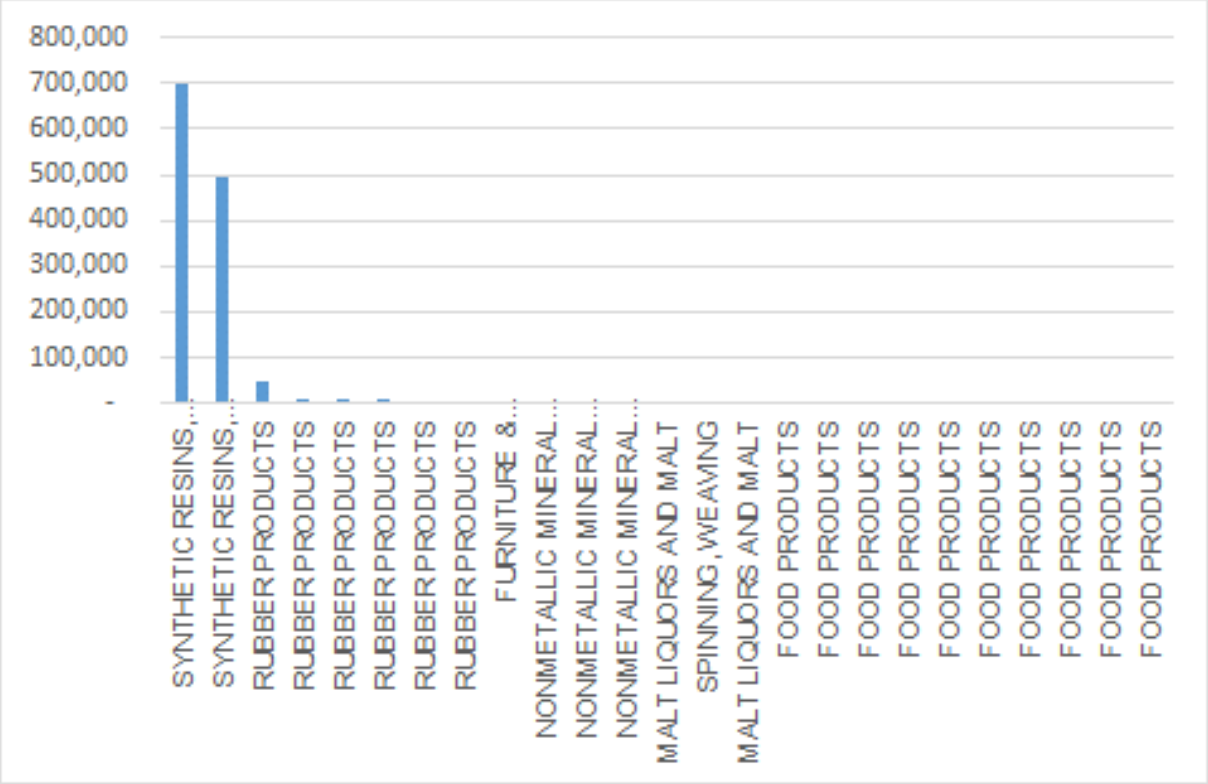
The results are surprising given that Tboung Khmum has only 28 enterprises in the dataset. As shown in Figure 14, one enterprise alone in the synthetic resins, plastic materials, and manmade fibers sector explains this result. This enterprise accounts for 86.0% of the total toxic pollutants in the province.

A similar result applies to the province of Kampong Thom. Of the 25 enterprises in the province, two enterprises from the same synthetic resins, plastic materials, and manmade fibers sector represent 93.2% of total discharges of toxic pollutants (Figure 15).

While it is in principle possible to display the results of the IPPS from the commune level to further break down the data above, the pilot study decided against it in light of the challenges and limitations encountered with the enterprise database (no enterprise address or other village level geolocation included, no enterprise records in many densely populated communes, and uncertainties about the accuracy of the enterprise databases available to the pilot study).

Figure 14: Enterprises in Tboung Khmum Discharging Toxic Pollutants

Figure 15: Enterprises in Kampong Thom Discharging Toxic Pollutants



4. Conclusions and Recommendations

Environmental regulators in numerous developing economies, including Cambodia, have insufficient capacity, staffing, and resources to adequately address industrial pollution. In particular, the lack of monitoring resources—staff, budget, and technology—often prevents the accounting of plant-specific industrial discharges. This presents an obstacle to the enforcement of national pollution control regulations and standards.

