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The Greater Accra Metropolitan Areas Air Quality Management Plan

ENVIRONMENTAL PROTECTION AGENCY GHANA

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Executive Summary

Indoor and outdoor pollution are currently the most significant environmental contributors to premature death in Africa, outpacing that of malaria and HIV. Yet for many African government, addressing air pollution is not a pressing concern. According to present knowledge, one in eight of today's global deaths is a result of exposure to air pollution - either (outdoor) ambient air pollution (AAP) or (indoor) household air pollution (WHO (2014a, 2014b), jointly causing around 7 million deaths per year. The estimated economic cost of these deaths is greater than that caused by unsafe sanitation or underweight children. Over 45,000 African children under the age of 5 die annually due to air pollution (2012), which is one of the highest regional child mortality rates in the world. Estimates of the economic cost to Africa of indoor and outdoor air pollution approach $250 billion annually (Roy, 2016).

The growing rural-urban migration and increase in population being experienced in Ghana, is likely to outpace and challenge the already inadequate infrastructure that exists to manage pollution. The cities of Accra and Tema host most of the country's industries, some of which are aged and high emitting. The vehicle fleet of Ghana is also increasing, with the current population of registered vehicles as of February 2017 standing at approximately 2.1 million (DVLA data). The Greater Accra Metropolitan area (GAMA) has the highest number of registered vehicles of about 1.2 million (59% of the national fleet). These activities, including settlement issues, if not addressed holistically could pose serious risk to ambient air quality and public health in the Greater Accra Region

In the Greater Accra Region, EPA Ghana estimates that in 2015, 2,800 lives were lost due to the effects of air pollution. This number is projected to increase to approximately 4,600 by 2030 if no action is taken to reduce current and projected future levels of air pollution. Implementing this air quality management plan, can reduce that number by 430 each year. Additional negative health outcomes associated with air pollution, such as asthma cases and missed school and work days, can be reduced as well.

EPA Ghana developed this comprehensive Air Quality Management Plan (AQMP) for the GAMA and Greater Accra Region as the next step in addressing these problems. This plan complements the National Development Planning Commission that seeks to encourage the Local Government to take up the developmental challenges of their jurisdiction and improve the lives of citizens. Key features of this plan include:

- Baseline air quality characterization and projected emission trends
- Health burden estimates
- Source-specific and ambient air quality standards
- Air quality monitoring network
- Detailed implementation plan

EPA Ghana expects to update this plan again in five years to take advantage of new knowledge, new technologies, and continually work to improve the public health of those who live, work and play in Accra.

1.0 INTRODUCTION

The EPA Act 1994, Act 490 mandates the EPA Ghana to co-manage, protect and enhance the country's environment and seek common solutions to global environmental problems. To achieve this goal, the Agency collaborates with government agencies and other institutions, foreign and multi-national bodies for the purpose of controlling the volume, types, constituents and effects of waste discharges, emissions, deposits or any other source of pollutants and of substances which are hazardous or potentially dangerous to the quality of the environment or a segment of the environment; as well as promote studies, research, surveys and analyses for the improvement and protection of the environment and the maintenance of sound ecological systems in Ghana among other functions.

The Agency has made significant efforts to undertake air pollution control since 1994. Specifically, EPA Ghana has implemented a number of programmes aimed at prevention, control and management of air emissions from the transport, mining, energy and manufacturing sectors as well as from the built environment (including indoor air pollution). The Agency has developed and maintained an active industrial air emissions source permitting and inspection programme nationwide; and has sought international partnerships through a host of United Nations organizations and World Bank funding opportunities.

Efforts to monitor and manage air pollution emissions, both prior and ongoing, have been successful, but significant gaps remain and further progress is expected. To bridge these gaps, EPA Ghana has developed this draft Air Quality Management Plan (AQMP) that covers both the Greater Accra Metropolitan Area (GAMA) and, more broadly the Greater Accra Region (GAR; see Map in Figure 1 below), with the goal of clarifying and analyzing a series of new steps that the Agency is proposing to further reduce emissions from vehicles, electric generating units, industrial and other anthropogenic sources among others. The ultimate goal of the plan is to reduce the concentration of hazardous particulate matter (PM) and other air pollutants in the Greater Accra region. This first AQMP has been developed by EPA Ghana in collaboration with the United States Environmental Protection Agency (USEPA) to take advantage of USEPA's significant and broad experience in air quality management. Prior collaborations with USEPA have provided significant contributions toward the development of an air quality monitoring system for the Accra Metropolitan Area, which has since been expanded and continues to function and provides valuable data to characterize current conditions with respect to ambient particulate matter (PM).

Ghana's first AQMP focuses on the Greater Accra region for three reasons:

- Current conditions, as characterized by roughly 10 years of PM data from air quality monitor readings, present an unacceptable health burden for the population of Accra, and are not in line with international standards for air quality.
- The health burden of high PM concentrations has clear economic implications for GAMA, limiting healthy time that could be available for working or schooling, and presenting a direct social and economic cost for respiratory health treatments.

- Without action, economic growth could lead to higher emissions in the vehicle and industrial sectors, in particular, which will worsen air quality over time.

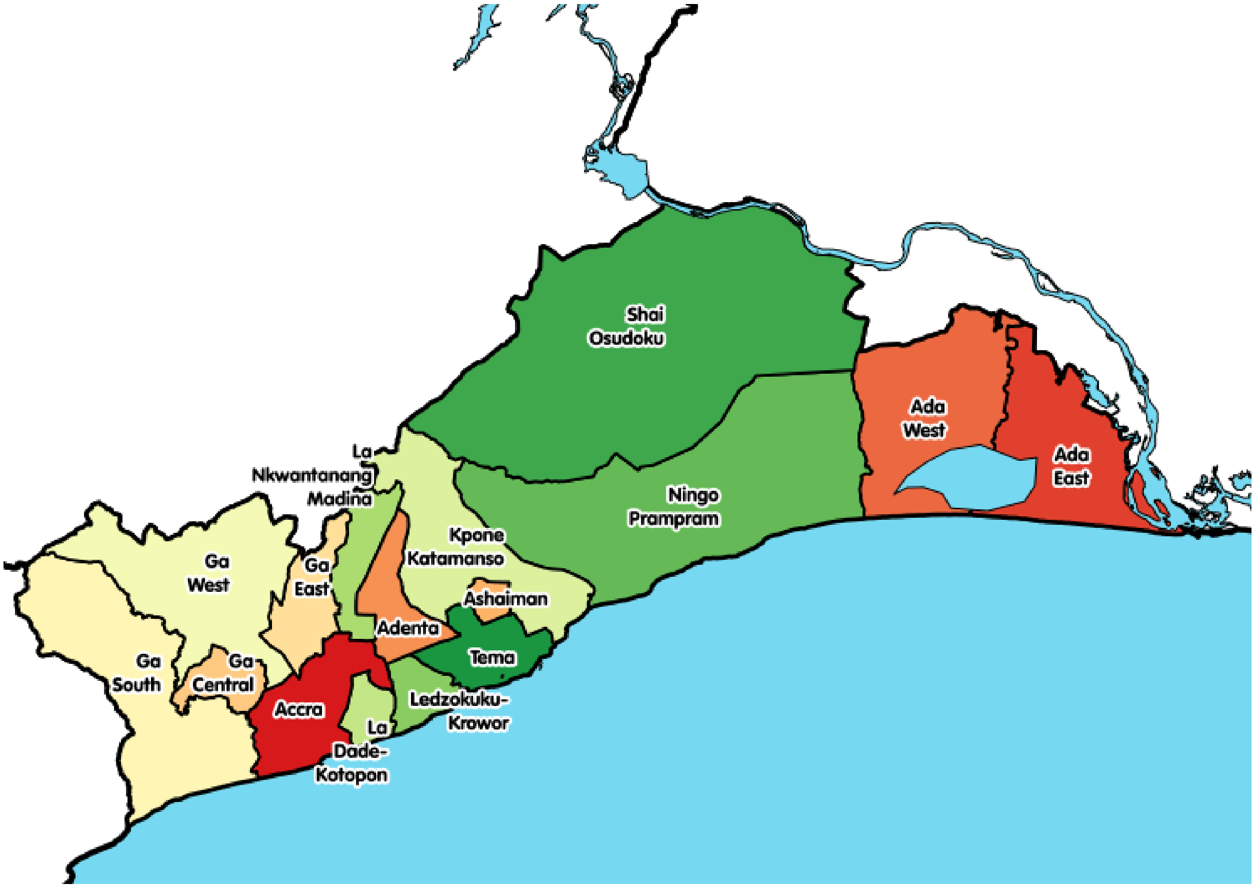


Figure 1: Map of Greater Accra Region

Figure 1: Goal 5: Knowledge And Understanding Amongst Decision-Makers, Stakeholders, And The General Public In The Greater Accra Region Is Enhanced

Note: Accra Metropolitan District is show in red at lower left. The Greater Accra Metropolitan Area (GAMA) is contained within the Greater Accra Region, and includes the Accra Metropolitan Authority districts (Accra and La Dade-Kotopon), the four Ga Districts, and the Tema Districts (Tema, Ashaiman, Adenta, and Ledzokuku-Krowor). GAMA excludes the five easternmost districts shown in the map, but those districts are part of the Greater Accra Region and are considered within the scope of this Air Quality Management Plan.

2.0 AQMP DEVELOPMENT PROCESS

2.1 Proposed Source-Specific and Ambient Air Quality Standards

One of the main functions of the EPA Ghana is to prescribe standards and guidelines with respect to the pollution of air, water, land, vehicular emissions and any other forms of environmental pollution, including the discharge of waste and the control of toxic substances.

