Understanding Air Pollution in the Garment Sector and Health Impacts on Workers: A Cambodian Case Study

Him Chandath
Ing Chhay Por
Sam Sokyimeng
San Dana
Yim Raksmey

IDRC · CRDI
International Development Research Centre
Centre de recherches pour le développement international
Canada

SEI Stockholm Environment Institute

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Him Chandath[1], Ing Chhay Por[2], San Sokyimeng[3], San Dana[4] and Yim Raksmey[5]

1. Introduction

With its growing economy, Cambodia is not immune to rapidly rising air pollution levels. Growing industrial processes and usage of fuel-intensive vehicles, open field burning of solid waste, and increasing construction sites, are seen as the main contributors of air pollution in Cambodia (DoAQNVM, 2020). Air pollution has no boundary, and exposure to air pollutants - both short and long-term exposure - can affect human health. Particles with a diameter of 2.5 μm or less (PM2.5) are the most health-damaging as they can penetrate and lodge deep inside the lungs (USEPA, 2022). According to Socioeconomic Disparities and Air Pollution Exposure: A Global Review, exposure to air pollution varies greatly by socioeconomic status, with poorer communities disproportionately exposed to higher concentrations of air pollution (Anjum et al, 2015). Thus, improving air quality would not only benefit the environment, it will also contribute to sustainable development via delivering better health outcomes, especially for marginalized groups.

1.1 Air Pollution in Cambodia

Air pollution has an impact on public and individual health by increasing morbidity and mortality. Increased exposure to air pollution, specifically PM2.5, has been associated with increased risks of respiratory and cardiovascular diseases, diabetes, stroke, and lung cancer (GBD 2019). Besides PM2.5, the high concentration of ozone at ground level could be harmful to human health by affecting the respiratory and cardiovascular system. Nitrogen oxide, sulfur dioxide, carbon monoxide, and volatile organic compounds are also the major pollutants that are harmful to humans (Loanis., et al. 2020).

Cambodia recently published its first action plan to reduce ambient air pollution, the “Clean Air Plan of Cambodia”, in 2021. In the Plan, historic emissions of PM2.5 in Cambodia were quantified and were used to perform a health impact assessment. PM2.5 was used as a major pollutant for premature mortality estimation. Premature mortality is estimated for children (less than 5 years) and adults from 5 disease categories. This analysis estimated that there were 3100 premature deaths in 2015 due to exposure to PM2.5, which primarily affected older people (over 70 years old) and infants, with an estimated death of about 500 infants in 2015, accounting for 17percent of the total number of premature deaths. This impact was projected to increase, as

[1] Deputy Director of Air Quality, Noise and Vibration Management Department (DAQNVM), General Directorate of Environmental Protection of Ministry of Environment of Cambodia
[2] Vice Chief Office of DAQNVM
[3] Vice Chief Office of DAQNVM
[4] Chief Office of DAQNVM
[5] National Consultant

annual PM2.5 exposure is expected to worsen from 21 µg.m-3 in 2015 to 24 µg.m-3 in 2030 for percent the baseline scenario, which is a total 14percent increase.

The Phnom Penh Atmospheric Emission Inventory (2015) and Clean Air Plan of Cambodia show that the priority sector for air pollutants mitigation nationally is transportation coming from mobile sources, especially from vehicles. The increasing number of vehicles used in main cities such as Phnom Penh, Siem Reap and Sihanoukville raised concerns over and contributed a source of air pollution. There were more than 3 million vehicles registered at the Ministry of Public Works and Transport at the end of 2015, of which 80 percent were motorcycles. These factors have caused urban traffic congestion and affected air quality.

Open burning of waste and home cooking are also sources of air pollution in Cambodia. Persistent organic pollutants such as dioxins and furans mainly from plastics and electronic waste pose a bigger threat to the environment. Burning waste remains a common practice in Cambodia, especially in rural areas where open burning is considered to be the simplest disposal method due to the lack of landfills or waste collection services. For households, carbon and soot emissions during cooking with fossil fuels are significant.

Forest fires are also a source of air pollutants in Cambodia at certain times of the year, especially during the dry season. While forest fires have not been studied adequately (James and Rick, 2013) in Cambodia, 60 percent of deciduous forests are estimated to catch fire at least once a year (Maxwell 2004).

1.2 Air Quality Management in Cambodia

The Ministry of Environment of the Royal Government of Cambodia is the leader of environmental protection, biodiversity conservation, sustainable development, and sustainable livelihoods for the lasting benefits for Cambodia. For environmental protection, the Ministry of Environment plays a major role for water quality management, waste management and air quality management. The Ministry of Public Works and Transport, Ministry of Mines and Energy, Ministry of Industry, Science, Technology and Innovation, Ministry of Agriculture, Forestry and Fisheries, Ministry of Commerce, Ministry of Land Management, Urban Planning and Construction, and Ministry of Economy and Finance also participate in air quality management based on their respective responsibilities. For example, the Ministry of Public Works and Transport is responsible for emission inspection from vehicles and working with the Ministry of Environment to set the vehicle emission standard.

1.1.1 Air Quality Monitoring Network and Air Quality Management Laws, Policies

In Cambodia, air quality monitoring has been in place since 1999 by using the conventional method of “passive tube” to measure air quality, and since 2017 air quality monitoring has been further strengthened by installing the first equipment for monitoring PM2.5 in the capital, Phnom Penh. The Ministry of Environment maintains one of the most comprehensive air quality monitoring networks in the country, consisting of over 10 stations and

51 low-cost sensors distributed around the counties. The data from the air quality monitoring equipment is daily posted on the MoE Facebook page and the LED screen in front of the MOE building in Phnom Penh (DoAQNVM, 2020).

For over a decade, the Ministry of Environment has paid serious attention to formulation of many policies, laws and environmental legal regulations to ensure the effectiveness to enhance the environmental quality in the Kingdom of Cambodia. Some of these policies and measures are detailed in Table 1.1.

Table 1.1 The existing framework for air quality management in Cambodia

Name of Policy/Measures	Type of Policy/Measures	Year went into implemention/ adopted	Related Air Quality / 25 Clean Air Measures[6]
Constitution of the Kingdon of Cambodia	National Constitution	1993	The state shall protect the environment, water, air,..
Law on Environmental Protection and Natural Resource Management	Law	1996	Protection of the water, land, air,..
Sub-decree on Environmental Impact Assessment Process	Regulation	1999	Managing environmental pollution from investment projects
Sub-decree on Water Pollution Control	Regulation	1999	Stop biogas leakage from wastewater treatment
Sub-decree on the Control of Air Pollution and Noise Disturbance	Regulation	2000	Strengthen industral process emission standards, air quality standard
Sub-decree on Solid Waste Management	Regulation	1999, amended 2015	Improve solid waste management
Sub-decree on Management of Garbage and Solid Waste of Urban Areas	Regulation	2015	Improve solid waste management
Regulation on General Conditions for Connecting Solar PV	Regualtion	2018	Promote renewable electricity generation

[6] The UNEP (2018) Report 'Air Pollution in Asia and the Pacific: Science-based Solutions' provides 25 policy and technology clean air measures that could help achieve safe air quality levels for 1 billion people by 2030 – with numerous benefits for public health, economic development and the climate. https://ccacoalition.org/en/solutions

Name of Policy/Measures	Type of Policy/Measures	Year went into implemention/ adopted	Related Air Quality / 25 Clean Air Measures[6]
Generation Sources to the Electricity Supply System of National Grid			
National Implementation Plan for Management of Persistent Organic Pollutants	Strategic Plan	2006	Strictly enforce ban on household waste burning
Climate Change Strategic Plan 2014-2023	Strategic Plan	2013	Provide incentives for improved energy efficiency in households
National Strategic Plan for Climate Change Adaptation and Greenhouse Gas Mitigation in Transport	Strategic Plan	2013	Regularly maintain and inspect vehicles
National Strategic Plan on Green Growth 2013-2030	Strategic Plan	2013	Clean energy promotion
National Policy, Stretegy and Action Plan on Energy Efficiency	Strategic Plan	2013	Improve energy efficiency for industry
National Determined Contribution (UNFCCC)	Strategic Plan	2015	Clean cooking and heating, provide better mobility options, mainstream electric vehicles
Blue Mobility	Strategic Plan	2015	Mainstream electric vehicles
National Environmental Strategy and Action Plan 2016-2023	Strategic Plan	2016	Strengthen industrial process emissions standards
Cambodia National REDD+ Strategy 2017-2026	Strategy Plan	2017	Prevention of forest and peatland fires
Green City Strategic Plan for Phnom Penh	Strategic Plan	2017	Promote renewable electricity generation, incentives for improved energy

Name of Policy/Measures	Type of Policy/Measures	Year went into implemention/ adopted	Related Air Quality / 25 Clean Air Measures[6]
			efficiency in households
Deika on Solid Waste Management in Battambang	Strategic Plan	2017	Improve solid waste management, strictly enforce bans on household waste burning
Phnom Penh Sustainable City Plan 2018-2030	Strategic Plan	2018	Strengthen emission standards for road vehicles, Promote renewable electricity generation
Phnom Penh Waste Management Strategy and Action Plan 2018-2035	Strategic Plan	2018	Improve solid waste management
Circular on Measures to Prevent and Reduce the Ambient Air Pollution	Strategic Plan	2020	new ambient air quality standards for PM10, and PM2.5, emissions standards for vehicles, and a fuel quality standard
Cambodia's Updated Nationally Determined Contribution	Strategic Plan	2020	Emission reduction measurement, renewable energy