The application of IPPS in Cambodia describes the country's manufacturing sector and an estimation of associated industrial pollution. It has been shown that a high percentage of industrial pollution is generated by a limited number of industrial sectors. The cement, lime and plaster sector alone accounts for approximately 31.8% of total industrial air pollution emissions in the country and 88.4% of PM10 emissions. The iron and steel basic industries sector accounts for approximately 68.7% of total industrial water pollution discharges. When combined with sporting and athletic goods, and drugs and medicines sectors, these three sectors account for approximately 82.0% of total industrial water pollution discharges. Yet, these three sectors comprise only 51 of the 1,744 enterprises in our dataset.

Furthermore, within the sectors identified as largest dischargers of pollution, a disproportionate share of industrial pollution is accounted for by a limited number of industrial facilities.

It has also been shown that a majority of industrial pollution originates from a limited number of provinces in Cambodia. While the ranking of provinces changes across pollutants, only Phnom Penh, Kampot, Thoung Khmum, Kandal, Preah Sihanouk, Svay Rieng, Kampong Thom and Takeo rank as the largest provincial emitters. These results are encouraging as they suggest that large overall reductions in industrial pollution discharge could be achieved by focusing attention and resources on a limited number of industrial facilities located in a few geographical areas.

This information should be used as a basis to review and revise present resource allocation for industrial pollution control at the national and provincial levels. Plotting available resources and their current use against the results of the IPPS should help authorities identify gaps and shift resources to better align to those areas and sectors where industrial pollution is concentrated.

These results should also support the design and implementation of industrial pollution audits of facilities identified as the largest producers of air, water and toxic pollutants in Cambodia. Such audits should identify not only the quantity of pollution emissions and discharges, but also the facilities' production technologies and pollution control and abatement processes. These audits can then be used to identify where pollution may be reduced at least cost and also where opportunities may exist so as to decrease overall production costs, increasing the enterprises' profitability and competitiveness.

Beyond the immediate use of IPPS to optimize the use of pollution control resources, these results may be used by planners in those sectors or areas that are adversely affected by industrial pollution—such as urban planners and health authorities—to advocate for stronger and more empowered pollution control authorities.

In this context it is important to recognize some limitations of the exercise described in this report and the need for improvements. More importantly, as pointed out at the outset of the report and as recognized in Cambodia's IDP, a large number of enterprises in Cambodia operate in the informal sector. By definition, these were not included in the analyses. Furthermore, multiple agencies in Cambodia maintain distinctive datasets of industrial and manufacturing enterprises in the country. None of these appear to be completely

comprehensive and there remain inconsistencies in the nature of the information contained across datasets.

Given the limited resources available to pollution control activities, it is important for the industrial pollution control authorities to recognize that an adequate and reliable national industrial activity database is the key to a speedy achievement of greater efficiency and effectiveness by authorities. In this respect, there may be an opportunity for interministerial collaboration that would benefit both industrial promotion and pollution control authorities.

Second, it must be recognized that the estimates presented in this report should not be used to assess compliance with national regulatory standards or to assess pollution discharge fees, if there were to be such policies. These results simply point to specific industrial sectors and, within these sectors, to specific firms in well-defined areas where pollution may reach high levels. While the results presented in this paper may serve to better focus limited monitoring and enforcement resources, they should not be used in lieu of actual monitoring data for the enforcement of pollution control regulations.

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Appendices

Table 7: Distribution of Enterprises and Industrial Employment by Industrial Sector