To achieve this function, the EPA Ghana in 2007 initiated the process of drafting air quality standards for the country. A series of meetings were held and relevant stakeholders involved in the initial and final drafting of the standards (see list of stakeholders involved in 2.2 (1 & 2).

The main goal of the Air Quality Standards development was to review the existing ambient and point source air quality guidelines into enforceable standards in line with the statutory functions of the Agency. The development of the air quality standards will provide the following benefits:

(i) Comparison of ambient air-quality levels with standards and the objectives,

(ii) Assessment of the effectiveness of control measures

(iii) adequate public health-based benchmarks for key air pollution indicators, and this will include the Sustainable Development Goal 3 (SDG-3), target 3.9 (on substantial reduction on the number of deaths and illnesses from air, hazardous chemicals, water and soil pollution (contamination) indicators that could inform the health trends associated with exposure to air pollution (ie. to ensure healthy lives and promote well-being for all and at all ages).

(iv) encourage the Government of Ghana to take cross-sectorial action to improve air quality and to formulate action plans while establishing (and implementing) nationally determined air quality and emissions standards, taking into account all available relevant information (from WHO, IFC, World Bank USEPA, among others);

(v) Encourage relevant actors to share results and experiences of their efforts and make air quality data more easily accessible and understandable to the public and request the actors to undertake several supportive activities.

The development of emission and ambient air quality standards involved the use of existing and newly collected Ghana data, information from other countries, comparing and adoption of standards from both developed and undeveloped countries and some research findings.

In all, eighteen (18) existing ambient air quality parameters were reviewed and will be refined, while the ten (10) parameters of the point/stationary source air emission guidelines were also converted into fuel-type/energy used standards (namely, Solid, Liquid and gaseous fuels, electrical energy and incinerators) . Based on the current fuel quality and vehicle emission data, Motor Vehicle Emission standards have been proposed for Ghana at the national level (see Appendix A). The draft standards have been sent to the Ghana Standards Authority (GSA) for development and gazette. The draft regulations required to back the standards has been developed and submitted to the drafting section of the Attorney General's

Department. It is expected that work on the Air Quality Standards development and Regulations will be accomplished in 2018 and implemented in 2019.

2.2 Stakeholder Engagement in the AQMP Development Process

1. Prior to the development of the Air Quality monitoring programme, the EPA Ghana in collaboration with USEPA and USAID built and established local capacity in air quality monitoring and data analysis in 2005. The output of this, provided policy makers with a 'snapshot' of the air quality in Accra and formed a basis to further develop an air quality management strategy for Ghana.

   The first stakeholder committee was constituted in 2007, to review the existing air quality guidelines (into standards and regulations). The stakeholders comprised of the following:

   - EPA Ghana,
   - Ghana Health Services,
   - KITE,
   - DVLA,
   - Ghana Meteorological Agency,
   - MESTI,
   - Accra Metropolitan Assembly,
   - Council for Scientific and Industrial Research (CSIR),
   - Tema Oil Refinery,
   - Ghana Police Service,
   - Earth Service (NGO),
   - Friends of the Earth (NGO),
   - ITDP/CCE,
   - Ghana News Agency,
   - Attorney General Department,
   - University of Ghana,
   - Enterprise-Works Ghana,
   - Ministry of Roads and Transport and
   - Ghana Atomic Energy Commission (GAEC).

   As a follow-up to the earlier stakeholder engagement, EPA Ghana developed draft air quality standards for the consideration by the Ghana Standards Authority (GSA). Consequently, a National Technical Committee was constituted including experts from

   - GSA,
   - EPA Ghana,
   - Ministry of Environment, Science, Technology and Innovations (MESTI),
   - Ghana Atomic Energy Commission,
   - University of Ghana (School of Public Health and Institute of Environmental and Sanitation Studies),

- Envaserv Consult,
- National Petroleum Authority and
- Accra Metropolitan Authority (AMA).

The developed Draft National Air Quality Standards are currently undergoing review by a broader National stakeholder group drawn from the Academia/Research, Industry, Power producers, Policy makers (MESTI, Ministry of Transport), Local Government and Consultants among others.

2. The USEPA supported the EPA Ghana to build capacity in Air Quality Monitoring in Accra. Following the progress made in Ghana towards improved air quality monitoring and reporting, laboratory development, and identification of air quality mitigation options for implementation, the Climate and Clean Air Coalition and the USEPA in collaboration with EPA Ghana under the Megacity Partnership Project for Africa, organized a two-day training workshop on Air Quality Management Planning and SNAP/Short-Lived Climate Pollutant (SLCP) National Planning for both local and foreign stakeholders between 20 and 27 April 2016 in Accra. The stakeholders were trained in the application of relevant tools (BenMap) and chemical analysis (to stimulate actions that will address air pollution in the Greater Accra metropolitan area); and developed communication and public participation plans for air quality management in GAMA.

As a follow-up to this, a core team comprising of staff from EPA and Ghana Health Services were trained on communication planning and drafted the AQMP and communication plan, in November 2016.
The following stakeholders involved at various stages of the preparatory work and the drafting of the AQMP include:

- EPA,
- Ghana Health Services,
- Ministry of Environment, Science Technology and Innovation,
- Space Science Systems Research Institute,
- Accra Metropolitan Assembly,
- Driver Vehicle Licensing Authority,
- National Petroleum Authority,
- Ghana Meteorological Agency (GMA),
- Ghana Atomic Energy Commission,
- Global Alliance for Clean Cookstoves (Ghana) and
- USEPA.

Finally, in preparation for execution of the AQMP, extensive training was conducted in collaboration with USEPA and the University of Ghana to further standardize laboratory techniques for analysis of air quality monitor filters, enhance the function of laboratory equipment at EPA Ghana, and to improve the capabilities of EPA Ghana to conduct laboratory analyses that will be needed to conduct local source apportionment work. Most recently, a small network of air pollution sensors was deployed to provide additional monitoring information to EPA Ghana. These actions will improve EPA Ghana’s ability to monitor pollution levels in GAR, and to eventually perform an evaluation of the effectiveness of pollution control actions to be taken over the life of the plan on ambient air pollution.

2.3 Status of the GAMA Air Quality Network

The EPA Ghana operates an air quality monitoring network that collects PM_{10} and limited $PM_{2.5}$ data from up to fifteen locations throughout the city of Accra and its environs. EPA Ghana has also conducted several focused studies in the past fifteen years that aimed to measure air pollution in specific geographic locations, or that originated from specific sources. Additionally, several academic studies have collected and analyzed air quality data in Accra. When examined together, these data collection and analysis efforts provide support for the initiation of the AQMP. A summary of data collection efforts, by both EPA Ghana and outside researchers is presented in Table 1 below. This figure displays the monitoring efforts by year, pollutant, and program. Blue boxes represent coverage of the specified pollutant in the specified year by EPA Ghana monitoring efforts. Green boxes represent monitoring efforts by academic researchers studying air pollution in Accra.

Consistent air quality monitoring and data collection by the EPA Ghana over time is the most reliable source of long term trends in air quality. EPA Ghana has faced many challenges in collecting this data including funding gaps and malfunctioning or stolen equipment, but the existing monitoring network has been in use, with some disruption, since 1997.

In 1997, EPA Ghana partnered with the World Bank to monitor several air quality indicators, including sulfur dioxide, carbon monoxide, black carbon, PM_{10}, and total suspended particulate matter. This program came to an end in 2001. In 2004, USAID, USEPA, and EPA Ghana began an Air Quality Management Capacity Building Programme. This programme involved installing air quality monitors at residential, commercial, industrial, and roadside locations throughout Accra, and focused on particulate matter air pollution. The programme has also included some monitoring of other pollutants including sulfur dioxide, ozone, carbon monoxide, lead, manganese, and nitrogen dioxide.

Table 1: History of Air Quality Monitoring Efforts in Ghana and Accra

YEAR	ORGANIZATION / SPONSORSHIP		SO2	O3	CO	BC	MN	PB	NO2	NO3	PM10	PM2.5	TSP	OTHER*	LOCATION	
1997	World Bank, EPA Ghana: AQM Program		■		■	■					■		■		Accra ,Tema, Takoradi, Kumasi and Tarkwa	
1998			■		■	■					■		■			
1999			■		■	■					■		■			
2000			■		■	■					■		■			
2001			■		■	■					■		■			
2002	EPA Ghana: Lead Phase-out Baseline Monitoring							■							Accra, roadside locations	
2003								■								
2004	USAID, UNEP, USEPA, EPA Ghana: AQM Capacity Building Program		■	■	■		■	■		■	■					A growing number of monitoring sites in Accra: Residential East Legon Dansoman Asylum Down Industrial North Industrial Area South Industrial Area Commercial Odorkor Roadside Kaneshie First Light Tetteh Quarshie Labadi Road Achimota (2006) Mallam (August 2008) Graphic Road (2009), Weija,Kasoa (2013), Tantra Hill and Amasaman (October 2015)
2005			■	■	■		■	■		■	■					
		EPA Ghana Indoor AQ Monitoring			■										Accra, five residences	
2006			■	■	■		■	■		■	■					
		Outside Research: Arku et al.	▲						▲		▲	▲			Jamestown/Ussher town and Nima	
2007			■	■	■		■	■		■	■					
		Outside Research: Dionisio et al.									▲	▲			Jamestown/Usshertown, Nima, Asylum Down, East Legon	
		Outside Research: Zhou et al.				▲	▲	▲			▲	▲				
2008			■	■	■		■	■		■	■					
		Outside Research: Zhou et al.				▲	▲	▲			▲	▲		▲	Jamestown/Ussher town, Nima, Asylum Down, East Legon	
2009			■	■	■		■	■		■	■					
2010			■	■	■		■	■		■	■					
2011			■	■	■		■	■		■	■					
2012			■	■	■		■	■		■	■					
2013			■	■	■		■	■		■	■					
2014			■	■	■		■	■		■	■					
2008-2015		Urban Transport Program	■	■	■				■		■	■			Accra, five major traffic route roadside locations	

* Other elements monitored are sodium (Na), magnesium (Mg), aluminum (Al), silicon, (Si), sulfur (S), chlorine (Cl), potassium (K), calcium (Ca), titanium (Ti), vanadium (V), chromium (Cr), nickel (Ni), iron (Fe), copper (Cu), zinc (Zn), and bromine (Br) and Manganese (Mn).