1.2 The Textiles and Garment Sector in Cambodia

Over the last two decades, Cambodia had one of the highest economic growth rates in the Asia-Pacific region, with an average growth of 7.7 percent per year (World bank, 2022) Consequently, the poverty line in Cambodia dropped significantly from 47.8 percent in 2007 to 13.5 percent in 2014 (World Bank, 2019). Cambodia's structural economy is developing rapidly. To maintain the economic growth, the nation relied on four drivers of growth: agriculture, tourism, industry and services. Among those, the industrial sector has a rapid growth with its share in total GDP increasing over the years, from 23 percent in 2009 to almost 32 percent in 2016 (GGGI, 2018; World Bank, 2022). Consequently, the poverty line in Cambodia dropped significantly from 47.8 percent in 2007 to 13.5 percent in 2014 (World Bank, 2019

Cambodia's industrial sector is dominated by manufacturing and construction. The former accounted for 70 percent, while the construction accounted for 20 percent of the total sectors in

2011. About 80 percent of manufacturing factories in Cambodia consists of textiles, wearing apparel, footwear (TWF), and food, beverage and tobacco (FBT). While the share of FBT has dropped from 50 percent to just about 25 percent in recent years, the share of TWF has increased from barely 20 percent in 1993 to approximately 60 percent in 2011 (Chhair, S., & Ung L, 2013). According to a 2018 report from Global Green Growth Institute, the garment sector plays a crucial role in the industrial sector with its share jumping from just 8.2 percent in 1993 to 51.8 percent in 2004 (GGGI, 2018). Cambodia's garment sector contributes about 19 percent to gross national product and 72 percent of the nation's export revenue. This makes the garment sector one of the most important manufacturing industries in Cambodia (MIH, 2015).

As of 2015, Cambodia has 640 officially registered garment, textile and footwear factories (GTF) (CNV International, 2016). In the same year, the sector accounted for 686,150 employees, (MIH, 2015) while a study by CNV International (2016) indicates that this number might exceed 800,000 workers if the informal workforce is taken into account. The garment and footwear factories provide about 77 percent of all manufacturing work in Cambodia (CNV International, 2016). Not only is it the largest sector for formal employment, it is also a major sector for women's employment in the country (ADB, 2013). GTF workers engage almost 7 per cent of Cambodia's total estimated population of 15.6 million people (2016 estimate), come up with approximately one million GTF workers in Cambodia. The GTF workers in Cambodia are young and predominantly female. In fact, more than 80 per cent of GTF workers in Cambodia are under the age of 35, while four-out-of-five GTF workers in Cambodia are female. There are 71 percent of GTF workers in Cambodia have attained between Grade 5 and Grade 11 levels of education, among around 57 percent of the national population of those aged 15 years and above who have completed primary school. On average, female GTF workers have lower levels of educational attainment than their male counterparts (International Labour Organization, 2018).

1.3 The garment sector and environmental issue

Although the garment sector creates much needed jobs and fuels the country's economy, it also causes pollution (e.g., water and air pollution) and increasing pressure on society (e.g., through negative health impacts due to long working hours, nutrient deficiency because of eating unhealthy foods) and the environment. This includes pollutants to air from intensive energy consumption (including off-grid and back up diesel generation and typically the factories operate using outdated and inefficient equipment), solid and hazardous waste, noise pollution and wastewater pollution discharge (MOE and GGGI, 2016).

The textile industry is considered to be the most environmentally harmful industry in the world. It is made up of several units dedicated to spinning, weaving, dyeing, printing, finishing, and a series of other processes necessary to convert the fiber into a finished fabric or garment. There are huge safety and health problems associated with the textile industry. The main health and safety problems in the textile industry can be indicated as exposure to cotton dust, exposure

to chemical products, noise exposure, and ergonomics problems. There are therefore a multitude of health issues which may affect workers in this industry (Chowdhury & Asim, 2014).

The main sources of air pollution from textile industries are boilers, thermos packs and diesel generators. The majority of boilers in the textile industries in Cambodia are using wood as the main fuel supply. Burning wood releases pollutants, such as particulate matter, nitrous oxide, and sulphur dioxide to the ambient air. In addition, while the boilers emit a huge amount of pollutants, the chimney height is generally less than 30 meters which causes the pollutants to be released in the vicinity of humans. Nowadays, some textiles or garment manufacturing sites have introduced coal as a burning supply for boilers and machinery, while air pollutant treatment of these boilers are not well known.

It is worth noting that factories in Cambodia sometimes are combining both textile and garment manufacturing together. Therefore, when working in these kinds of factories, workers may be exposed to both outdoor air pollution from the factory itself and from the surrounding environment, and to pollutants emitted during textile manufacturing. Textile industries transform fibers into other products. Textile industries use large amounts of dyes, chemical, auxiliary and sizing materials. Employees may be exposed to indoor air pollution by various pollutants including toxic gases emitted during textile manufacturing process. Exposed to these pollutants, workers may meet various problems that irritate the respiratory system and cause bronchitis, irritates all parts of the respiratory system, causes lung irritation and also irritation in eyes, and deprives body cells of oxygen which can cause unconsciousness (Dasom et al., 2019).

Within Cambodia's garment sector, there are key challenges to greener operations, these include reducing energy consumption, reducing pollution, improving occupational health and safety, and improving working conditions. Some of these challenges have potential solutions: energy consumption can be improved through energy efficiency and conservation measures, while occupational health and safety and working conditions can be improved through providing adequate work place ventilation and avoiding worker exposure to toxic chemicals through personal protective equipment. These measures are necessary to improve the working environment (MOE and GGGI, 2016) and could lead to reduced resource consumption and a decoupling of industrial growth from environmental and social impacts.

2. Research objectives

The textile industry, including garment factories and their environmental impact in Cambodia, particularly in relation to air pollution, are not well known and were highlighted as a major gap in the development of Cambodia's Clean Air Plan. Therefore, the overall objective of this study is to improve understanding of air pollutant emissions from the textile industry and the health impacts on workers in Cambodia's garment industry.

This study focuses on the health impacts of occupational air pollution on workers. It uses qualitative methods such as conducting interviews to explore how their symptoms might have

been caused by air pollution. It does not employ medical research to assess their health status. It concludes by providing recommendations for policy and labour practice to better protect garment industry workers from exposure to air pollution.

3. Research Methodology

This section outlines the four different stages of research undertaken in this study: 1) Identifying stakeholders and designing questionnaires, 2) Defining the study area 3) Collecting data and 4) Data entry and analysis. Figure 3.1 shows the flow diagram of the research process. First, stakeholder analysis and designing questionnaires were an important step before conducting interviews with workers. Second, data collection was conducted by interviewing key informants and factory owners to get their perception on air pollution and health impacts on workers in the factory. Third, air pollution concentrations were measured during interviews with factory owners and workers in each factory. Finally, data was analyzed to understand the estimated exposure of air pollution for the workers and to estimate the contribution of the textile industry to overall air pollution in Cambodia.

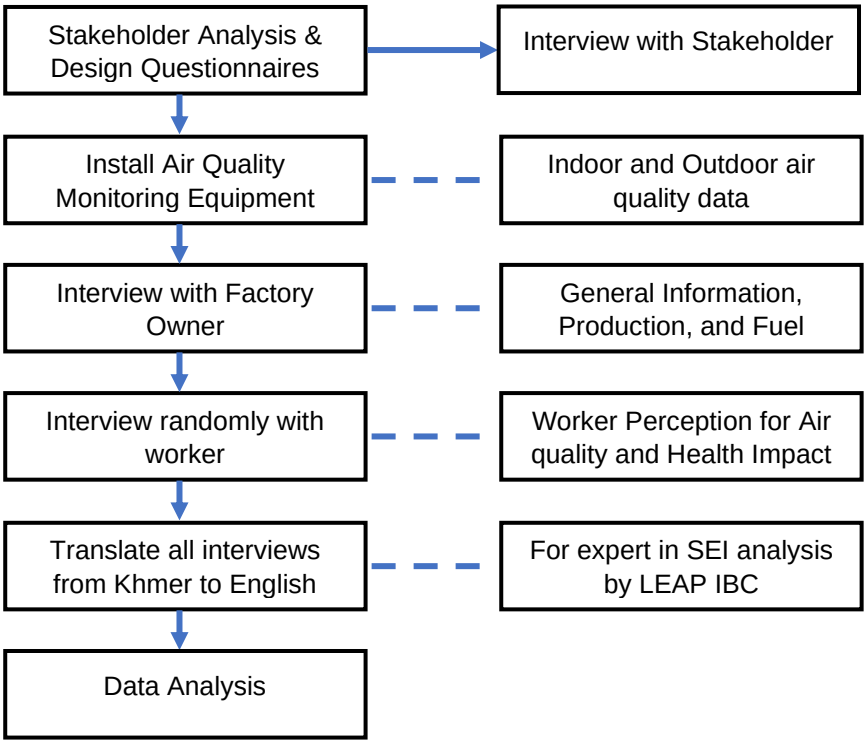

Figure 3.1: Flow diagram of the research process

3.1 Stakeholder identification

To understand and tackle occupational health issues within the textile industry, it is crucial to collect inputs and perceptions of stakeholders where there are no health data recorded on the actual number of people impact by air pollution, especially from this particularly sector. To begin, the project team reviewed relevant policy and regulations from relevant line ministries to find out their role and level of involvement on air pollution and health impact for workers in garment sector in Cambodia. The assessment criteria included environmental, policy and regulation aspects, responsibility, worker' s health concern, training and awareness on worker's health. Due to time and financial constraints, the project team identified 4 government agencies and 4 non-

government organizations to interview to gather their perceptions on air pollution and health impacts on workers in garment factories.