	Number of enterprises		Number of employees	
Name of industrial sector	**Total**	**%**	**Total**	**%**
WEARING APPAREL	624	35.8	499,714	61.2
SPINNING, WEAVING, & FINISHING TEXTILES	270	15.5	82,507	10.1
FOOTWEAR	111	6.4	115,901	14.2
MALT LIQUORS AND MALT	90	5.2	6,566	0.8
PRINTING & PUBLISHING	86	4.9	6,137	0.8
FOOD PRODUCTS, N.E.C.	64	3.7	1,236	0.2
MADE-UP TEXTILES EXCEPT APPAREL	52	3.0	3,986	0.5
RUBBER PRODUCTS, N.E.C.	46	2.6	6,352	0.8
KNITTING MILLS	41	2.4	22,444	2.8
IRON AND STEEL	40	2.3	1,412	0.2
NONMETALLIC MINERAL PRODUCTS, N.E.C.	34	1.9	1,513	0.2
PAPER & PAPERBOARD CONTAINERS & BOXES	31	1.8	2,490	0.3
BAKERY PRODUCTS	30	1.7	1,201	0.1
LEATHER PRODUCTS	27	1.5	13,434	1.6
MANUFACTURING INDUSTRIES, N.E.C.	22	1.3	4,971	0.6
FURNITURE & FIXTURES, NONMETAL	17	1.0	404	0.0
SYNTHETIC RESINS, PLASTICS MATERIALS, & MANMADE FIBRES	15	0.9	3,250	0.4
GRAIN MILL PRODUCTS	14	0.8	768	0.1
TOBACCO MANUFACTURES	12	0.7	1,185	0.1
ELECTRICAL APPARATUS AND SUPPLIES, N.E.C.	10	0.6	3,634	0.4
MOTORCYCLES AND BICYCLES	10	0.6	6,164	0.8
PLASTICS PRODUCTS, N.E.C.	9	0.5	4,042	0.5
PREPARED ANIMAL FOODS	9	0.5	1,775	0.2
RADIO, TV, & COMMUNICATION EQUIPMENT	8	0.5	7,090	0.9
DRUGS AND MEDICINES	6	0.3	816	0.1
FABRICATED METAL PRODUCTS	6	0.3	519	0.1
JEWELERY AND RELATED ARTICLES	6	0.3	899	0.1
MOTOR VEHICLES	6	0.3	1,427	0.2
PRESERVED FRUITS & VEGETABLES	6	0.3	472	0.1
SPORTING AND ATHLETIC GOODS	5	0.3	2,357	0.3
CEMENT, LIME, AND PLASTER	4	0.2	917	0.1
WOOD & CORK PRODUCTS, N.E.C.	4	0.2	429	0.1
FISH PRODUCTS	3	0.2	29	0.0
GLASS AND GLASS PRODUCTS	3	0.2	65	0.0
NONFERROUS METALS	3	0.2	66	0.0
SAWMILLS, PLANING & OTHER WOOD MILLS	3	0.2	800	0.1
CONFECTIONERY PRODUCTS	2	0.1	28	0.0
DAIRY PRODUCTS	2	0.1	83	0.0
ELECTRICAL INDUSTRIAL MACHINERY	2	0.1	5,771	0.7
FERTILIZERS & PESTICIDES	2	0.1	151	0.0
STRUCTURAL METAL PRODUCTS	2	0.1	29	0.0
CARPETS AND RUGS	1	0.1	22	0.0
ELECTRICAL APPLIANCES & HOUSEWARES	1	0.1	476	0.1
FUR DRESSING AND DYEING	1	0.1	90	0.0
MEAT PRODUCTS	1	0.1	1,708	0.2
OILS AND FATS	1	0.1	41	0.0
SOAP, CLEANING PREPS., PERFUMES, & TOILET PREPS.	1	0.1	321	0.0
SUGAR FACTORIES & REFINERIES	1	0.1	370	0.0
Grand Total	**1,744**	**100**	**816,062**	**100.0**

Note: (Red: 3 most important; yellow: 3 next most important)

Table 8: Distribution of Enterprises and Industrial Employment by Province

	Number of enterprises		Number of employees	
Provinces	**Total**	**%**	**Total**	**%**
Phnom Penh	1068	61.2	448,213	54.9
Kandal	165	9.5	123,113	15.1
Kampong Speu	91	5.2	67,473	8.3
Preah Sihanouk	65	3.7	21,144	2.6
Svay Rieng	55	3.2	35,963	4.4
Takeo	52	3.0	29,603	3.6
Tboung Khmum	28	1.6	5,936	0.7
Kampong Chhnang	27	1.5	32,916	4.0
Kratie	27	1.5	2,267	0.3
Kampong Thom	25	1.4	2,011	0.2
Kampong Cham	23	1.3	19,331	2.4
Battambang	18	1.0	1,032	0.1
Ratanak Kiri	15	0.9	574	0.1
Stung Treng	13	0.7	178	0.0
Siem Reap	12	0.7	197	0.0
Banteay Meanchey	10	0.6	2,268	0.3
Kampot	8	0.5	2,343	0.3
Pursat	8	0.5	6,246	0.8
Koh Kong	6	0.3	6,983	0.9
Mondul Kiri	6	0.3	329	0.0
Pailin	6	0.3	64	0.0
Preah Vihear	6	0.3	163	0.0
Prey Veng	6	0.3	7,601	0.9
Oddar Meanchey	2	0.1	101	0.0
Kep	1	0.1	6	0.0
Preah Sihanouk	1	0.1	7	0.0
Grand Total	**1744**	**100.0**	**816,062**	**100.0**