■ International Partnership project for comprehensive monitoring

▲ Outside academic research

EPA Ghana has ten (10) air monitoring stations from its earlier partnership with the US EPA and USAID. These include ten permanent sites with three monitors in residential areas, two in industrial areas, one in a commercial area, and four at roadside sites. Since 2006, EPA Ghana has augmented the monitoring network with up to six additional roadside monitoring locations bringing the total number of possible monitor locations to sixteen (16), but one of these monitoring locations (Asylum Down) is currently closed. These additional locations were selected as part of the Urban Transport Programme, under which Bus Rapid Transit (BRT) systems are being developed across Accra, but are not currently operational. Figure 2 shows the locations of historical, proposed and current monitoring sites.

Ghana's air monitoring site selection criteria is based on urban scale best practices (4km apart). EPA Ghana has developed a proposal for additional monitoring sites (in yellow in Figure 2 below). The proposed sites are meant to fulfil the criteria and also monitor a new corridor to the North-Eastern end of Accra and Tema where there are no monitoring stations. The maps show coverage throughout the Greater Accra area, with concentrations in both Accra and Tema.

Additionally, in August 2018, EPA Ghana deployed a low-cost PM air sensor network in Accra. This network will complement the Ghana EPA's existing network of air quality monitors and enhance local air quality management capacity by enabling the Ghana EPA to measure continuous PM2.5 and characterize PM2.5 spatial variability in Accra. As a result of this work, Ghana EPA will be able to integrate an advanced data system into their air quality monitoring and management practices and communicate timely air quality information to the public.

Figure 2. Proposed, Existing, and Historical Air Monitoring Sites (As of May 2015)

Figure 2: Goal 5: Knowledge And Understanding Amongst Decision-Makers, Stakeholders, And The General Public In The Greater Accra Region Is Enhanced

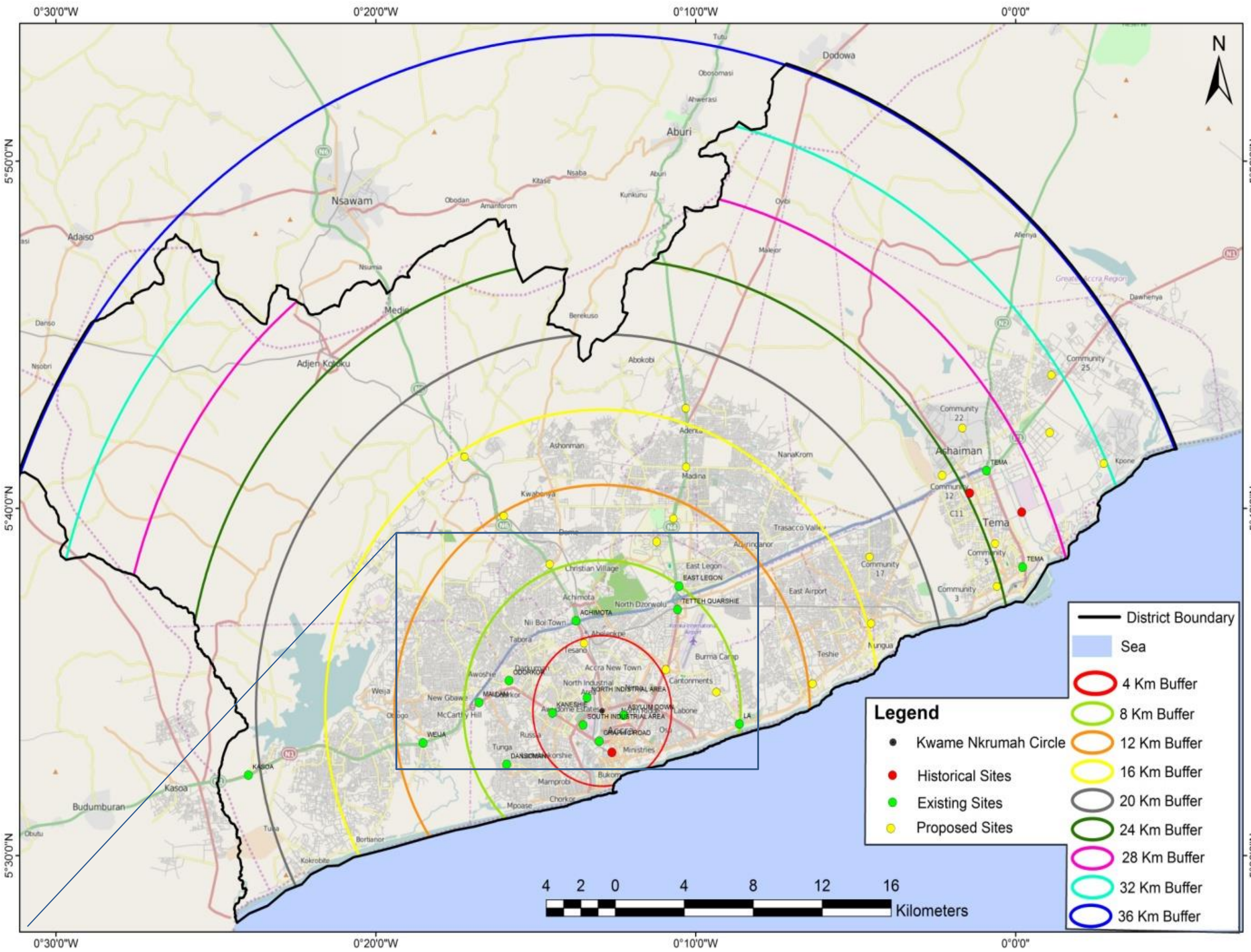
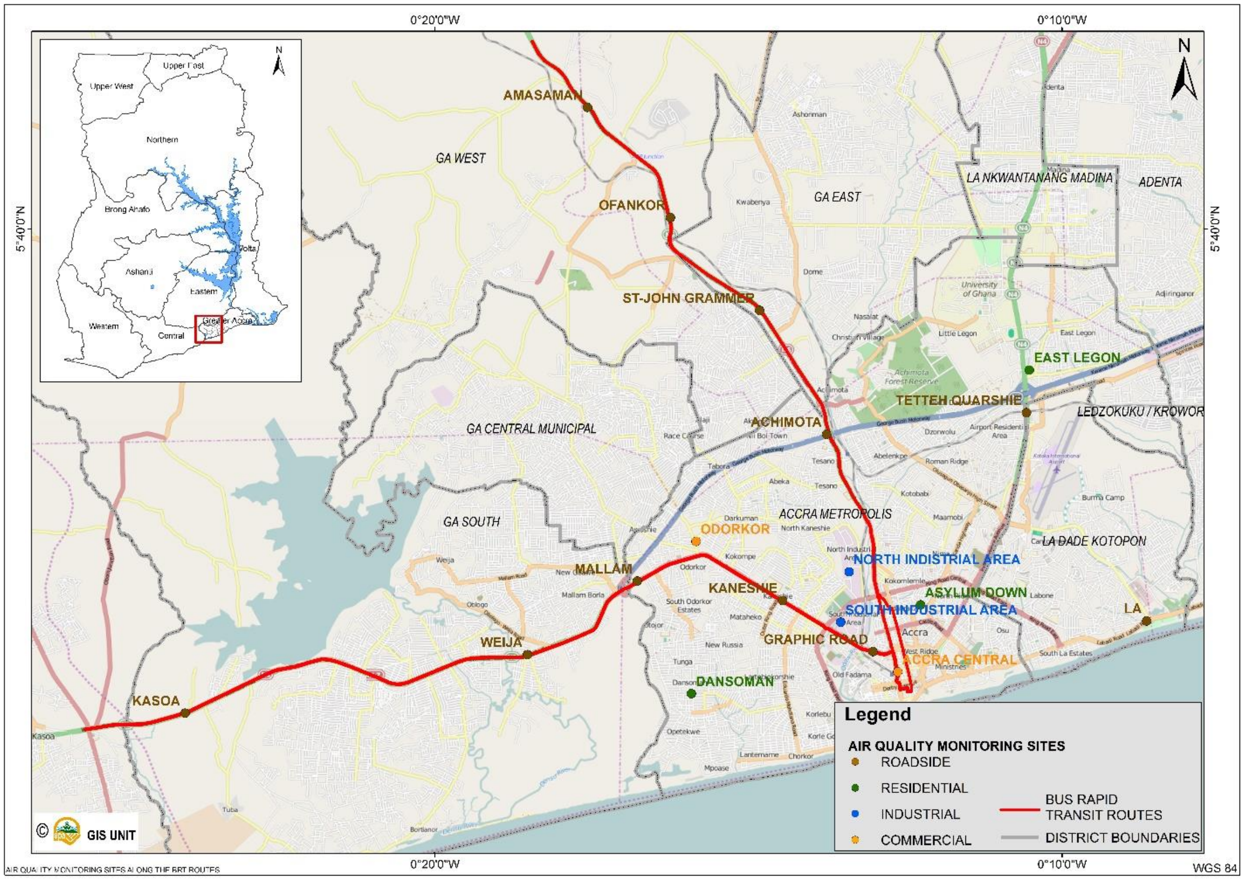