The data collection was conducted from May to August, 2022 and included both qualitative, and quantitative data. Four government agencies - the Ministry of Environment (MOE); Ministry of Mines and Energy (MME); Ministry of Industry, Science, Technology and Innovation (MISTI); Ministry of Labour and Vocational Training (MLVT) - and 4 non-government organizations -the Garment Manufacturers Association in Cambodia (GMAC); International Labour Organization (ILO); and Cambodian Labour Confederation (CLC) - were interviewed to gather insights air pollution's impacts on workers in the garment industry. One representative from each government agency and non-government organization was involved in interview, making up 8 interviewees.

After the desk review of the existing policy/regulation/mandate of targeted stakeholders, the project team prepared an official letter to ministries and non-government organizations. The responses were compiled and analyzed and lastly the recommendations were drawn for employers to improve health impacts of worker in garment factory from air pollution in factories.

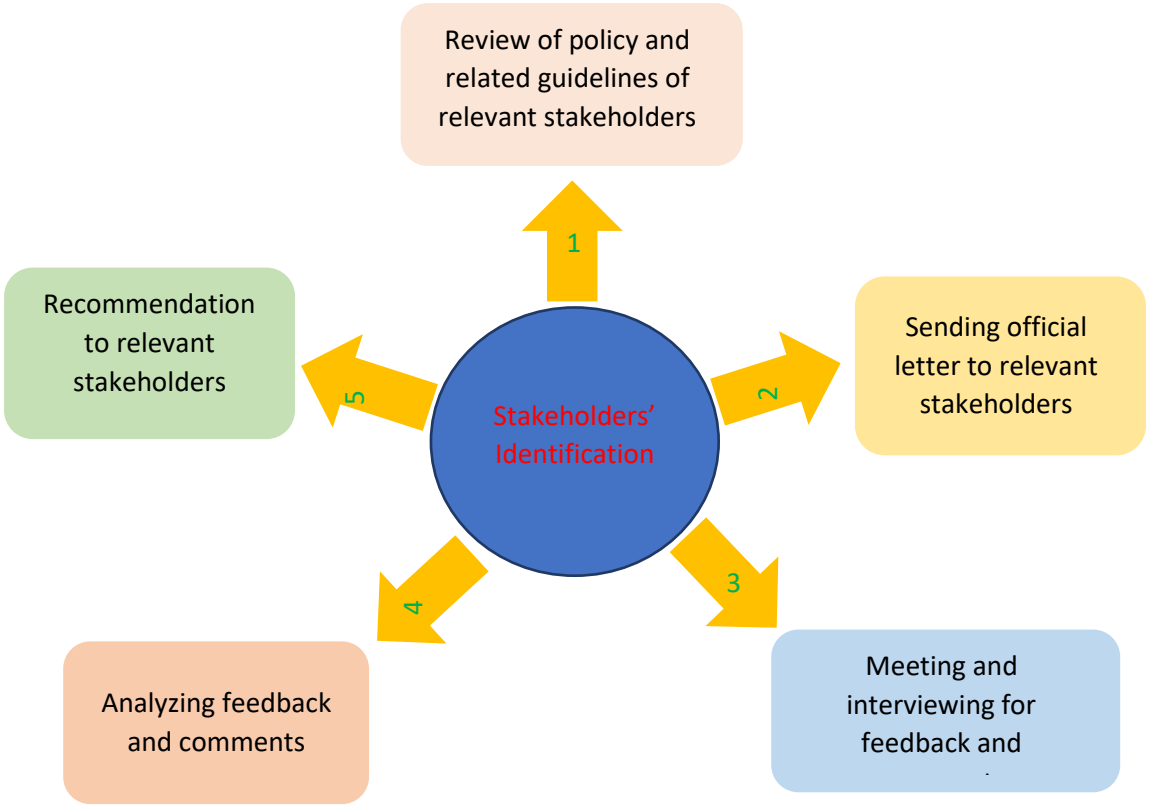

Figure 3.2: The process of stakeholders' identification

3.2 Study Area

This study was carried out in four provinces: Phnom Penh, Kandal, Kampong Speu, and Sihanouk Province, with a total of 16 garment and footwear factories as shown in Figure 3.3. These four provinces have more garment and footwear worker compared to other provinces in

Cambodia. Data from International Labour Organization shows the percentage share of workers in Phnom Penh, Kandal, Kampong Speu and Sihanouk Province were 17.7 percent, 15 percent, 14.2 percent and 3.2 percent respectively. As time and finance constraints limited the study to 16 factories from the whole country, the number of factories selected in each province was stratified depended on the number of factories occupied within each target province, with 20 workers in each factory. The difficulty of accessing the factory was a problem we face during data collection, as data collection was based on voluntary participation. Therefore the 16 factories were selected by willingness of the factory want to do interviews. The working group of the Ministry of Environment cooperated with the Garment Manufacturers Association in Cambodia (GMAC) and International Labour Organization to inform the factories within the study areas.

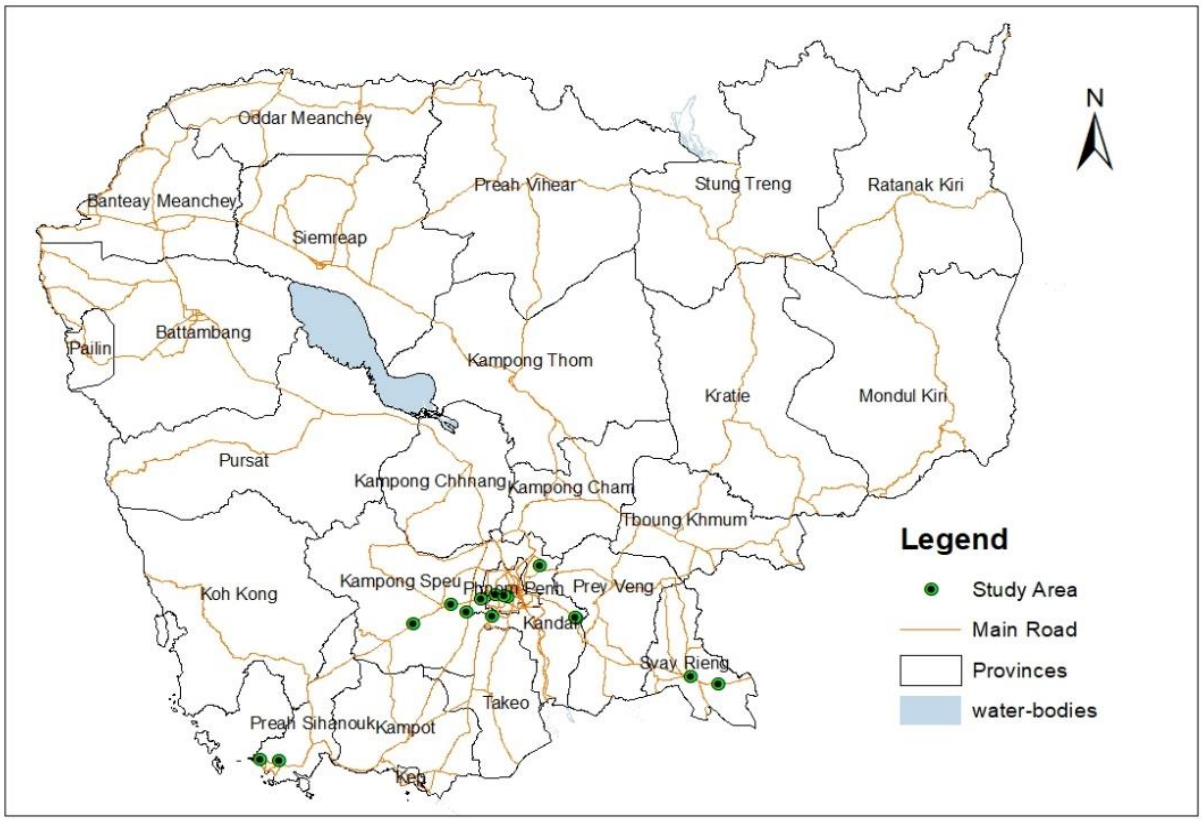

Figure 3.3: Map of Study Area

3.3 Data collection and analysis

3.3.1 Air Quality Data

At each location, two sampling sites were selected to assess the air quality of each factory: inside the factory to represent indoor air quality and outside the factory to represent outdoor air quality. Indoor and outdoor air quality data (PM2.5 and PM10) were measured over a time period of 8 hours from 8:00 AM to 4:00 PM. The air quality data was used to analyze air quality in the factory and compare this to background station in each province, in order to understand the differences in exposure level for workers in the factory. Figure 3.4 shows the place where the air quality monitoring was installed in each factory.

Figure 3.4: Sampling site in the factory

The air quality data was collected by the low-cost sensor equipment model OCEANUS AQM-09 (Figure 3.5). The AQM-09 Air Quality Monitoring Station can measure outdoor air pollutants in real-time, measuring data quickly and accurately. It can be customized for different applications demands, the measurement parameter can be chosen from the following: the gas type Ozone(O3), Nitrogen Dioxide (NO2), Sulfur Dioxide (SO2), Carbon Monoxide (CO), Particulate matter PM2.5 and PM10, as well as noise, meteorological parameters (including temperature, humidity, wind speed, wind direction, barometric pressure). In this study, air quality monitoring equipment was only used to measure PM2.5 and PM10. Table 3.1 provides technical details on the equipment used.