(Red: 3 most important; Yellow: 3 next most important)

Table 9: Air Pollution Emissions by Industrial Sector

Industrial Sector	Total	SO2	NO2	CO	VOC	PM10	TSP
CEMENT, LIME, AND PLASTER	31,031,154	10,931,864	5,075,747	617,811	28,896	9,089,792	5,287,043
SPINNING, WEAVING, & FINISHING TEXTILES	26,743,955	8,492,340	11,717,625	1,572,579	3,214,432	227,317	1,519,661
SYNTHETIC RESINS, PLASTICS MATERIALS, & MANMADE FIBRES	12,178,405	2,016,639	5,241,454	774,989	3,835,623	1,627	308,073
IRON AND STEEL	6,625,206	1,822,774	791,773	2,840,540	244,000	503,789	422,330
MALT LIQUORS AND MALT	5,406,268	2,737,746	2,156,456	133,543	223,961	4,167	150,395
MOTORCYCLES AND BICYCLES	3,409,262	111,592	65,022	18,453	3,146,535	-	67,659
ELECTRICAL INDUSTRIAL MACHINERY	1,118,221	751,974	197,889	30,889	123,123	382	13,965
NONMETALLIC MINERAL PRODUCTS, N.E.C.	1,092,018	267,695	119,438	57,319	32,870	163,639	451,058
SUGAR FACTORIES & REFINERIES	1,015,039	305,014	292,815	156,891	51,902	6,383	202,033
PREPARED ANIMAL FOODS	763,690	212,371	58,386	15,933	6,736	87,793	382,469
WEARING APPAREL	707,879	395,986	149,147	41,707	98,827	3,627	18,587
ELECTRICAL APPARATUS AND SUPPLIES, N.E.C.	676,910	70,846	153,178	320,872	74,679	1,998	55,337
SAWMILLS, PLANING & OTHER WOOD MILLS	610,084	41,767	94,363	237,815	101,112	3,723	131,304
TOBACCO MANUFACTURES	604,807	316,747	191,686	24,969	63,002	2,487	5,916
MEAT PRODUCTS	487,716	34,339	352,583	88,079	1,788	981	9,946
FOOTWEAR	465,997	47,840	5,625	-	409,692	-	2,839
PAPER & PAPERBOARD CONTAINERS & BOXES	387,147	31,022	226,610	52,560	68,630	1,250	7,075
KNITTING MILLS	386,775	148,268	61,337	25,594	49,833	8,806	92,937
NONFERROUS METALS	365,403	224,546	7,314	104,453	8,169	2,063	18,859
GRAIN MILL PRODUCTS	365,098	38,894	31,162	6,026	32,899	64,296	191,822
DRUGS AND MEDICINES	339,993	156,873	66,570	7,812	78,037	1,088	29,614
MOTOR VEHICLES	327,505	44,401	22,405	30,027	206,482	1,880	22,311
OILS AND FATS	321,566	95,566	34,208	7,638	26,182	60,079	97,894
PRINTING & PUBLISHING	278,812	6,764	8,794	33,864	225,666	89	3,636
WOOD & CORK PRODUCTS, N.E.C.	267,106	37,524	24,305	54,263	73,545	22,184	55,284
RADIO, TV, & COMMUNICATION EQUIPMENT	186,809	23,869	11,934	3,100	145,169	929	1,807
FOOD PRODUCTS, N.E.C.	160,519	53,195	53,976	11,595	16,217	1,455	24,082
PLASTICS PRODUCTS, N.E.C.	150,615	10,858	2,363	776	131,040	2,266	3,313
LEATHER PRODUCTS	129,116	-	6,612	1,164	117,063	-	4,278
FABRICATED METAL PRODUCTS	108,434	4,296	9,664	49,349	41,504	179	3,442
RUBBER PRODUCTS, N.E.C.	92,758	282	1,135	282	90,208	282	568
FERTILIZERS & PESTICIDES	89,747	26,502	25,526	5,081	24,156	1,117	7,365
FURNITURE & FIXTURES, NONMETAL	86,152	3,071	2,170	2,302	69,671	2,025	6,912
MANUFACTURING INDUSTRIES, N.E.C.	84,059	5,123	2,492	1,910	73,207	-	1,328
SOAP, CLEANING PREPS., PERFUMES, & TOILET PREPS.	82,481	20,985	24,998	8,653	8,094	8,516	11,235
SPORTING AND ATHLETIC GOODS	72,852	939	1,322	171	57,965	5,544	6,910
PRESERVED FRUITS & VEGETABLES	54,048	28,489	14,498	2,781	5,258	195	2,827
GLASS AND GLASS PRODUCTS	50,671	12,000	23,879	6,432	3,063	506	4,791
MADE-UP TEXTILES EXCEPT APPAREL	26,932	2,596	1,600	371	18,521	-	3,844
JEWELERY AND RELATED ARTICLES	18,178	9,034	3,024	756	2,470	-	2,894
ELECTRICAL APPLIANCES & HOUSEWARES	17,768	49	367	61	17,255	24	12
BAKERY PRODUCTS	15,699	1,004	2,254	292	11,139	-	1,009
FUR DRESSING AND DYEING	7,812	2,805	660	157	1,757	63	2,370
DAIRY PRODUCTS	5,535	1,709	2,402	428	111	5	880
STRUCTURAL METAL PRODUCTS	2,376	201	849	340	928	13	44
FISH PRODUCTS	564	336	148	10	4	3	63
CONFECTIONERY PRODUCTS	327	240	49	8	5	-	26
CARPETS AND RUGS	-	-	-	-	-	-	-
Grand Total	**97,419,468**	**29,548,976**	**27,337,812**	**7,350,644**	**13,261,426**	**10,282,564**	**9,638,046**