Figure 3: Air Quality Monitoring Sites by Land Use Category (As of May 2015)ity Monitoring Sites by Land Use Category (As of May 2015)



2.4 AQMP Development: Analytic Steps

This AQMP has been developed through a process of collaboration and consultation with stakeholders in industry and government and support from USEPA. The process included the following steps:

1. ***Development of emissions and ambient standards***. For many years, the EPA Ghana has implemented and enforced industrial emissions guidelines through the source permitting process, and vehicular emissions and fuel quality standards (in collaboration with DVLA and the National Petroleum Authority) through controls on fuel content (i.e., Sulphur content), the gradual evolution of the vehicle fleet to more clean-running models, and a vehicle inspection process that for enforcement purposes has focused on vehicle safety and roadworthiness. The inspection process does provide an opportunity for emissions testing as part of the vehicle registration and annual renewal of road worthy certificate process. The draft Air Quality and motor vehicle emission standards that would carry the force of law was submitted to GSA for review and gazette, in September 2016. The vehicular and industry emissions standards will provide the backbone of the AQMP implementation – they are summarized in Appendix A.

2. ***Analysis of emissions source contributions.*** Existing studies of the contribution of particulate matter emission categories provide a basis for focusing the plan on vehicle and industry among others sources. These data are summarized in Sections 3.1 and 3.2 of the plan.
3. ***Evaluation of AQ monitoring data.*** As described above, data on ambient concentrations of particulate matter has been collected for many years; these data provide a characterization of the baseline conditions present at the outset of the plan. The data for 2015, which is used as the baseline year for the AQMP, are summarized in Section 3.3 of this plan document.
4. ***Estimation of current and projected future health burden of air quality on GAMA's population.*** With the assistance of USEPA and application of the BenMAP tool for air quality health effects estimation, the health burden of air quality has been assessed for GAMA and GAR. The results are summarized in Section 3.4 of the plan.
5. ***Establishment of goals and objectives for the plan.*** The EPA Ghana has used the information from steps 1 through 4 to develop clear goals and objectives to be pursued to ensure that particulate matter concentrations are reduced over the ten-year time-frame of the plan. These are proposed in Section 5 of the plan.
6. ***Development of a detailed implementation plan.*** Achieving the goals and objectives of the plan requires a detailed implementation plan – this is proposed in Section 6 of this plan and will be continuously updated through stakeholder engagements and as part of the ongoing monitoring and evaluation of the plan's effectiveness, which is outlined in Section 7.

3.0 SUMMARY OF THE AIR QUALITY BASELINE CHARACTERIZATION

The air quality baseline reflects current emission sources and their expected trends for the foreseeable future, as well as current and projected future air quality, which also has implications on public health. The baseline characterization further includes the state of air quality and EPA's capacity for air quality monitoring in the GAMA and GAR area.

3.1 Emission sources

Air pollution in the Greater Accra Region is generated by a diverse set of sources including point sources (e.g. industrial sites), mobile sources (vehicles), and area sources, both from naturally occurring (Harmattan wind-blown dusts and sea salt) and man-made (cook stoves and open burning of wastes) sources. Some of these sources are common among developing cities in Africa, while others are specific to Accra or the West African coast. Also, certain challenges faced by the Agency in the implementation of guidelines and monitoring of air quality are not unique to Ghana.

Air pollution in Accra is influenced by both the meteorological and demographic characteristics of the city. Accra is located on the Atlantic coast of Ghana in West Africa, south of the Sahara. The climate is defined by a fairly constant temperature (22-33^{0}C) and two rainy seasons, occurring in April-June and September-Mid-November. After the second rainy season, from December to March, the Harmattan Winds (North-eastern trade winds) bring dry air from the Sahara to the country, including to the Greater Accra area. These winds affect air pollution by carrying dust particles of crustal and also rural area wildfire origin into the city of Accra. Additionally, the predominant wind direction in Accra and its environs (south-east) could potentially bring polluted air from the industrial areas in Accra to Tema.

The population of Accra increased from 1.7 million in 2000 to 2.1 million (out of the 4 million recorded for the Greater Accra Region) in 2010 (Ghana Statistical Service (GSS) 2012). Accra Metropolis is one out of the sixteen districts in Greater Accra Metropolitan Areas (GAMA). Almost half of all households in Greater Accra use charcoal (45.4 percent) or wood (3.5 percent) as their main cooking fuel (GSS, 2012). Accra also faces challenges due to high population density, urban slums and significant traffic problems. Air pollution issues related to vehicle emissions and cook stoves are likely to become increasingly significant as the population and housing density continues to grow in a limited land space. While the growth of electricity access in Ghana is an important indicator of economic development, and reflects an opportunity to centralize emissions at larger electric generation stations, the increase in access to electricity may also signal the need to control emissions at these power generation facilities, as well as regulate the increased use of diesel generators in residential and industrial settings. The potential for hydropower to meet the increasing electricity demand in Greater Accra has largely been exhausted, so meeting a mostly growing electric energy demand requires a combination of measures including increased deployment of fossil fuel based generation (which implies increased emissions), and/or new deployment of renewable power generation and improvement of energy use efficiency.

As part of the DANIDA Transport Sector Programme Support implemented in 2006, an inventory of the status of vehicle emissions, particularly in Accra, Kumasi and Takoradi was conducted. The outcome of the inventory influenced policy on annual vehicle emissions testing by DVLA. In 2011, the Driver and Vehicle Licensing Authority (DVLA) started a pilot programme to include emissions testing in the annual road worthiness certification test, on advisory note. The DVLA is waiting for the EPA to develop vehicular emission standards to help regularize the emission testing programme in Ghana.

The World Bank funded the Urban Transport Project which started in 2007, and was aimed at further reducing vehicular emissions through traffic engineering improvements, regulation of public transportation, and implementation of a Bus Rapid Transit (BRT) system in selected road networks in Accra. Currently, the proposed BRT buses (now called quality bus system) are running on one of the four selected road routes (Accra Central Business District to Amasaman). This will very soon be extended to the Adenta Route. Roadside air quality monitoring has also been an important part of the transport sector plans, which will be discussed in the following section of this plan.

Following a successful campaign to eliminate lead from gasoline, EPA Ghana has been working with the National Petroleum Authority (NPA) and the Ghana Standards Authority to reduce the sulfur content in fuels. In January 2014, the national specifications for maximum sulfur content in diesel was reduced from 5000 parts per million (ppm) to 3000 ppm. Along with Nigeria and other members of the Economic Community of West African States (ECOWAS), Ghana was to meet the Afri-4 fuel specification of 50 ppm maximum or lower by 2020 (Abidjan Agreement, 2009; ECOWAS Communique, 2016). Ghana has since 2017 published and implementing a new sulphur standards of 50ppm in fuel. As was the case with the elimination of lead in gasoline, lower sulfur in fuels will improve fuel economy, engine performance and durability, and at the same time improve roadside air quality and public health.

Most of the progress in the transport sector has been driven by the initiatives of EPA Ghana and her partners, but for other issues, such as household cooking fuel, opportunities to improve air quality may be driven by Ghana Energy Commission, Non-Governmental Organizations (NGOs), researchers and other third party funders. An example of this is the replacement of traditional wood stoves with more efficient and lower emitting Liquefied Petroleum Gas stoves and more efficient biomass stoves (Gyapa cook stoves, etc.) in households in Accra and beyond. The Ghanaian government (Ghana Energy Commission) together with the Global Alliance for Clean Cookstoves and the Ghana Alliance for Clean Cook stoves (GHACCO), is aiming to provide 50 percent of Ghana's population with access to clean cooking solutions by 2020. This effort involves funding for development and testing of new improved cook stove technologies and transitioning to LPG stoves, as well as information campaigns designed to raise awareness of the health risks of indoor air pollution from traditional cook stoves and empowerment of women and children, who experience the highest levels of exposure, to be advocates for clean cook stoves in their communities (Global Alliance for Clean Cookstoves, 2015b).

Ghana's commitment to pursue sustainable development is not in doubt. The country has firmly demonstrated in many respects that environment is central to its development planning. Environmental sustainability is being mainstreamed into development, with a resultant positive spin-off of cumulative benefits from different initiatives on climate change, green economy and sustainable development.

In this regards, Ghana has been successfully engaging in international conventions and seeking out opportunities for collaboration. Ghana has been an early adopter of numerous international agreements and conventions focused on air quality management. In 2012, Ghana became a founding member of the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC), a program within the United Nations Environmental Programme. Through this group, Ghana has hosted and attended several international workshops that promotes awareness on SLCPs including black carbon, a large contributor to particulate matter in Accra, and bringing together government officials to share effective management techniques.

Ghana was the first developing country to join Sustainable Energy for All (SE4ALL), a UN sponsored global initiative aiming for universal sustainable energy use by 2030 (International Energy Agency (IEA) and the World Bank, 2015). The Parliament of Ghana passed the Renewable Energy Act of 2011 (Act 832) intended to be included in the electricity generation mix, and which provides fiscal incentives including a feed-in-tariff among other measures to guarantee the necessary legal and fiscal incentives to ensure returns on the investment.