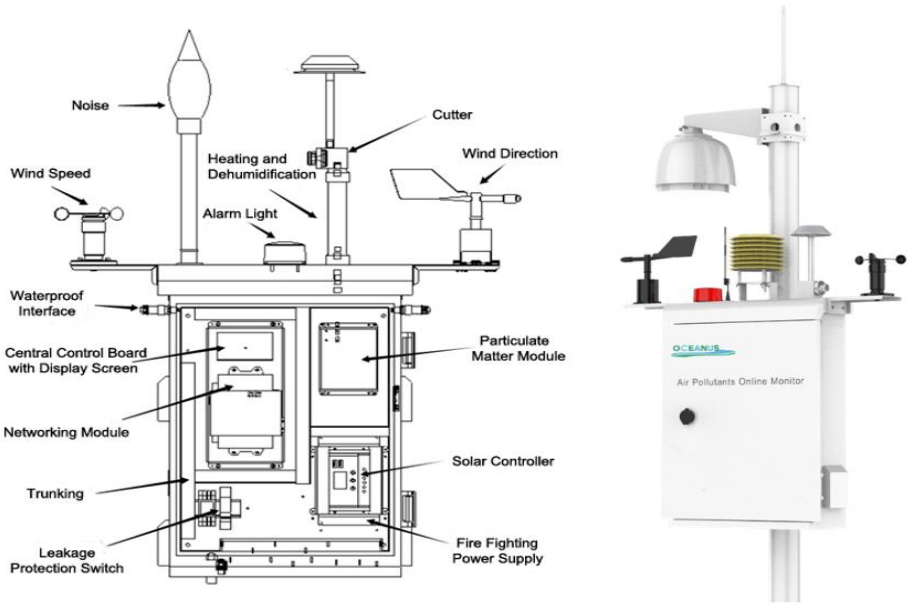

Figure 3.5: Picture of Air quality monitoring equipment in Factory

Table 3.1: Technical Parameter of AQM-09 Air Quality Monitoring Station

Items	Description	Specification
Particle Modules	Monitor method	Continuously, automatically and real-time
	Working principle	Light scattering technique
	Measurement data	PM2.5, PM10
	Measuring range	0~10mg/m3
	Response time	≤60s
	Measuring time	0.1min (Shortest measurement time) 1min (Standard measurement time)
	Minimum detection limit	≤0.001 mg/m3
	Instrument parallelism	≤±10percent
	Data validity	> 75percent
	Dehumidification	With the automatic dehumidification function module
	Alarm function	With high concentration alarm function, the platform can configure the alarm threshold

3.3.2 Interview Data

The interview questions were developed in collaboration with Stockholm Environment Institute (SEI) and Ministry of Environment of Cambodia (MoE) to access various aspects of public perception on air pollution and perceived health impact on workers in garment factories, as well as to estimate emissions of both air pollutants and greenhouse gases (GHGs) coming from the

factory. Factory owners were interviewed for general information about the factory, factory production per month, and fuel consumption. Data on production and fuel consumption was used to estimate air pollution and GHG emissions coming directly from each of the factory types, to improve the existing estimates of emissions which had been calculated for the industry sector during a previous project which led to the development of the clean air plan.

Twenty workers were chosen randomly for interviews in each factory, which all took place while they were working in the factory. In total, 323 employees were interviewed. We aimed to balance female and male worker compared to the total number of garment and footwear workers in Cambodia. Interview data from workers was collected to analyze workers' perceptions on air pollution and health impact. Before the interview with the workers, the interview team explained the project's purpose and read the consent form for the workers. All information gathered during worker interviews is kept anonymous and securely stored. The interviews were undertaken by the working team from the Ministry of Environment of Cambodia.

4. Research Findings

4.1 Emission contribution from garment sector

4.2 Health impact on workers in the garment sector

In total interviews and sampling were conducted at 16 factories, and the data provided was sufficient to estimate emissions of health-damaging air pollutants, as well as greenhouse gases like carbon dioxide at all 16 factories. Comprehensive air pollutant emissions were not directly measured, due to technical constraints and the inability to deploy monitors to factories for extended periods of time, though limited daytime monitoring was carried out as outlined in section 4.3. In contrast, the emissions of air pollutants were modelled using international standard emission inventory methodologies described in the IPCC National GHG emission inventory guidance, and EMEP/EEA national air pollutant emission inventory guidelines. The key equation to estimate emissions is shown in Equation 1:

$$Emissions = Activity\ x\ Emission\ Factor \quad (1)$$

For each factory, Equation 1 was applied to estimate the emissions of health-damaging air pollutants and greenhouse gases. These emissions were calculated for the consumption of different fuels by each factory. Emissions from fuel consumption were divided between direct fuel consumption emissions, i.e. where solid (wood) and liquid (diesel, gasoline, LPG) fuels are directly consumed at the factory location, e.g. to power machinery, and indirect emissions that include emissions resulting from fuel consumption at power stations generating electricity that is consumed in factories. The quantification of direct and indirect air pollutant emissions from the 16 garment factories comprehensively quantifies those air pollutant emissions that the factories cause, even where the emission sources, in the case of power stations, may be a long distance from the factory.

For each factory, the interview asked factory representatives for their monthly fuel consumption in the production of garments. This monthly fuel consumption was then scaled to an annual value. Across the 16 factories, fuels consumed included electricity, diesel, gasoline, LPG and wood/biomass. For direct emissions, the fuel consumption was multiplied by international default emission factors (Table 4.1) for each key air pollutant. For indirect emissions, the electricity grid emission factor (kg pollutant emitted per GJ electricity generated) was calculated based on the 2015 electricity mix, and efficiency of power stations and international default emissions factors for power generation using coal and heavy fuel oil (Table 4.2). The full emission calculations are included in a supplementary Excel Spreadsheet.

Table 4.1: Emission factors used for direct consumption of fuels in factories

Direct Emission Factors (kg/Terajoules)	**LPG**	**Diesel**	**Gasoline**	**Biomass**
CO2	63100	74100	69300	112000 - biogenic
CO	29	66	66	570
CH4	1	3	3	30

NMVOC	23	25	25	300
NOx	74	513	513	91
N2O	0.1	0.6	0.6	4
SO2				
PM10	0.78	20	20	143
PM2.5	0.78	20	20	140
BC	0.03	11.2	11.2	39.2
OC	0.26	3.6	3.2	72

Equation 1 has been applied previously to estimate national total emissions of key air pollutants from all major source sectors across Cambodia (Sokharavust et al. 2022, submitted). Table 4.1 and Figure 4.1 below show the magnitude of national total emissions, and contribution from all major source sectors. Particulate matter (PM2.5) has the largest impact on human health of all air pollutants, and it was estimates that all sources in Cambodia emitted 68 thousand tonnes. Across all industries, 2 thousand tonnes of PM2.5 was estimated to be emitted in 2015, but due to a lack of data the contribution of different source sectors to these emissions could not be made. The development of these emission estimates resulted in the development of Cambodia's National Action Plan on Air Pollutants, which, in addition to identifying the major sources, also identified specific actions to reduce air pollution. These actions included implementation of emission controls within industry, but the lack of specificity of air pollutant emission estimates in Cambodia limits the ability to target specific sectors which may make the largest contribution to industrial air pollutant emissions. The collection of data on fuel consumption in the garment industry in Cambodia as part of this work represents the first opportunity to understand the magnitude of emissions emitted at the factory-level within any industry in Cambodia. This process could be repeated at other facilities and industries to develop a more comprehensive, and detailed assessment of industrial emissions.

Table 4.2: Emissions of air pollutants from major sources in 2015 in Cambodia (thousand metric tonnes)

	OC	**BC**	**PM2.5**	**NH3**	**SO2**	**PM10**	**NOx**	**NMVOC**	**CO**	**CO2**
Residential	12.7	3.8	29.3	4.0	3.6	36.5	9.9	118.0	372.0	14.9
Transport	2.3	1.9	6.2	0.2	2.4	6.2	90.5	189.5	437.5	8,233.4
Industry	1.0	0.6	2.0	0.0	2.7	2.0	3.7	4.1	8.3	402.5
Electricity Generation	0.0	0.0	0.2	0.0	20.8	0.4	10.2	0.1	0.4	4,043.9
Charcoal Production	4.2	0.6	8.4	1.2	1.9	8.4	0.6	105.5	311.5	-
Other Energy	0.0	0.1	0.2	0.0	0.3	0.2	1.7	0.1	0.3	226.8
Agriculture	1.7	0.3	2.9	117.4	0.2	3.0	1.2	2.3	32.5	-
Industrial Processes	-	0.0	0.7	-	0.2	4.8	0.1	0.2	0.4	686.6
Waste	9.9	1.2	18.4	2.1	0.9	22.4	9.2	42.5	71.4	-

Total	31.8	8.5	68.1	124.9	32.9	83.9	127.0	462.2	1,234.2	13,608.1

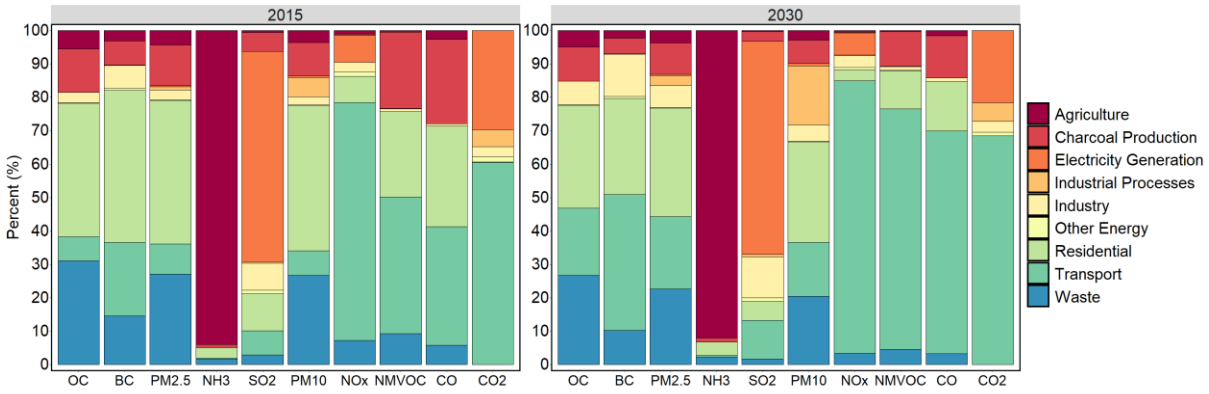

Figure 4.1: Contribution of major sources to national total air pollutant emissions in a) 2015 and b) 2030