(Red: 3 most important; Yellow: 3 next most important)

Table 10: Toxic Metal Discharges by Industrial Sector

	Toxic Metal			
Industrial Sector	**Total**	**Air**	**Land**	**Water**
IRON AND STEEL	400,244	17,252	380,383	2,608
SPINNING, WEAVING, & FINISHING TEXTILES	216,023	10,140	205,199	684
SYNTHETIC RESINS, PLASTICS MATERIALS	98,235	614	95,621	2,000
ELECTRICAL APPARATUS AND SUPPLIES, N.E.C.	87,228	2,239	84,909	80
RUBBER PRODUCTS, N.E.C.	73,833	780	72,986	66
NONFERROUS METALS	41,025	1,201	39,800	24
MALT LIQUORS AND MALT	34,276	106	34,159	11
RADIO, TV, & COMMUNICATION EQUIPMENT	26,341	301	25,983	58
ELECTRICAL INDUSTRIAL MACHINERY	20,861	2,473	18,094	294
MOTORCYCLES AND BICYCLES	16,761	1,933	14,059	769
MANUFACTURING INDUSTRIES, N.E.C.	16,272	1,382	14,837	52
FABRICATED METAL PRODUCTS	12,301	266	11,944	91
WEARING APPAREL	10,710	131	10,579	-
MOTOR VEHICLES	6,778	309	6,463	6
FERTILIZERS & PESTICIDES	6,736	95	6,625	16
NONMETALLIC MINERAL PRODUCTS, N.E.C.	4,659	578	4,077	5
PLASTICS PRODUCTS, N.E.C.	3,562	85	3,291	185
CEMENT, LIME, AND PLASTER	3,502	83	3,419	0
DRUGS AND MEDICINES	2,454	21	2,420	12
SPORTING AND ATHLETIC GOODS	1,898	32	1,837	29
FUR DRESSING AND DYEING	1,593	2	1,591	1
MADE-UP TEXTILES EXCEPT APPAREL	1,343	345	998	-
SAWMILLS, PLANING & OTHER WOOD MILLS	1,338	94	1,242	2
SOAP, CLEANING PREPS., PERFUMES	1,163	15	1,138	10
KNITTING MILLS	881	-	881	-
JEWELERY AND RELATED ARTICLES	518	12	494	12
ELECTRICAL APPLIANCES & HOUSEWARES	392	3	388	1
PRINTING & PUBLISHING	365	5	359	0
PREPARED ANIMAL FOODS	266	117	149	-
OILS AND FATS	198	1	197	0
GRAIN MILL PRODUCTS	189	7	182	-
GLASS AND GLASS PRODUCTS	177	78	99	0
STRUCTURAL METAL PRODUCTS	139	8	129	2
FOOD PRODUCTS, N.E.C.	79	1	33	44
MEAT PRODUCTS	70	-	5	65
SUGAR FACTORIES & REFINERIES	52	-	52	-
FURNITURE & FIXTURES, NONMETAL	34	11	23	-
PRESERVED FRUITS & VEGETABLES	27	-	22	5
PAPER & PAPERBOARD CONTAINERS & BOXES	11	-	11	-
WOOD & CORK PRODUCTS, N.E.C.	9	1	8	-
DAIRY PRODUCTS	0	0	-	-
BAKERY PRODUCTS	-	-	-	-
CARPETS AND RUGS	-	-	-	-
CONFECTIONERY PRODUCTS	-	-	-	-
FISH PRODUCTS	-	-	-	-
FOOTWEAR	-	-	-	-
LEATHER PRODUCTS	-	-	-	-
TOBACCO MANUFACTURES	-	-	-	-
Grand Total	**1,092,542**	**40,725**	**1,044,684**	**7,133**