Increasing the share of renewable energy is becoming more important as expanding access to electricity to all households in Ghana is also a priority issue. Between 1990 and 2012, the percentage of the population with access to electricity more than doubled, and the percentage of the population with access to non-solid cooking fuel has increased even more dramatically as seen in Table 2. The new fuel use patterns are more efficient than traditional biomass sources, and because they burn more completely, they produce less black carbon and particulate matter.

Table 2: Growth of access to electricity in Ghana, 1990-2012

PERCENT OF GHANAIAN POPULATION WITH:	TOTAL				RURAL	URBAN
	1990	2000	2010	2012	2012	2012
Access to electricity[1]	31%	45%	61%	64%	41%	85%
Access to non-solid fuel[2]	2%	8%	15%	17%	4%	29%

[1] Data are from the WHO Global Health Observatory at http://apps.who.int/gho/data/node.main.134?lang=en (accessed 15 January 2015).
[2] Data are from UNICEF Multiple Indicators Cluster Survey (MICS 2010).
Source: International Energy Agency (IEA) and the World Bank 2015

3.2 Expected emission trends

The Government of Ghana under the Strengthening National Action Plan (SNAP, 2013), projects that total black carbon emissions from transport sources throughout the country are expected to increase by up to 9-fold. While the growth of emissions specifically in Accra may diverge from the country-wide projection, it is reasonable to expect that mobile source activity (vehicle miles traveled - VMT) will increase in Accra across all vehicle classes. Estimates in the SNAP suggest that shifts to BRT and changes in emissions factors, as the fleet turns over and new generations of cars are imported, could provide some counterbalance to these trends, but that counterbalance may not be significant without further interventions to reduce emissions from the sector. Currently, about 96 percent of total emissions for passenger vehicles is emitted from vehicle stock manufactured prior to 1996 (Government of Ghana 2013).

In addition, it is not clear whether the planned sharp curtailment of sulfur content in fuels will be sufficient to counterbalance increases in fuel usage in Accra in the future. As a result, it is not clear whether mobile source sulfur dioxide emissions may show a net increase or net decrease.

Trends in point source emissions are less well documented. Activity at the Tema Oil Refinery, for example, appears to have fluctuated over the past decade, and there is some indication that modernization and new investment may accompany the new limits on sulfur in gasoline (ie. 50ppm maximum sulphur levels). If so, emissions reductions may be a co-benefit.

It is also reasonable to expect that the baseline of emissions from household sources will continue to increase, as population increases, if they remain uncontrolled and efforts to transition to LPG or other non-solid fuel sources are not successful.

3.3 Ambient air quality

Data collected from sites in the EPA Ghana air quality monitoring network show high levels of PM_{10} across monitoring locations. In 2014, monitor readings at roadside locations showed concentrations well above the previously established PM_{10} guidelines set by both EPA Ghana (70µg /m^3) and the World Health Organization (WHO) (50µg/m^3, 24-hr mean). Very few readings met the guidelines. Many readings showed concentrations over 200µg /m^3 for the 24-hr mean, and several readings exceeded 800µg /m^3. Concentrations at monitoring sites away from major roads met EPA guidelines more often than the roadside locations, however many readings still exceeded both guidelines, especially in December (perhaps due to Harmattan wind- blown dust). Elemental and gaseous concentrations (Pb, Mn, SO_2, NO_2, and O_3) were generally lower than EPA Ghana/WHO guidelines. To estimate $PM_{2.5}$ concentrations based on EPA -monitored PM_{10} concentrations in the Greater Accra region, we calculated the relationship between PM_{10} and $PM_{2.5}$ concentrations at co-located sites from an academic study (Dionisio et al., 2010) ($PM_{2.5} = 0.61*PM_{10}$), and applied that relationship to monitored PM_{10} concentrations. These estimated annual average $PM_{2.5}$ concentrations for 2015 are shown in Table 3.

Table 3: Estimated annual average PM2.5 concentrations in 2015 at EPA Ghana monitor sites

SITE NAME	CATEGORY	ESTIMATED $PM_{2.5}$ CONCENTRATION ($\mu g/m^3$)
Tetteh Quarshie Interchange	Roadside	101.6
Achimota Interchange	Roadside	89.0
Odorkor	Stationary	65.3
South Industrial Area	Stationary	50.3
North Industrial Area	Stationary	56.5
Labadi T-Junction	Roadside	196.8
Dansoman	Stationary	69.4
Mallam Junction	Roadside	101.1
Graphic Communication Group of Companies	Roadside	86.6
Weija	Roadside	125.7
Kasoa	Roadside	110.3

EPA Ghana also reports air pollution levels through an Air Quality Index (AQI) which communicates health risk based on the concentration of monitored pollutants – the suite of monitored pollutants that is comprehensively measured is currently limited to particulate matter. Roadside conditions tend to perform the worst under this AQI measure, with over a quarter of measurements signifying unhealthy conditions for the majority of the population. Table 4 reports air quality index measurements in Accra between 2013 and 2014. Note that residential readings refer to ambient air conditions in residential neighborhoods, not indoor air quality.

Table 4: Air Quality Index Results by Monitor Location updated to 2016

		ROADSIDE		RESIDENTIAL		COMMERCIAL		INDUSTRIAL	
		N[1]	%[2]	N	%	N	%	N	%
0-50	Good	31	9%	10	48%	5	19%	11	23%
51-100	Moderate	116	34%	9	43%	15	56%	26	55%
101-150	Unhealthy for Sensitive Groups	100	30%	2	10%	6	22%	6	13%
151-200	Unhealthy	55	16%	0	0%	1	4%	0	0%
201-300	Very Unhealthy	23	7%	0	0%	0	0%	2	4%
301-500	Hazardous	13	4%	0	0%	0	0%	2	4%
	Unhealthy or above		27%		0%		4%		9%

[1] Number of monitor readings
[2] Percentage of total reading per location
Source: EPA Ghana Presentation to the World Bank, July 2014

In addition to the EPA Ghana monitoring, a group of researchers has conducted a series of studies on air pollution in Accra which have relied on primary air quality data collection. The data collected as part of this research provides important information on localized air pollution conditions. Additionally, the research teams have used a variety of methods to assign likely sources to the detected pollution. The first study in the series by Arku et al. (2008) collected three weeks of data in June and July of 2006 in two low-income neighborhoods of Accra. A model of PM concentration levels based on monitoring site characteristics (i.e. proximity of biomass stoves and main roads, traffic conditions, road surface, temperature and humidity, and time of day) suggests that biomass combustion plays an important role in air quality. Arku et al. recommended further research on the distribution of sources between and within neighborhoods and across time of day, as well as a more detailed analysis of the particle composition.

The next study in the series (Dionisio et al. 2010) followed up on the earlier study by examining within-neighborhood patterns with stationary and mobile data collected over three months in 2007, across four neighborhoods of Accra. Potential sources of PM were identified based on a visual survey at several data collection points each sampled day. The study found a strong positive relationship between wood and charcoal stoves, congested and heavy traffic, and trash burning and local particulate matter pollution. Rooney et al. (2012) use the same monitoring data as Dionisio et al. (2010) along with geographic information on the location of wood and charcoal stoves, and other large PM sources, along the mobile data collection route, as well as Census data on other household fuel use and trash burning habits. The authors of this study concluded that the density of wood stoves, fish smoking, and trash burning is related to higher levels of $PM_{2.5}$, and road capacity and road surfaces were related to PM_{10} levels.

The most recent study in this series (Zhou et al. 2013) collected monitoring data in the same four neighborhoods for one year, beginning in September 2007. This study includes an in depth analysis of the chemical composition of the particulate matter, as suggested in Arku et al. (2008), to estimate the contribution of various sources to the total particulate matter. The results, broken down by source, are presented by neighborhood in non-Harmattan months, and aggregated for Harmattan months.

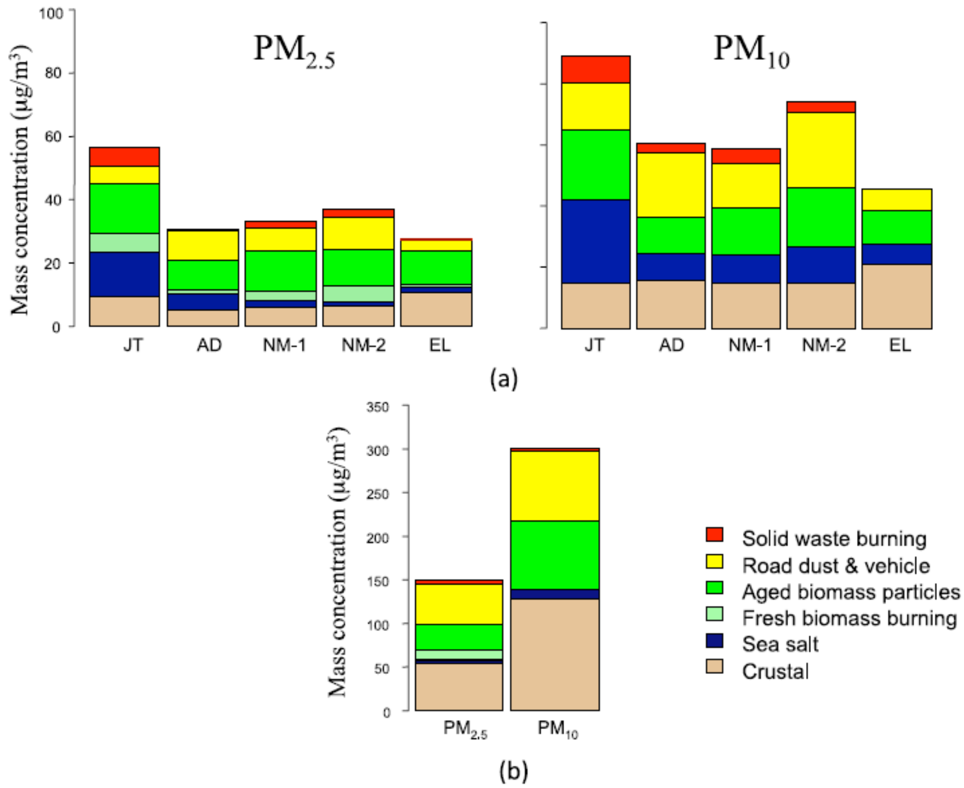
As shown in Figure 3, crustal sources are the largest contributors of both $PM_{2.5}$ and PM_{10} in the Accra Metropolitan Area during the Harmattan season, with large contributions also coming from aged biomass particles[1] and road dust and vehicles. In non-Harmattan months, aged biomass is generally the largest contributor to $PM_{2.5}$, although sea salt and road dust and vehicle emissions are also large contributors in certain neighborhoods. These results are generally consistent with the source attribution findings in the earlier studies, where proximity of wood stoves to the monitoring site was found to be a strong indicator of PM concentrations. Sea salt, road dust and vehicle emissions, and crustal sources are all fairly equal contributors to PM_{10}; however the distribution varies across neighborhoods.