Estimated emissions from the 16 factories are summarized in Table 4.3. For PM2.5 emissions, the five factories that used wood contributed the majority of PM2.5 emissions (98percent), reflecting the substantially higher emissions associated with biomass consumption compared to other fuels used in the factories (diesel and LPG). The five factories using wood were the most polluting in terms of emissions of other pollutants, such as nitrogen oxides and NMVOCs, but for these pollutants other fuels, such as diesel, gasoline and LPG, also had substantial emissions associated with them. For all air pollutants considered, the direct fuel consumption at factories contributed the majority of emissions compared with indirect emissions. For greenhouse gas emissions, like carbon dioxide, indirect emissions at power stations were the largest source of CO2 emissions from the garment factory operations, but there was also a significant contribution from direct consumption of LPG, diesel and gasoline in garment factories themselves.

Table 4.3: Emissions of health-damaging air pollutants from 16 garment factories in Cambodia

Factory	Fuel Used	Direct				Indirect				Units
		PM2.5	NOx	NMVOC	CO2	PM2.5	NOx	NMVOC	CO2	
1	Electricity	0.0	0.0	0.0	0.0	0.0	0.1	0.0	47.7	tonnes
2	Electricity	0.0	0.0	0.0	0.0	0.0	0.3	0.0	122.9	tonnes
3	Electricity LPG	0.0	0.0	0.0	6.3	0.2	12.5	0.1	4940.7	tonnes
4	Electricity LPG Diesel	0.0	0.6	0.0	91.9	0.0	2.2	0.0	865.8	tonnes
5	Electricity LPG	0.0	0.0	0.0	0.6	0.0	0.2	0.0	62.3	tonnes

6	Electricity LPG Wood	0.0	5.5	18.2	2.5	0.1	4.7	0.0	1875.3	tonnes
7	Electricity LPG Diesel Wood	3.5	2.3	7.5	5.6	0.0	1.7	0.0	692.6	tonnes
8	Electricity LPG Gasoline	0.0	0.4	0.0	61.8	0.0	1.5	0.0	612.2	tonnes
9	Electricity LPG Biomass	0.1	0.1	0.2	0.9	0.0	0.3	0.0	136.4	tonnes
10	Electricity Diesel	0.1	3.0	0.1	435.8	0.1	5.6	0.0	2213.9	tonnes
11	Electricity LPG Wood	2.0	1.3	4.4	5.2	0.0	2.5	0.0	999.5	tonnes
12	Electricity LPG	0.0	0.1	0.0	53.7	0.0	0.3	0.0	99.9	tonnes
13	Electricity LPG Wood	2.9	1.9	6.2	3.4	0.0	1.2	0.0	493.5	tonnes
14	Electricity LPG Wood	2.2	1.5	4.8	5.0	0.0	1.3	0.0	519.5	tonnes
15	Electricity	0.0	0.0	0.0	0.0	0.0	1.2	0.0	489.1	tonnes
16	Electricity	0.0	0.0	0.0	0.0	0.1	2.9	0.0	1142.8	tonnes
	Total	10.9	16.7	41.5	672.6	0.7	38.6	0.2	15314	tonnes

4.3 Data on health impact for workers from garment sector

In addition to the emission calculated, air pollutant (PM10 and PM2.5 concentrations) were monitored for 8 hours at each site. To assess whether indoor or outdoor PM2.5 or PM10 concentrations at each factory were elevated compared to other locations within the same region, the measurements were compared with data from the nearest reference monitoring station that is maintained by the Ministry of Environment. While a higher measurement at the factory does not necessarily mean that it is processes and activities within the factory that are resulting in the entirety of the increment compared to the reference stations, it does provide an indication of the extent to which workers at the factory are being exposed to particulate matter concentrations that are higher than less polluted areas of the region.

Table 4.4 shows the average concentration measured between 8 am and 4 pm at each factory, and at the nearest reference monitor where available. At nine of the factories, outdoor PM2.5 concentrations in the vicinity of the factory exceeded the reference monitor PM2.5

concentrations, and at five factories for PM10 concentrations. Reference monitors were unavailable for 4 of the factories for PM10. The largest increment over reference stations was at stations using wood, which is expected given the major contribution wood consumption makes to factory emissions. However, this was not the case at all sites using wood. This may reflect the placement of the monitoring instrument relative to the fuel combustion at the site, or may reflect different technologies and efficiencies of wood combustion at different factories. Indoor PM2.5 and PM10 concentrations were in many cases similar or lower than outdoor, and reference concentrations. Only at Factory 11 were indoor PM concentrations substantially elevated compared to outdoor concentrations. Lower indoor PM concentrations is consistent with the major source of indoor PM being the infiltration of outdoor air indoors, and the deposition of PM to indoor surfaces, rather than the presence of significant indoor PM emission sources.

In terms of the impact of air pollution on the health of workers, the snapshot of PM concentrations provided by the monitoring in 16 factories provides two insights outlined below.

Indoor and outdoor PM concentrations in factories are above World Health Organisation Guidelines for the protection of human health. At all but one factory, the measured PM2.5 concentrations were above annual average PM2.5 (5 µg m-3), and PM10 (10 µg m-3) air quality guidelines levels. Therefore, if these measures are representative of average PM exposure, elevated health risks, compared to WHO guideline values, would be expected among factory workers.

At some factories, outdoor and indoor PM concentrations are above reference values, but more research is necessary to determine the contribution of the factory to these increments, to understand how activities within the factory contributes to increasing PM concentrations outdoors (and indoors) near the factory. The higher exceedance of reference PM measures at factories using wood indicates that using this as the feedstock fuel to the garment making process may contribute to higher PM concentrations (and potentially worker exposure) compared to using other fuels. However, given the small number of factories analysed, and the limited monitoring period, further measurements would be necessary to confirm the extend to which wood combustion, and the use of other fuels, as the source of the PM increment at the factories analysed.

Table 4.4: Average concentrations of $PM_{2.5}$ and PM_{10} (µg m^{-3}) measured between 8 am and 4 pm inside and outside 16 factories across Cambodia, and at nearby reference monitoring sites

Factory	**Fuel Used**	**PM2.5**			**PM10**		
		Indoor	**Outdoor**	**Reference**	**Indoor**	**Outdoor**	**Reference**
1	Electricity	10.5		7.5	15.9		12.1
2	Electricity	4.3	11.1	7.9	7.3	16.6	24.2
3	Electricity LPG	10.5	15.7	19.3	16.0	20.9	
4	Electricity LPG Diesel	11.4	11.4	14.9	17.3	17.7	

5	Electricity LPG	10.7	10.6	17.8	16.3	16.3	
6	Electricity LPG Wood	10.4	11.1	19.5	15.5	19.7	
7	Electricity LPG Diesel Wood	11.2	10.6	5.1	16.3	16.2	8.5
8	Electricity LPG Gasoline	11.0	11.2	6.9	16.1	16.2	29.2
9	Electricity LPG Biomass	11.0	7.8	6.0	16.4	12.6	21.0
10	Electricity Diesel	11.3	10.8	5.8	17.1	16.7	19.3
11	Electricity LPG Wood	13.8	8.8	9.0	24.7	17.5	13.6
12	Electricity LPG	5.2	9.5	6.8	14.7	14.6	10.6
13	Electricity LPG Wood	5.8	14.8	9.7	12.4	21.3	15.2
14	Electricity LPG Wood	6.4	13.6	6.0	11.5	22.0	9.4
15	Electricity	5.7	7.1	6.2	8.9	9.2	10.2
16	Electricity	5.5	5.4	6.0	13.7	8.7	9.8

4.4 Stakeholders interview results

A. Perception on sources of air pollution

According to the results from the interviews, all stakeholders from both non-government and government agencies highlight that air pollution originates mainly from the burning of fuels such as petroleum, diesel and coal in the transport, household, industrial and energy sectors, construction, and waste burning. The respondents believed that the construction field also contributed to air pollution due to the increase of demands for offices, houses, hotels, apartments, condominiums, in the country, especially in Phnom Penh and other fast-growing provinces like Preah Sihanouk. They also felt the industrial manufacturing sector shared the contribution of air pollution/CO2 emission into the atmosphere. They observed that there was black smoke from stacks in every factory, especially in the morning. The other sources of air pollution included waste burning and household activity. Based on the understanding of the relevant stakeholders, they might discharge the CO2 into the atmosphere, which contributed to climate change and global warming.

Additionally, according to the point of view of the factory owners, the production chains of factories contribute to air pollution as they used wood, electricity, gas, etc. to support the

production lines. Moreover, some factory representatives pointed out that the waste from their factories also negatively impacts air quality, although the waste was collected by the private waste collection company.