(Red: 3 most important; Yellow: 3 next most important)

Table 11: Toxic Discharges by Industrial Sector

Industrial Sector	Total	Air	Land	Water
SYNTHETIC RESINS, PLASTICS MATERIALS	4,210,911	2,213,795	1,835,252	161,863
SPINNING, WEAVING, & FINISHING TEXTILES	3,001,636	1,230,631	1,143,844	627,123
FOOTWEAR	1,482,157	1,439,469	42,531	158
IRON AND STEEL	712,330	100,504	576,104	35,722
RUBBER PRODUCTS, N.E.C.	570,550	412,746	157,704	101
RADIO, TV, & COMMUNICATION EQUIPMENT	497,639	260,410	234,927	2,303
PLASTICS PRODUCTS, N.E.C.	477,041	367,318	108,826	897
DRUGS AND MEDICINES	316,246	124,732	186,695	4,819
KNITTING MILLS	291,618	95,655	187,147	8,816
ELECTRICAL APPARATUS AND SUPPLIES, N.E.C.	232,532	75,144	155,517	1,871
MALT LIQUORS AND MALT	223,812	140,227	75,643	7,946
WEARING APPAREL	219,640	159,347	60,067	-
MOTORCYCLES AND BICYCLES	213,423	100,170	72,709	40,544
ELECTRICAL INDUSTRIAL MACHINERY	150,234	100,202	49,511	518
FERTILIZERS & PESTICIDES	136,053	56,634	76,762	2,657
MANUFACTURING INDUSTRIES, N.E.C.	130,355	89,029	40,589	735
PRINTING & PUBLISHING	122,730	108,124	14,603	6
MOTOR VEHICLES	103,329	70,915	32,063	351
NONMETALLIC MINERAL PRODUCTS, N.E.C.	92,832	35,014	57,645	174
PAPER & PAPERBOARD CONTAINERS & BOXES	80,308	67,036	12,254	1,018
TOBACCO MANUFACTURES	75,252	68,046	6,743	462
FABRICATED METAL PRODUCTS	73,802	32,729	39,976	1,097
NONFERROUS METALS	64,062	17,363	46,024	674
SPORTING AND ATHLETIC GOODS	52,376	40,033	12,314	29
SOAP, CLEANING PREPS., PERFUMES, & TOILET PREPS.	43,414	16,037	27,146	231
MADE-UP TEXTILES EXCEPT APPAREL	42,282	35,768	6,032	485
LEATHER PRODUCTS	35,580	33,594	1,987	-
WOOD & CORK PRODUCTS, N.E.C.	20,595	18,838	1,755	2
FURNITURE & FIXTURES, NONMETAL	19,181	17,584	1,584	13
MEAT PRODUCTS	17,465	8,380	7,829	1,256
FOOD PRODUCTS, N.E.C.	17,204	6,032	10,742	429
SUGAR FACTORIES & REFINERIES	15,248	2,626	12,548	73
PREPARED ANIMAL FOODS	13,893	5,792	7,610	492
CEMENT, LIME, AND PLASTER	12,818	2,375	6,776	3,667
SAWMILLS, PLANING & OTHER WOOD MILLS	12,064	9,146	2,874	44
PRESERVED FRUITS & VEGETABLES	11,946	2,500	8,743	703
OILS AND FATS	11,790	1,645	9,612	532
JEWELERY AND RELATED ARTICLES	9,527	6,528	2,350	648
ELECTRICAL APPLIANCES & HOUSEWARES	7,969	5,045	2,924	1
FUR DRESSING AND DYEING	4,739	2,085	2,594	60
DAIRY PRODUCTS	3,724	376	3,078	271
GLASS AND GLASS PRODUCTS	1,296	752	484	61
CARPETS AND RUGS	1,085	356	643	86
GRAIN MILL PRODUCTS	967	680	287	-
STRUCTURAL METAL PRODUCTS	897	377	425	95
BAKERY PRODUCTS	659	297	362	-
CONFECTIONERY PRODUCTS	164	73	91	-
FISH PRODUCTS	47	22	25	-
Grand Total	**13,835,422**	**7,582,181**	**5,343,948**	**909,032**