A second monitoring and source apportionment study was conducted by an academic team in the Ashaiman district, just north of the Tema Industrial Area. The results of the Ofosu et al. (2012) study show a higher influence of industrial sources on ambient air quality in the air-shed influenced by the Tema Industrial Area, suggesting this area is likely to be one of the main beneficiaries of actions to limit industrial emissions as outlined in this AQMP. Ofosu et al. conducted ambient air sampling at a residential site from the period February 2008 to August 2008, with adjustments to the sampling during the Harmattan period (February and March) to avoid over-loading the capacity of the instruments to accurately measure

[1] Fresh biomass particles are the direct result of biomass burning. Aged biomass particles are residual biomass particles that transform over time.

ambient air. The team used a standard form of source attribution (positive matrix factorization, or PMF) to identify the contribution of eight anthropogenic and biogenic sources: industrial emissions (11.4%), fresh sea salt (15.5%), diesel emissions (18.4%), biomass burning (9.5%), two stroke engines (5.1%), gasoline emissions (15.8%), aged sea salt (6.2%), and soil dust (17.7%) – see Table 4 below.

Figure 4: Particulate Matter by Source for non-Harmattan and Harmattan Month Readings



cember 2007 to
, Asylum Down

Source: Zhou et al. (2013)

Table 5: Average source contributions (%) to PM2.5 mass concentrations in the Ashaiman district

Emissions Source Category	Estimated Source Contribution to Ambient $PM_{2.5}$ Concentration
Industrial emissions	11%
Fresh sea salt	16%
Diesel	18%
Biomass	9.5%
Two stroke engines	5.1%
Gasoline	16%
Aged sea salt	6.2%
Soil dust	18%

Source: Ofosu et al. (2012)

3.4 Health implications of the baseline air quality scenario

The EPA Ghana, collaborating with the USEPA, has estimated the health implications of the baseline air quality scenario using the BenMAP-CE air quality impact estimation tool. The analysis reflects the burden of particulate matter air pollution within the central AMA[2] consistent with the full set of air quality monitor results for 2015, with estimation of exposures using non-roadside monitor values[3] only for the areas within Greater Accra but outside the existing monitor network.

The analysis also projected $PM_{2.5}$ concentrations for the years 2020 and 2030 by assuming a 1% annual growth rate in PM concentrations through 2030. This PM concentration growth rate is based on analysis of historical trends in PM10 concentrations from the EPA Ghana network, and an estimated relationship between historical PM concentrations and historical GDP per capita in the Greater Accra region, which is then used in combination with a World Bank forecast of GDP in Ghana and the Ghana Statistical Service's forecast of population growth in the Greater Accra region to forecast a baseline of PM concentration in the future.[4]

[2] The monitor network is centralized within the Accra and La-Dade-Kotopon districts within the Greater Accra Region.

[3] EPA Ghana's monitor network is over-representative of roadside PM concentrations, as 10 of 15 currently active monitors are located at roadside locations. This analysis aims to capture the baseline health burden associated with the population's exposure to PM concentrations. Within Accra city, many people live and work very near to roadways, and as such, we include all monitored PM measurements in the baseline health analysis. Outside of Accra city, people are less exposed to roadside PM concentrations. To estimate population exposure to PM outside of Accra city, we apply average non-roadside monitor concentrations.

[4] The statistical analysis of PM monitor data over time and its relationship to GDP/capita trends in Ghana also controls for the location of the monitor (roadside and residential). The result of this analysis is an estimated elasticity of PM_{10} concentrations with respect to GDP/capita of 0.28 – in other words, for each percentage increase in per capita GDP, we could expect a 0.28 percent increase in PM_{10} concentrations. The forecast of GDP/capita is based on a World Bank GDP forecast to 2020 (see https://data.worldbank.org/country/ghana) and a Ghana Statistical Service forecast of population for the Greater Accra region, also to 2020. The resulting GDP per capita

In addition, the estimates make use of a national-scale projection of population from the Global Burden of Disease study, and district level population estimates from the Ghana Statistical Service, adjusted where necessary to reflect historically higher growth rates in the Greater Accra Region relative to the remainder of Ghana. These assumptions are consistent with a "no further controls" projection of air quality for the major point, mobile and area sources contributions to air quality. The results for the cause-specific premature mortality category of health effects are provided in Table 6 below.

Table 6: Estimates of premature mortality associated with particulate matter exposure in the Greater Accra Region for 2015, 2020, & 2030

Health Endpoint	Epidemiological Study	Age Range	2015 Air Pollution Attributable Incidence	2020 Air Pollution Attributable Incidence	2030 Air Pollution Attributable Incidence
Mortality, Chronic Obstructive Pulmonary Disease	Cohen et al., 2015	30-99	210	230	350
Mortality, Ischemic Heart Disease	Cohen et al., 2015	25-99	810	870	1300
Mortality, Cerebrovascular Disease	Cohen et al., 2015	25-99	590	660	970
Mortality, Lower Respiratory Infection	Cohen et al., 2015	30-99	1200	1300	1900
Mortality, Lung Cancer	Cohen et al., 2015	30-99	47	55	84
Total Mortality for Causes Listed Above			2800	3100	4600

Note: Columns may not add to totals due to rounding. The total mortality estimate provided is relevant for the five specific causes of death listed in the table. There is evidence that air pollution may also increase the risk of mortality from other causes of death not listed above, however the Cohen et al. (2015) study and available baseline incidence data in Ghana does not currently support development of an estimate that reflects other causes of mortality not listed here.

forecast is an increase of just over 4% annually, which we project to 2030. Application of the elasticity of 0.28 to the estimated GDP/capita yields a forecast increase of both PM_{10} and $PM_{2.5}$ of 1% annually.

Cohen et al. (2015) is a state-of-the-art study that estimated the health burden attributable to $PM_{2.5}$ for cause-specific mortality, including chronic obstructive pulmonary disease, ischemic heart disease, cerebrovascular disease, lower respiratory infection, and lung cancer. While most air pollution epidemiology studies are performed in the US or Europe and relate mortality to a lower range of PM2.5 concentrations, authors calculated integrated exposure response (IER) functions to estimate the relative risk of mortality across the global range of ambient $PM_{2.5}$ concentrations. Using a greater range of ambient $PM_{2.5}$ concentrations provides a linear relationship between exposure and health impacts at lower concentrations that flattens (i.e., the effect attenuates) at higher concentrations, similar to those concentrations measured in Accra. We use the IER to estimate cause-specific mortality impacts from current and estimated future-year $PM_{2.5}$ concentrations in the Greater Accra region.

The EPA Ghana team also analyzed an alternative air quality scenario that incorporates the estimated effects of the industrial, transport, and residential open waste burning emissions reductions expected to be achieved by implementation of the AQMP. This alternative scenario reflects lower PM concentrations than the baseline forecast. To estimate the impacts of the AQMP on the transport, industrial, and waste burning sectors, we roll back future year estimated air quality concentrations by 10% in 2020 and 20% in 2030. These estimated rollbacks reflect a detailed analysis of emissions data for these sectors, and the effect of the AQMP measures in reducing these emissions, combined with the source apportionment studies summarized in Section 3.2 above, which are used to estimate the effect of emissions reductions by sector on ambient concentrations. Our analysis concludes that cause-specific mortalities associated with $PM_{2.5}$ will potentially decrease by 140 in 2020 and by 430 in 2030. Results are shown in Table 7, below.

Table 7: Estimates of reductions in premature mortality associated with implementation of the AQMP in the Greater Accra Region for 2020 and 2030

2020 10% Air Quality Improvement	2030 20% Air Quality Improvement
140	430

3.5 Capacity Assessment

There is a wide range of air quality management capacity that exists at EPA Ghana, as well as additional research and local resources (e.g., at the University of Ghana) that can be accessed to enhance air quality management efforts in Accra. Table 8 below provides a summary of capabilities for each major component of a complete air quality management system.