B. Existing policies and programs

The existing policies and programs of the stakeholders regarding air pollution and health of workers in garment factories have been set in accordance to their mandate. From interview, the focus of non-governmental organizations on air pollution and worker's health seems to be stronger than that of the government. However, MOE has formulated policy/regulations related to air pollution both indoors and outdoors. MOE has set standards for emissions from immobile sources into ambient air, emission standards for industrial sources, emission standards for power plants with continuous emission monitoring system (CEMS), and gas emissions standards of mobile sources.

According to interviews with officers from the Department of Inspection and Law Enforcement, General Directorate of Environmental Protection, MOE, the department sends its officers to inspect all manufacturing industries on working condition, air pollution, waste management, water treatment management, etc., nationwide twice a year, regardless of any complaint. Within this inspection framework, the working environment conditions are improved, which subsequently reduces the negative impact on workers' health and has led to an observed increase in productivity.

Moreover, other government agencies have programs related to improvement of environment, although it is not directly involved in air pollution. For instance, the Ministry of Industry, Sciences, Technology, and Innovation (MISTI) established the program Resource Efficient and Cleaner Production (RECP) to encourage industry sectors to make production more sustainable through preventing the generation of waste and emissions in industry and trying to recycle, recover and treat waste and pollutants once created or already discharged into the environment. Additionally, the survey team reported that the RECP program can be a triple-win for the economy, the environment and society by using more efficient and greener technologies. MISTI also creates the Cambodia Green Industry Award to encourage all companies, factories and enterprises in Cambodia to embrace more sustainable production and business activities. The program aims to recognize and reward companies and factories for their usage of technologies and policies in the production and supply chains that help protect and cause less harm to the environment.

At the same time, non-governmental agencies whose mandate focuses on workers in garment factory have set up programs that help garment factories to improve working conditions, worker's rights and benefits. The ILO has established a program "Better Factories Cambodia (BFC)" supported by the government, trade unions and the industry employers' association. Through its initiative, ILO/BFC states that the employers and workers in garment factory have

been working cooperatively and some challenges have been tackled. This has resulted in reduced negative impacts to the environment and will ensure worker's health and safety.

Table 4.5: The approach of the Better Factories Cambodia program

Policies/programs	Air pollution reduction	Worker's health enhancement
Annual assessment to factories registered under ILO/BFC program on legal documents required by the concerned ministry such as MOE, MOH, MOL, building permit etc. to ensure the legal compliance, Occupational Safety and Health	The assessment service to registered BFC member aims at improving working conditions, reducing negative impacts to the environment, reducing non-compliance, contributing to the community development as part of social responsibility, and archiving sustainable development goals	The benefits of the improvement by the factory help ensuring the worker's health and safety at work, reducing the negative impacts to the environment and community, and contributing to the social responsibility for sustainable business operation
Advisory services to mandatory and non-mandatory factories under BFC program assist in guiding factories to develop the bipartite committee in improving working condition in their own factories, providing capacity building to the bipartite committee on legal compliance, experiences, and best practice for the decent work	Providing capacity building on management of hazardous chemical, storing and discharging of waste. Installing air conditionings, fans, and other equipment to help produce clean air in the factory.	Reducing environmental impacts through business activities and improving working condition for better health of worker which leads to increase in productivities
Providing training to BFC members and non-members on labour laws and occupational safety and health, etc.,		Once the factory management understand the laws, safety and environmental impacts, the factory can reduce the negatives impacts to workers and environment

In addition to the programs mentioned above, the interviewee from Cambodian Labour Confederation (CLC) said that it is critical that the experts, employers, and workers work closely to address the concerns (working condition, waste water, solid waste, water treatment) in garment factories that is considered to be harmful to workers and environment.

C. Results of factory owner interviews

This section focused on opinion of the factory owners on air quality in different types of buildings and factor that contribute to air pollution in the factories. All respondents said that the air quality in their different buildings was acceptable in their view, especially as the production buildings were equipped with water cooler, fans and exhaust fans, making the environment more comfortable to the workers in the production buildings. Moreover, the storage/raw material building was separated from the office and production, and equipped with air conditioning to keep the raw material in good condition. When the survey team asked the owners about the source of air pollution and air quality degradation in the garment factories, and provided four choices, all the owners responded that at least one of the given options were factors: emissions from stacks of boiler/generators, small working building space and high number of workers, no installation of cooling fan or ventilation system, and mix used space (working and material storage).

With regards to the reduction of air pollution and promotion of air quality in the factories, the 16 selected factory owners responded that they have implemented and practiced measures/activities for energy saving and mitigate emission as listed in Table 4.6.

Table 4.6: Measures to reduce emissions from sampled factories

Policies/practices	Yes	No	Remark
Use clean energy (solar)	4	12	- Install in the factory - 60 Kwh (one factory), no specifying for others - 2 factories are studying
Energy saving practices (use energy efficient machinery and appliance, promote energy saving habit)	16		- Turn off power when not in use - Change to LED, which uses less power
Properly managing waste from production (avoiding open waste burning and improper waste disposal	16		- Solid waste (collected weekly) - Household waste (collected every 2-3 weeks) - Fabric debris (collected weekly)
Install cooling fan/ventilation system	16		
Properly allocate number of worker and size building	16		

Properly separate production building/storage or material building	16		

Based on the above responses, the factory owners have tried to take actions in order to improve the air quality in their factory, for instance, the installation of cooling fan/ventilation system; the appropriate number of workers according to building size; energy saving practices; as well as the separation of production building from storage or material building; etc. However, only 25 percent of targeted survey factories used clean energy (solar) for production as well as other related activities.

All 16 of our interviewed factory owners took actions to improve air quality and prevent their workers from air pollution exposure as outlined in Table 4.7 - chemicals and raw materials were stored properly and separated from production buildings, wastes were collected by private companies, and protective equipment as well as, knowledge on safety practices/health protection were also provided to workers. However, the air quality monitoring was not done regularly though, 50 percent of the factory owners reported that they conducted air quality monitoring frequently.

Table 4.7: Measures to reduce air pollution exposure in factories

Policies/practices	Yes	No	Remark
Properly store chemical and raw material (in storage room avoid expose to workers)	16		
Regularly monitor indoor air quality and emission	8	8	- EIA for every 6 months - For license once a year
Provide mask/gloves/safety clothes/protective equipment to workers	16		For mask, the workers needed to buy more for wearing
Provide knowledge on safety practices/health protection during working in the building	16		- Training on safety - PPE - Meeting (monthly)

4.5 Worker's knowledge and perception regarding air pollution in workplace

323 employees from various textile factories in Cambodia were interviewed**,** 83.6 percent of respondents were female and 16.4 percent were male which is similar to the national ratio of male-female who working in textile factory that nearly 80 percent are women (International Labor Organization, 2018). Amongst the interviewees, 22 percent were aged 18-25, 49 percent were

aged 25-35, 26 percent were aged 35-45 percent and 3 percent were aged 45-55, compared to age classification of all workers in garment and footwear sector in Cambodia which are respectively 38.5 percent, 11 percent, 3.1 percent, and 1.3 percent (International Labor Organization, 2018). Figure 4.2 summaries the average years of work experience, and their perception of health impacts. The large majority of workers do not perceive any negative health impacts from working in their factory, with only 1 percent responding yes.

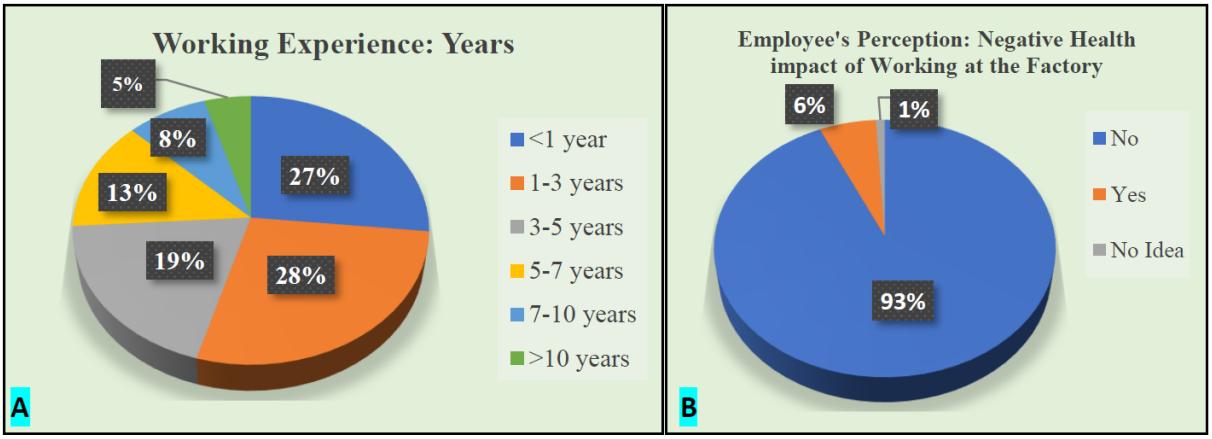

Figure 4.2: A) the years of working experiences, and B) the perception of the health impact of working at the factory.

Regarding the air quality status inside the working building, almost all of the workers (99 percent) responded that the air quality within their working place was acceptable, but that sometime they feel hot, especially during the dry season. Importantly, most workers seemed not to know what air quality was referring to. Therefore, when asked about air quality status, they equated it with temperature. Similarly, it is difficult to investigate workers' perception on health impacts of factory work as most do not know what type of symptoms or diseases are caused by air pollution. As interviewed, 23 percent of workers responded that they have experienced negative health effects from air pollution, while 76 percent respondent said they never got disease, illness, or other negative health effects from air pollution (figure 4.3). However, when we asked them only "have you been experiencing negative health impact from air pollution?" without telling them the related symptoms, most workers may respond that they never experienced health effect (Figure 4.2).