(Red: 3 most important; Yellow: 3 next most important)

Table 12: Air Pollutants Discharged per Province

Provinces	Total	SO2	NO2	CO	VOC	PM10	TSP
Phnom Penh	36,498,962	11,892,906	11,955,887	3,764,177	4,865,876	1,321,369	2,698,746
Kampot	29,005,445	10,218,483	4,744,836	577,670	27,873	8,495,071	4,941,512
Tboung Khmum	5,696,760	1,036,847	2,426,146	356,264	1,708,372	6,413	162,718
Kandal	5,103,995	1,310,933	1,949,569	528,297	843,909	63,479	407,808
Preah Sihanouk	4,907,982	1,369,335	1,591,749	660,466	804,063	145,658	336,711
Svay Rieng	4,057,905	518,826	470,851	249,964	2,662,190	21,677	134,397
Kampong Thom	3,522,259	590,596	1,499,156	222,284	1,106,549	4,150	99,524
Takeo	2,796,214	828,563	904,636	488,193	305,002	82,963	186,856
Kampong Speu	1,232,125	320,929	335,892	51,102	277,175	53,052	193,975
Koh Kong	1,134,484	328,600	311,110	159,947	122,972	7,234	204,621
Kampong Chhnang	793,123	285,786	273,501	47,548	139,123	6,883	40,282
Prey Veng	748,348	241,289	315,810	44,293	90,408	6,909	49,639
Battambang	522,109	217,774	174,185	13,999	28,084	19,370	68,698
Kratie	310,916	86,978	46,552	98,413	40,893	18,478	19,602
Ratanak Kiri	230,615	58,350	57,584	39,055	33,839	13,042	28,746
Mondul Kiri	207,385	34,401	84,858	12,866	65,394	1,336	8,530
Stung Treng	153,275	37,168	52,390	14,767	41,135	1,861	5,955
Kampong Cham	141,725	41,232	28,206	2,609	66,714	168	2,795
Banteay Meanchey	130,637	42,670	53,433	9,913	17,418	714	6,488
Siem Reap	98,381	39,715	29,980	3,567	5,841	4,356	14,921
Preah Vihear	49,021	11,844	5,592	2,541	2,783	6,940	19,321
Pailin	41,074	18,196	13,754	1,348	1,720	1,339	4,717
Pursat	19,662	9,548	5,842	968	2,194	85	1,025
Oddar Meanchey	11,989	5,424	4,285	268	1,693	12	306
Kep	4,940	2,502	1,971	122	205	4	137
Preah Sihanouk	136	81	36	3	1	1	15
Grand Total	**97,419,468**	**29,548,976**	**27,337,812**	**7,350,644**	**13,261,426**	**10,282,564**	**9,638,046**

(Red: 3 most important; Yellow: 3 next most important)