Table 8: Available Air Quality Management Information

COMPONENT OF AQMS	INITIAL ASSESSMENT OF STATUS	POTENTIAL CAPACITY GAPS
Laws and Regulations	Ghana has EPA Act 490, passed in 1994, and has enacted Environmental Assessment Regulations (LI1652) as of 1999 to implement the Act. Hazardous and Electronic waste control and Management Act passed in 2016, Act 917. It obliges the Agency to manage hazardous and other wastes to prevent any harmful effects on public health & environment National Ambient Air Quality Guidelines were developed in 2000 and provide some authority for action. The guidelines are being transformed into standards and may be gazette in 2018 and implemented in 2019. EPA prescribes guidelines and standards to control emissions, discharges of all forms of hazardous wastes including health care, municipal and industrial	Authorities established in the Acts do not apply to municipal waste burning in Accra and surroundings. EPA Act has jurisdiction on small scale household emissions sources but is yet to prescribe emission standards. EPA Act has jurisdiction over Industrial sources and regulatory control over Local Government (prescription of waste management guidelines and enforcement etc.). Local Governance Act, Act 936 of 2016 has operational jurisdiction over Municipal wastes, and open burning.
Emission Inventory	COPERT has been used for mobile source emissions, but it has not been updated since 2008 LEAP-IBC is being used to characterize emission sources associated with energy use among others Some information on emission rates at industrial sources is available from EPA Ghana compliance testing activities. Some information is available on emissions rates from vehicles from a national scale pilot test of emissions measurement.	LEAP estimates are at the national scale and not urban scale or district level. In addition, more detailed spatial resolution is needed. A comprehensive inventory for industrial and vehicle emissions has not been established, but could be initiated using information from pre-construction permits and ongoing EPA permit compliance and enforcement activities. A data management system for the emissions inventory would be required.
Ambient and Source Air Quality Monitoring	Good availability of data for key pollutants, in particular PM 10, for multiple monitoring sites throughout Accra Aside from monitors located at residential, commercial, industrial areas, others are sited along roadside (to characterize transport sources).	Speciated PM data needed for reliable source apportionment seems to be limited to short-term research studies. EPA Ghana has partnered with USEPA to enhance this capability in Ghana. Air quality monitoring needed in Tema, which is home to a significant number of the GAMA industrial point sources. Additional monitoring of GAMA residential areas is needed to better

COMPONENT OF AQMS	INITIAL ASSESSMENT OF STATUS	POTENTIAL CAPACITY GAPS
	Data are supplemented by additional information from short-term research studies that can be used for better source apportionment.	understand pollutant exposures in highly populated areas away from busy roadways.
Air Pollution Dispersion/Fate and Transport Modeling	None yet attempted	An emissions inventory is needed to perform this function. Some initial estimates using reduced-form methods will be possible using the soon to be launched District level LEAP-IBC software.
Data Analysis and Interpretation	Air Monitoring data has been well characterized and interpreted	Additional effort could enhance source apportionment, exposure assessments, and baseline health effects characterization.
Public Participation and Environmental Justice	The AQ index is reported retrospectively, in broad categories, but it is not spatially disaggregated.	Public not informed of daily status of air quality in Accra due to absence of real time monitors.
Control Strategy Planning and Development	Examples of successful control strategy planning and development including removing lead from gasoline and limiting sulfur content in fuel to a maximum of 50ppm. New environmental quality standards for industrial and transport sectors among others are currently being finalized.	No standard laboratory is in Ghana for testing sulphur levels on fuels, Regulatory framework for operationalizing the standards are being developed
Compliance and Enforcement	Implemented by EPA Ghana as part of permit compliance checks. Assistance provided through the DVLA and local police for vehicle inspections.	Vehicle inspections will soon incorporate emissions performance checks as part of the annual inspection process.

4.0 GAPS AND ISSUES

EPA Ghana has identified four major areas where capacity gaps can and should be addressed to further enhance their ability to implement the monitoring plan and emissions reduction performance:

- Enhancing AQ monitoring capabilities and governance
- District level emissions inventory development, including a data management system
- Access to laboratory facilities to enhance capabilities for speciation analyses and source attribution analyses
- Access to air pollution health-related data

4.1 Enhancing AQ monitoring capabilities

EPA Ghana has a well-developed air quality monitoring network, but it requires further enhancement to more effectively assess certain industrial emissions, particularly in Tema, and also to provide a continuous monitor capacity that can better inform the public in "real-time" during critical air pollution episodes (or used as an early warning system). Additional monitoring of highly-populated residential areas is also needed to better characterize neighborhood exposures away from busy roadways. EPA Ghana is currently working with the World Bank and USEPA to develop a plan for addressing these gaps.

4.2 Outline of Emissions Inventory

Developing a comprehensive emissions inventory for the Greater Accra region is one element of what would be necessary to better characterize the major sources of air pollution in the region. In general, emissions inventories incorporate four elements:

1. **A mobile source inventory**. It is not practical to measure pollutants from all mobile sources, so emissions are estimated from data on the population of vehicles by vehicle class, estimates of their activity (where, when, and how far they are driven), and the emissions characteristics of those vehicles. Sometimes "non-road" sources are also included in the mobile source component of a comprehensive inventory, reflecting the activity of combustion engines in construction equipment, farm equipment, mining equipment, and other small engines (perhaps including generators). Some efforts have been made in Ghana to characterize vehicle emissions, but they require updating.
2. **A point source inventory**. Point sources are stack emissions from major industrial and commercial facilities. The total emissions from a large point source can also include fugitive emissions from industrial plants. For example, petroleum refineries have significant emissions from stacks and flares, but also leaks around seals and from product storage containers.
3. **An area source inventory**. Area sources are small sources of air pollution that by themselves may not emit very much but, when their emissions are added together, account for a significant portion of total emissions. Area sources are often too small or too numerous to be inventoried individually. Examples of area sources include: industrial processes such as chromium electroplating, surface coating of cans and paper, metal parts cleaning, metal recycling, small

chemical manufacturing plants, and bakeries; emissions from consumer products, such as adhesives and sealants and coatings such as paints; residential heating and fuel use; prescribed agricultural burns, forest and wildfires, and structure fires; gasoline and diesel stations; dry cleaners.

4. **A biogenic inventory**. Biogenic emissions are emissions that originate from non-anthropogenic sources. These include sources such as forests which emit some VOCs, and sources of airborne particulates such as sea salt and crustal material.

For mobile sources, significant effort has been made in the recent past to develop a national emissions inventory, focused on on-road sources, and using the COPERT software tool. On-road vehicle registration information is available from the Driver Vehicle and Licensing Authority (DVLA), which also maintains information on vehicle class and engine technology. DVLA is also responsible for vehicle inspections to ensure roadworthiness, and will also be responsible for emission testing and collection of emission information. We expect that the mobile source emissions inventory will need to be updated with more recent information, and perhaps to reflect more recent fuels and/or tailpipe controls. The software used may be COPERT version 4, which is one of the tools recommended by IPCC for reporting greenhouse gas emissions. The COPERT tool used in the SNAP work focuses on national emissions volumes, and does not appear to have been deployed at the urban scale for Accra, or with the finer geographical detail that would be desired to support urban scale air quality modeling.

For major energy-using or electric energy generating sources, the Long-range Energy Alternatives Planning system (LEAP) can be used for first-order estimates of emissions of a wide range of pollutants that contribute to ambient air pollution and climate change. The LEAP system also can be applied for small-scale energy production (e.g., diesel generators), household energy use, biomass burning, and other sources of interest. Stockholm Environment Institute, the developers of the LEAP tool, are working with EPA Ghana to deploy these capabilities on a dis-aggregated basis for application at city-scale in Accra.

LEAP may also be appropriate for major industrial point sources such as the Tema Oil Refinery, Volta Aluminum Company, Wahome Steel Limited, and the food processing industry. Some of these sources may be less suitable for analysis in the LEAP framework, but may be usefully addressed using standard throughput driven emissions factors for first estimates of emissions potential, such as the United States AP-42 factors.

A key next step in advancing emissions inventory capabilities is to implement a data management system for emissions data from permits, modeling, and the LEAP application. EPA Ghana has begun work with a coalition of groups, let by WHO and the World Bank, to obtain and build capacity in implementing a data management system for this purpose.

4.3 Access to laboratory facilities

EPA Ghana requires capacity building to enhance local laboratory analysis to ensure a continuous data gathering of PM data; and also gain the necessary skills in speciation analysis that could provide better source apportionment results (using elemental/organic carbon differentiation, and both metals and organic analyses as “signature” constituents). EPA Ghana is currently working with USEPA on building a portion of these capabilities, and with the World Bank to identify a longer term plan.

4.4 Access to suitable air pollution health-related data

Ghana Health Service need enhanced collection and management of targeted health data associated with air pollution related health ailments. The current data management system collects health data of ailments derived from various sources including air pollution and does not provide the true reflection of respiratory incidences. Therefore, the District Health Data collection system requires improvement.

5.0 OVERALL OBJECTIVE AND GOALS OF THE GAMA AQMP

The overall objective of the GAMA Air Quality Management Plan (AQMP) is as follows:

> "Ambient particulate air quality in the GAMA is brought into full compliance with national ambient air quality standards by 2025, and the state of compliance is maintained as the region develops economically."

This objective will be fulfilled by adherence to the following five goals:

- Goal 1: Ambient concentrations of air pollutants comply with the new ambient air quality standard for PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, O_3 in the Greater Accra region as a result of emission reductions

- Goal 2: Cooperative governance promotes the implementation of the AQMP

- Goal 3: Air quality management in the Greater Accra region is supported by effective systems and tools

- Goal 4: Air Quality Decision-making is informed by sound research

- Goal 5: Knowledge and understanding amongst decision-makers, stakeholders, and the general public in the Greater Accra region is enhanced

6.0 IMPLEMENTATION PLAN

The implementation plan outlined below is designed to fulfill the five goals for achieving the main objective of the AQMP.