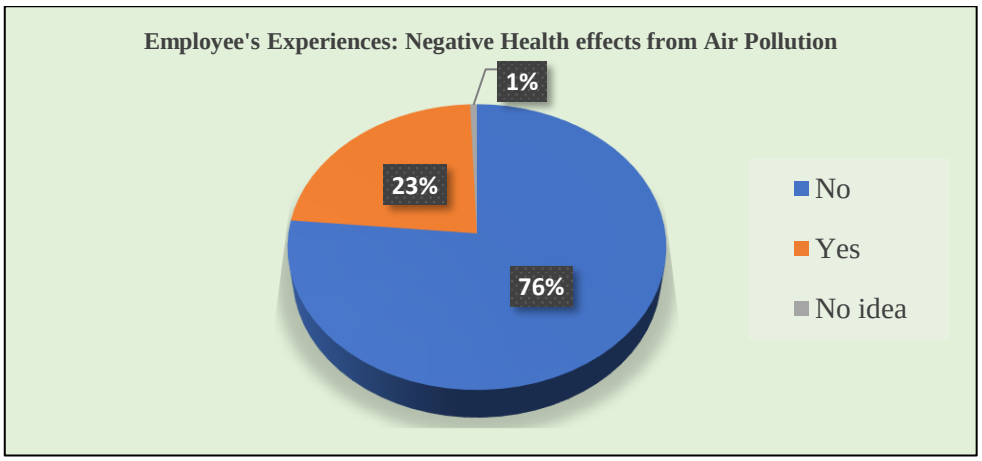

Figure 4.3: Graphic showing the worker's experience of negative health effects from air pollution while they were working at the factory.

In contrast, when questioned on the various symptoms they may have experienced (regardless of whether they felt this was linked to air pollution), the results showed all the interviewed workers experienced at least one of the symptoms that can be related to air pollution. The most common symptoms reported were headaches, followed by runny nose and fatigue (figure 4.4A). From these results, we recognize that the workers' response depended on how the question was framed, as their understanding of health pollution impacts was limited. Headache is the common symptom the workers experienced for the last 6 months with around 1/3 of total respondents (figure 4.4B).

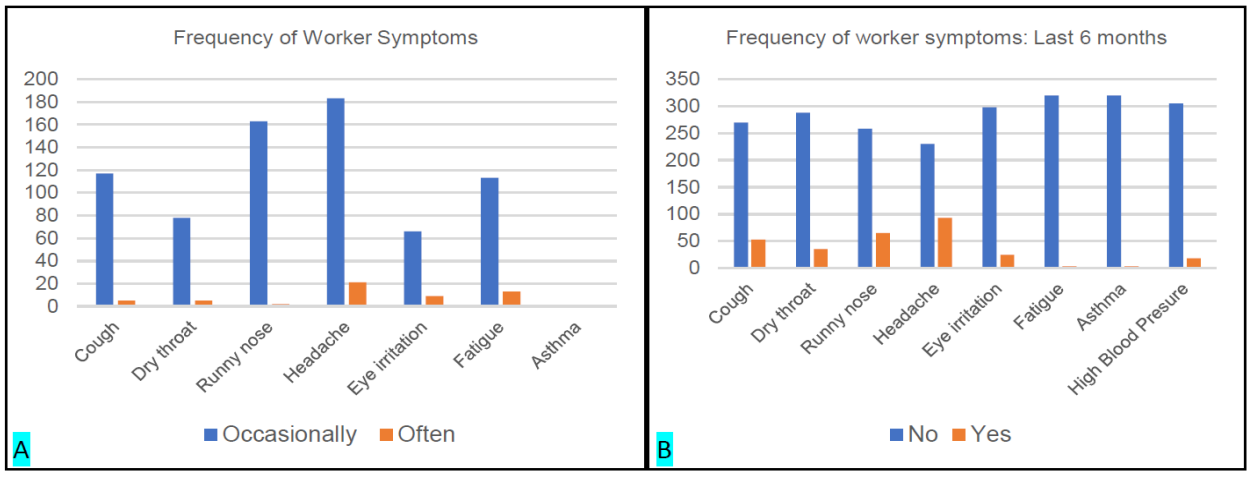

Figure 4.4: The description frequency of symptoms the workers had during they were working at the factory; A is since the beginning until now, and B is for the last 6 months.

The headache symptom may be caused by air pollution, however we cannot conclude that headache is most likely due to poor air quality, as many other things can lead to headache, including tiredness. While we cannot conclude that these symptoms were caused by poor air quality, their incidence can signal that there may be concerns with the air quality that should be addressed. Nutrient deficiency, such as insufficient vitamin D, vitamin B group, Omega-3 also

causes headaches (Shadi et al., 2022). A study in 2016, found that 64.9 percent of women in Cambodia were vitamin D deficient, a high percentage of whom live in rural areas (Geoffry et al., 2016). Therefore, while we cannot conclude that these symptoms were caused exclusive by poor air quality, and other factors can contribute, their incidence can signal that there may be correlations with poor air quality that should be addressed.

Statistically, the frequency of worker's symptoms is related to age. Generally, older workers have more symptoms than younger workers. In fact, about 50 percent of workers aged 45-55 years old experienced all related air pollution symptoms while only 26.94 percent of younger workers (age from 18-25) were experiencing symptoms (table 4.8).

Table 4.8: The percentage frequency of each symptom related to the worker's age ranking.

Age	Number of Interviewee	Cough		Dry throat		Runny nose		Headache		Eye irritation		Fatigue		Asthma		Percentage Mean
		Case	%	Case	%	Case	%	Case	%	Case	%	Case	%	Case	%	
18-25	70	16	22.86	15	21.43	25	35.71	39	55.71	10	14.29	27	38.57	0	0.00	26.94
25-35	158	65	41.14	42	26.58	89	56.33	102	64.56	36	22.78	60	37.97	2	1.27	35.80
35-45	84	35	41.67	22	26.19	46	54.76	55	65.48	22	26.19	31	36.90	0	0.00	35.88
45-55	11	6	54.55	4	36.36	5	45.45	8	72.73	7	63.64	8	72.73	0	0.00	49.35

5. Policy Recommendations

Based on the study findings, several recommendations to reduce air pollution and improve the health of workers in garment industry are identified.

Gender-related recommendations:

- Within garment sector-related policies, explicitly acknowledge the stark gender disparity that characterizes the sector, in particularly the disproportionate representation of young women workers in the garment supply chain.
- Align existing labour policies with relevant international frameworks on gender and labour practices. For example, the key ILO Conventions on gender includes the Equal Renumeration Convention, Discrimination (Employment and Occupation) Convention, Workers with Family Responsibilities Convention, Maternity Protection Convention, and the Violence and Harassment Convention.
- Develop written policies related to gender equality within Cambodia's garment sector, with explicit references to occupational health and safety. Importantly, the policies need to ensure provisions that addresses the specific needs of women workers, including fair pay, safety precautions, maternity-related risks, etc.
- Ensure formalization of garment sector work and guarantee workers' entitlements to health insurance and paid sick leave. Furthermore, acknowledge the gendered dimensions of air pollution impact and implement policies that responds to gender-specific needs, such as maternity-related risks.

- Facilitate social dialogue and awareness amongst garment workers, as supported by relevant labour policies, to encourage workers, especially women, to exercise their rights in the workplace.

Air quality related recommendations

- Strengthen the implementation of existing regulations and programs such as sub decree on control of air pollution and noise disturbance and to maintain conducive working conditions that will affect the health of workers through frequent inspection
- The air quality in a factory will get better if workers are trained and more people know about how air pollution affects their health and the factory's productivity. Raising awareness of air pollution and its health impacts among workers will help them become more aware of air pollution and health protection measurement practices.
- The public and private sectors that works closely with garment sector such as The Ministry of Labor and Vocational Training, Ministry of Industry, Sciences, Technology, and Innovation (MISTI should work cooperatively, ILO, buyers (European, USA market) in order to ensure that all garment industries comply with the required standards.
- WHO can provide more engagement in garment sector in the context of providing and training WHO guideline to government officers and factory’s staff in charging of health protection.

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Annex: Questionnaires for each key informant

A. Questionnaire for Line Ministries

Exposure to harmful air pollution is detrimental to the health effects of the population and the environment. Reducing air pollution is combined approach and actions. In this way of work, crucial and more relevant line ministry such as Ministry of Environment, Ministry of Labor and Vocational Training, Ministry of Industry, Science, Technology & Innovation, Ministry of Mine and Energy are selected for the survey. This section of the survey aims to gather information and data regarding existing policies and activities related to air pollution reduction and improve worker's health in textile industry.

1. Ministry Name	
2. Name of Interviewer	
3. What are the main sources of air pollution in Cambodia?	
4. Which sector emit the most air pollution	
5. Which ministry is involved in air pollution mitigation?	
6. How does the ministry monitor air pollution and impact on labor/workers?	

7. Is it important to develop the policy on protection of worker's health from air pollution in factory? What is the critical factor to enable the successful development and implementation of the policy?
8. What are the existing policies and action programs of your organization regarding air pollution and improvement of health of workers in textile industry?

Policies/Action Programs	Air Pollution Reduction/Environment	Improvement of worker's health

9. Do you feel health of workers is adequately addressed by these policies/programs?
10. What else do you think should be done to minimize the exposure of workers to air pollution?
11. Do you feel manufacturers/employers do enough to minimize air pollution in the workplace?
12. What are the incentives for manufacturers/employers to take action against air pollution?
13. Who is responsible for taking action and promoting factory worker's health against air pollution?
14. Do you think different groups are impacted differently by air pollution in workplace?
15. Are existing policies/interventions sufficient in tackling these differences?
16. Suggests/Recommendation for reduce air pollution/improving workers' health?