Table 13: Water Pollutants Discharged per Province

Provinces	Total	BOD	TSS
Phnom Penh	17,097,662	517,865	16,579,797
Preah Sihanouk	3,190,828	53,500	3,137,328
Takeo	2,490,702	57,509	2,433,193
Kandal	1,990,734	96,496	1,894,238
Kratie	934,094	415	933,678
Svay Rieng	682,284	97,265	585,019
Tboung Khmum	480,791	40,699	440,092
Kampong Chhnang	451,420	40,545	410,875
Koh Kong	363,656	107,893	255,764
Ratanak Kiri	263,570	746	262,824
Kampong Speu	223,344	71,516	151,829
Kampong Thom	209,129	23,573	185,556
Kampot	206,065	368	205,696
Kampong Cham	138,395	31,968	106,427
Stung Treng	60,972	794	60,178
Mondul Kiri	37,735	1,340	36,395
Prey Veng	23,532	9,195	14,337
Oddar Meanchey	10,908	75	10,833
Preah Vihear	10,755	89	10,666
Battambang	10,615	3,481	7,134
Banteay Meanchey	4,941	1,868	3,074
Siem Reap	1,478	470	1,008
Pailin	733	228	505
Preah Sihanouk	729	270	460
Pursat	161	53	107
Kep	112	34	78
Grand Total	**28,885,344**	**1,158,254**	**27,727,090**

(Red: 3 most important; Yellow: 3 next most important)

Table 14: Toxic Metal Pollutants Discharged per Province

Provinces	Total	Air	Land	Water
Phnom Penh	581,716	24,975	553,485	3,256
Preah Sihanouk	87,010	2,870	83,487	654
Takeo	73,364	3,031	69,967	367
Svay Rieng	72,737	3,607	68,308	822
Tboung Khmum	68,563	676	67,008	879
Kandal	55,505	2,346	52,950	210
Kratie	38,625	853	37,660	112
Kampong Thom	38,584	300	37,705	579
Kampong Speu	13,734	474	13,220	40
Koh Kong	12,253	145	12,080	28
Kampong Cham	10,247	298	9,933	15
Ratanak Kiri	9,972	282	9,648	43
Kampong Chhnang	7,459	255	7,175	28
Prey Veng	5,849	269	5,563	18
Mondul Kiri	4,689	47	4,607	35
Kampot	3,304	78	3,225	1
Battambang	2,624	20	2,600	4
Stung Treng	2,167	57	2,087	22
Preah Vihear	1,209	35	1,172	2
Oddar Meanchey	1,091	11	1,079	1
Banteay Meanchey	914	75	825	13
Siem Reap	488	14	470	3
Pailin	231	5	225	1
Pursat	176	2	173	1
Kep	31	0	31	0
Preah Sihanouk	-	-	-	-
Grand Total	**1,092,542**	**40,725**	**1,044,684**	**7,133**

(Red: 3 most important; Yellow: 3 next most important)

Table 15: Toxic Pollutants Discharged per Province

Provinces	Total	Air	Land	Water
Phnom Penh	5,386,129	2,736,230	2,147,618	502,119
Tboung Khmum	2,053,774	1,100,691	874,056	79,026
Kampong Thom	1,279,069	688,563	544,519	45,987
Preah Sihanouk	983,630	503,465	434,334	45,828
Kandal	893,844	483,845	330,976	78,978
Svay Rieng	776,224	480,090	243,981	52,143
Kampong Speu	551,381	412,810	122,522	16,033
Takeo	515,073	277,861	190,466	46,740
Kampong Chhnang	298,753	216,838	71,209	10,699
Koh Kong	245,148	123,517	120,030	1,599
Kampong Cham	233,681	205,485	27,836	357
Kratie	218,042	143,073	73,646	1,323
Prey Veng	110,305	43,258	49,627	17,418
Mondul Kiri	91,914	52,918	36,400	2,595
Ratanak Kiri	72,820	42,343	29,140	1,337
Stung Treng	36,881	20,274	15,351	1,257
Battambang	23,411	15,051	7,731	630
Banteay Meanchey	19,109	12,051	5,755	1,302
Kampot	14,134	4,010	6,690	3,434
Preah Vihear	11,908	7,193	4,703	13
Oddar Meanchey	8,347	5,996	2,335	17
Siem Reap	5,999	3,054	2,828	118
Pursat	3,422	2,294	1,105	20
Pailin	2,206	1,141	1,014	51
Kep	205	128	69	7
Preah Sihanouk	11	5	6	-
Grand Total	**13,835,422**	**7,582,181**	**5,343,948**	**909,032**

(Red: 3 most important; Yellow: 3 next most important)