B. Questionnaire for Other Stakeholders

Exposure to harmful air pollution is detrimental to the health effects of the population and the environment. Reducing air pollution is combined approach and actions. In this way of work, crucial and more relevant stakeholders such as Garment Manufacturing Association in Cambodia (GMAC), International Labour Organization (ILO), Coalition of Cambodian Apparel Workers' Democratic Union (CCAWDU), and Cambodian Labour Confederation (CLC) are selected for the survey. This section of the survey aims to gather information and data regarding existing policies and activities related to air pollution reduction and worker's health improvement in textile industry.

17. Organization Name	
18. Name of Interviewer	

19. Do you think air pollution is a serious issue in the industry?
20. What are existing policies, action programs of your organization regarding air pollution and improving worker's health worker in textile industry?

Policies/Action Programs	Air Pollution Reduction/Environment	Worker's health and compensation

21. Do you feel health of workers is adequately addressed by these policies/programs?
22. What else do you think should be done to minimize the exposure of workers to air pollution?
23. Do you feel manufacturers/employers do enough to minimize air pollution in the workplace?
24. What incentives exist for employers to take action on air pollution?
25. Whose responsibility is it to take action?
26. What is labour composition in the industry profile?
    - Total workers (Male: Female:)
    - Education:
    - Percentage of worker's age:
    - Different types of contracts (working condition and related benefits) for different worker groups
27. Which labour groups are more exposed to air pollution?
28. Do you think different group are impacted differently by air pollution in the workplace?
29. Are existing policies/interventions sufficient in tackling these differences?
30. Suggests/Recommendation for reduce air pollution/improve health workers?

C. Questionnaire for factory owner/representative in the Textiles Industry

Exposure to harmful air pollution is detrimental to the health effects of the population. In order to assess the levels of air pollution emissions occurring within Cambodia, an emission inventory of air pollutants and greenhouse gases has been developed which has been used in the development of Cambodia's first clean air plan. One major gap in the existing air pollution emission inventory for Cambodia is the textile industry. Air pollution emission inventories for specific sectors are developed through multiplying key activity data, such as specific fuel consumption by fuel type, the number, value and type of products produced by each factory and the total number of factories, by emission factors (normally default data) to estimate total emissions of air pollutants and greenhouse gases from, in this case the textile industry in Cambodia. This section of the survey aims to gather this data in order to better quantify emissions from this source.

31. Factory Name	
32. Name of Interviewer	
33. Sex	
34. Address (UTM)	Address: X: Y:
35. How many employees working in the factory (man/women/ethnic/age range)? Type of work? Working hours/shift? Type of contract?	- Number of workers: - Men: Women: - Ethnic composition: - Age range: - Type of work for men: Women: - Working hours: - Shift: - Overtime available: Yes/No - %man: %women: - Type of contract: full time/part-time/seasonal - % man: % women:
36. What is the size of the factory? How many buildings? How many square meters per building?	- Size of factory: m2 - Number of buildings: - Type of buildings: - A. Production building: size: m2 - Height: Width: Length: - B. Production building: size: m2 - Height: Width: Length: - C. Production building: size: m2 - Height: Width: Length: - Number of workers in production building:
37. What do you think about air quality in different buildings?	A. All the same (good/acceptable/bad) B. Office building is the best (yes/no) C. Production building (good/acceptable/bad) D. Storage/raw material building (bad/acceptable/same)

38. What is the source of air pollution or air quality degradation in factory?	A. Emission from stack of boiler/generators B. Small working building/space and high number of workers C. No install cooling fan or ventilation system D. Mix used space (working and material) F. All above

39. What type and how many products are produced in your factory every month?

Type of product	**Unit (e.g tonnes, m^3)**	**Number of products (per month)**

40. What is the amount of fuel consumed for each product per month?

Type of fuel	**Unit**	**Amount of fuel consumed per month**
Coal		
Charcoal		
Wood		
Electricity		
Gas		
Agricultural or crop waste (animal dung, straw)		
Other (please specify) ……..		

41. Do you have any policies or practices in place to reduce air pollution or enhance air quality in or from your factory? If yes, what are they?

Policies/practices	Yes/No	Remark
Use clean energy (solar)		
Energy saving practices (use energy efficient machinery and appliance, promote energy saving habit)		
Properly managing waste from production (avoiding open waste burning and improper waste disposal		
Install cooling fan/ventilation system		
Properly allocate number of worker and size building		
Properly separate production building/storage or material building		
Other (specify)		

42. Do you have any policies or practices in place to protect your workers from air pollution exposure? If yes, what are they?

Policies/practices	Yes/No	Remark

Properly store chemical and raw material (in storage room avoid expose to workers)		
Properly managing waste from production (avoiding open waste burning and improper waste disposal		
Regularly monitor indoor air quality and emission		
Provide mask/gloves/safety clothes/protective equipment to workers		
Provide knowledge on safety practices/health protection during working in the building		
Other (specify)		

43. Do you feel that exposure to air pollution can have an impact on your workers' productivity? If so, how?
44. How do you monitor worker's health? How's often?
45. What is the common sickness of workers?
46. What is health and social benefit your factory offers to the workers?
47. Is there difference between full-time/part-time workers?

D. Questionnaire for Workers in the Textile Industry

Exposure to air pollution, particularly fine particulate matter ($PM_{2.5}$) is linked to a variety of negative health effects including increased risks of lung cancer, respiratory and cardiovascular diseases and stroke. A large proportion of the global population is exposed to levels of ambient air pollution above the World Health Organizations recommended limit of 5 $\mu g/m^3$. Exposure to air pollution while working (or occupational exposure) is one way in which parts of the population may be exposed to harmful air pollution. This section of the questionnaire aims to understand workers perceptions of their exposure to air pollution both at work and in other areas of their life.

Participant Information

48.	Factory Name	
49.	Sex	A. Male B. Female
50.	Age	A. 18-25 B. 25-35 C. 35-45 D. 45-55 E. 55-65
51.	Ethnicity	A. Khmer B. Muslim C. Christian D. Other
52.	Nationality	A. Cambodian B. Vietnamese C. Chinses D. Other
53.	Education	A. Primary school B. Vocational training C. High school D. Diploma E. Bachelor
54.	Hometown	A. Local resident B. Migrate

55.	What is your monthly income?	A. 100-150 B. 151-200 C. 201-300 E. 301-400 F. >400
56.	How many family members are living in your household?	A. 1-3 B. 4-6 C. 6-8 D.>8
57.	How many dependents are living in your household?	A. 1-3 B. 4-6 C. 6-8 D.>8
58.	How close do you live to your place of work? (Km)	A. <2Km B. 3-5 C. 5-10 D. 10-20 E.>20
59.	How do you travel to your place of work?	A. Walk B. Motorbike C. Car D. Share ride
60.	What is your main role (brief description) in the factory where you work?	
61.	How long have you been doing your role?	A. <1 year B. 1-3 C. 3-5 D. 5-7 E. 7-10 F. >10
62.	How many days a week do you work?	A. <5days B. 6 C.7
63.	How many hours per day do you typically work?	A. 8h B. 8-10 C. >10h
64.	What are benefits do you received from factory beside salary?	A. Food B. Health benefit C. Food + health benefit D. Bonus E. All

Workplace exposure to air pollution and its health effects

65. Do you feel like working in the factory impacts your health? If yes please state how?	A. Yes B. No C. No idea
66. Do you wear personal protective equipment? Masks etc? Is it provided by the employer or do you have to buy it yourself?	A. Yes B. No
67. How do you feel about air quality at your place of work?	A. Good B. Acceptable C. Bad D. No idea
68. What are the main sources of air pollution at the workplace?	A. Oil burn B. Wood burn C. Chemical using D. Too crowded E. Small building F. No fan or ventilation system G. No idea

69. Have you ever had negative health effects from air pollution in your workplace?	A. Yes B. No
70. How do you cope with the negative health effects from workplace air pollution exposure?	A. Wearing protected musk B. Informed team leader C. Do Nothing
71. Are there opportunities to address these issues to management? If yes, has any action been taken by management?	A. Yes B. No
72. Is there any action taken by your management?	A. Yes B. No
73. Do you feel your employer takes adequate care to minimize your exposure to pollutants in the workplace? If yes, what types of measures do they take?	A. Yes B. No
74. Are workers aware of any labour protection law?	A. Yes B. No
75. What they are entitled to?	
76. Do workers have social/health insurance to cover medical costs?	A. Yes B. No

77. Are there any other sources of air pollution which you are exposed to? If yes, please list and rank them in order of highest impact on your personal air pollution exposure

Source e.g. cooking	Location e.g. home

78. Since starting your role have you noticed an increase in any of the following symptoms? List symptoms e.g cough, dry throat, runny nose, headache

Symptoms	Always	Often	Occasionally	Never
Cough				
Dry throat				
Runny nose				

Headache				
Eye irritation				
Fatigue				
Asthma				

79. In the last six months have you had to attend a doctor with any of the following symptoms /conditions? List symptoms/conditions here – e.g asthma, high blood pressure, cough etc.

Symptoms	
Cough	
Dry throat	
Runny nose	
Headache	
Eye irritation	
Fatigue	
Asthma	
High blood pressure	

80. Has anyone in your household been affected by air pollution? If yes, who cares for them?
A. No B. Yes

81. Any suggest to government/factory owner/other stakeholders