Table 9: GOAL 1: AMBIENT CONC. OF AIR POLLUTANTS COMPLY WITH THE NEW AMBIENT AIR QUALITY STANDARD & REGULATIONS (FOR PM10. PM2.5, SO2, NO2, CO, O3) IN THE GREATER ACCRA REGION AS A RESULT OF EMISSION REDUCTIONS

TABLE 9: GOAL 1: AMBIENT CONCENTRATIONS OF AIR POLLUTANTS COMPLY WITH THE NEW AMBIENT AIR QUALITY STANDARD & REGULATIONS (FOR PM10. $PM_{2.5}$, SO2, NO2, CO, O_3) IN THE GREATER ACCRA REGION AS A RESULT OF EMISSION REDUCTIONS					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIME-FRAMES**	**INDICATORS**
Convert AQ guidelines to AQ standards	• Development and gazette of the proposed point and ambient source standards by Ghana Standards Authority National Technical committee • Immediate implementation of vehicular emission standards and Regulations.	EPA Ghana	GSA, MESTI	Gazette standards by December 2018 • Fully implemented June 2019	Published proposed standards
Emission from point sources	• permitting of undertakings/ companies Ensure installation of appropriate air pollution control systems	EPA Ghana	, Industries	• All industries that generate air emissions have valid permit • appropriate air pollution monitoring devices are installed	Point source and Ambient monitors operated by EPA show a reduction in PM concentrations at both stationary and roadside locations, and reduction in respiratory diseases
Emission from vehicles addressed by the vehicular emissions standards	• commence implementation of the standards • ensure that vehicle testing centres are all equip with emission testing equipment	EPA Ghana	DVLA, Motor Traffic Transport Division (MTTD)of Ghana Police and GAMA	• Create awareness on the standards • testing of vehicle emission against the standards by June 2019	Ambient monitors operated by EPA show a reduction in PM concentrations at roadside locations, and reduction in respiratory diseases

				• enforce EPA permitting conditions	
Reduce dust from paved and unpaved roads	• regular sweeping of paved roads • Department of Urban Roads (DUR) should ensure that dusty roads are doused with water and roadsides grassed • district assemblies should acquire mechanized sweepers	DUR MMDAs		• Beginning January 2019	Ambient monitors operated by EPA show a reduction in PM concentrations at roadside locations, and reduction in respiratory diseases
Development of AQ and Vehicular emission Regulations	Promulgate regulations to fully implement the AQ standards	EPA Ghana	AG's department, MESTI, Parliament	• Development of Air Quality & Vehicular emissions regulations by December 2018 • implementation of vehicular emission standards in June 2019	Completed the enactment of regulations
Ensure supply of high quality fuels (50ppm maximum Sulphur content in fuels	Monitor imports of 50 ppm Maximum sulphur content in fuels	NPA	EPA Ghana, Petroleum Importers Association, African Refiners Association, Tema Oil Refinery, DVLA , GSA	Monitoring of imported fuels Refineries produce lower sulphur content in fuels by 2020	Fuel quality standard is codified; EPA Ghana and GSA will verify compliance at port offloading, distribution centers, and filling stations; EPA Ghana in collaboration with DVLA verifies that sulfur emission levels from tailpipe are lower,

Vehicular Exhaust Emissions (Tailpipe)	Monitor vehicles tail pipe emissions once a year for private cars and twice per annum for commercial vehicles	DVLA	EPA Ghana	ongoing	Emission testing is currently on advisory role awaiting gazette of vehicular emission standards and promulgation of regulations
Industrial sources	Industrial compliance monitoring and enforcements. Using Akoben disclosure and performance rating to name and shame non-performing industries	EPA Ghana		ongoing	Industries monitor emissions from stack monthly and report to EPA Ghana quarterly for assessment. EPA Ghana verifies data integrity and ensures compliance with permitting conditions by conducting monitoring quarterly.
Hazardous municipal waste sources	Hazardous and Electronic Waste Control and Management Law, 2016 (Act 917) enacted	EPA Ghana	Ghana Revenue Authority (customs Division)	ongoing	Reduce importation, exportation, transport, shipment, sell, purchase or deal with hazardous or any other wastes.
Other open burning/municipal waste sources	• Enforcement of Local Governance Act and enactment of by-laws to regulate open burning. • Awareness creation on effect of open burning	Local Government	NGOs	ongoing	Enforcement of the by-laws on open burning is weak. Need to strictly enforce the laws on open burning of municipal wastes

Table 10: GOAL 2: COLLABORATIVE GOVERNANCE IN THE IMPLEMENTATION OF THE AQMP

GOAL 2: COLLABORATIVE GOVERNANCE IN THE IMPLEMENTATION OF THE AQMP					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIME-FRAMES**	**INDICATORS**
Implement Vehicular emission regulations	Conduct mandatory inspections and monitor emission from vehicles	DVLA	EPA Ghana	June 2019	• Improve roadside air quality; • Number of vehicles that complied with the Vehicular emission standards. • roadworthiness and road safety requirements
Enforce Vehicular emissions regulations	License renewal process (6 months for commercial, and 12 months for private vehicles) Spot checks	DVLA National Road Safety Authority	EPA Ghana, MTTD of Ghana Police Service	June 2019	• Number of vehicles that complied with Mandatory vehicle emission standards. • Improve roadside air quality
Begin to reduce emissions from small and dispersed sources that are not currently addressed by the EPA air emission standards	Address open burning • Inventory on open burning sites • identify impacted communities • awareness creation • influence policy/bye-laws and interventions and enforcement • monitoring and evaluation	GAMA	National Development Planning Commission, EPA Ghana	2019	• Number of open burning in the city • Improve ambient air quality
Align with national development goals and activities with successful reduction of emissions	Integrate AQMP objectives into national planning guidelines for implementation of medium-term development plans (for adoption by district authorities)	NDPC, Ministry of Local Government and Rural Development	EPA Ghana	2019	Number of District Assemblies in GAMA that are implementing the relevant aspects of the AQMP

Table 11: Goal 3: Air Quality Management In The Greater Accra Region Is Supported By Effective Systems And Tools

GOAL 3: AIR QUALITY MANAGEMENT IN THE GREATER ACCRA REGION IS SUPPORTED BY EFFECTIVE SYSTEMS AND TOOLS					
OBJECTIVES	ACTIVITIES	MANDATORY RESPONSIBILITY	PARTICIPATORY RESPONSIBILITY	TIME-FRAMES	INDICATORS
Effectively collect, manage, and disseminate emissions and air quality data to partners	Explore the use of AirNow tech as a data management system	EPA Ghana and GHS	UG, Ghana Atomic Energy Commission, Ghana Meteorological Agency, World Bank PMEH, USEPA	beginning August 2018	Data base system established and functioning
Clarify data sharing and confidentiality policies	Develop a policy that outlines data sharing and purchasing options for types of data, types of uses, etc…and protocols for obtaining access to data	EPA Ghana	Input from academia, industrial user groups, etc…NGOs,	November 2018	Completed and published official policy
Enhance monitoring capabilities	Develop a continuous/real-time monitoring capability Develop the ongoing operations and maintenance capability for a real-time data collection, analysis, and reporting function to the general public and public health authorities. Enhance the coverage of the air quality monitor system to areas other than GAMA (with a priority for coverage of Tema portion of GAMA, then Kumasi and Takoradi)	EPA Ghana	World Bank PMEH	By October 2018	• Real-time monitoring capability developed and functioning. • Air quality monitoring system established in Tema, Takoradi and Kumasi

Enhance “bottom-up” (building up from source to ambient AQ) systems and tools	Fully implement and learn the urban-scale LEAP-IBC for GAMA for conventional air pollutants that contribute to PM and ozone air quality Fully implement and learn the urban-scale LEAP-IBC for GAMA for SLCPs and conventional GHGs and their impact on climate change (radiative forcing)	EPA Ghana, GHS	Energy Commission	-March 2018	Fully functional application of LEAP-IBC for GAMA

Table 12: GOAL 4: AIR QUALITY DECISION -MAKING IS INFORMED BY SOUND RESEARCH

GOAL 4: AIR QUALITY DECISION MAKING IS INFORMED BY SOUND RESEARCH					
OBJECTIVES	ACTIVITIES	MANDATORY RESPONSIBILITY	PARTICIPATORY RESPONSIBILITY	TIME-FRAMES	INDICATORS
Coordinate and align public health air quality research being conducted by academia to the needs and desires of EPA Ghana to implement the plan	Develop data sharing agreement(s) to facilitate research objectives	EPA Ghana	GAEC, UCC and University of Ghana	June 2019	MOU signed and operationalized
Utilize existing monitoring information to identify patterns and trends that can inform AQMP implementation	Develop a plan on the use of existing information. Perform trend analysis on historical AQ and GDP trends	EPA Ghana	USEPA, GHS	June 2018	• Research plan on use of existing information developed. • AQ and GDP trends performed
Develop local and external capabilities to perform source apportionment and PMF	Training of local personnel on source apportionment and PMF	EPA, Academia, GAEC	World Bank PMEH & Industrial Economics	By December 2018	Local personnel trained on Source apportionment

Table 13: Goal 5: Knowledge and Understanding amongst Decision-Makers, Stakeholders, And The General Public In The Greater Accra Region Is Enhanced

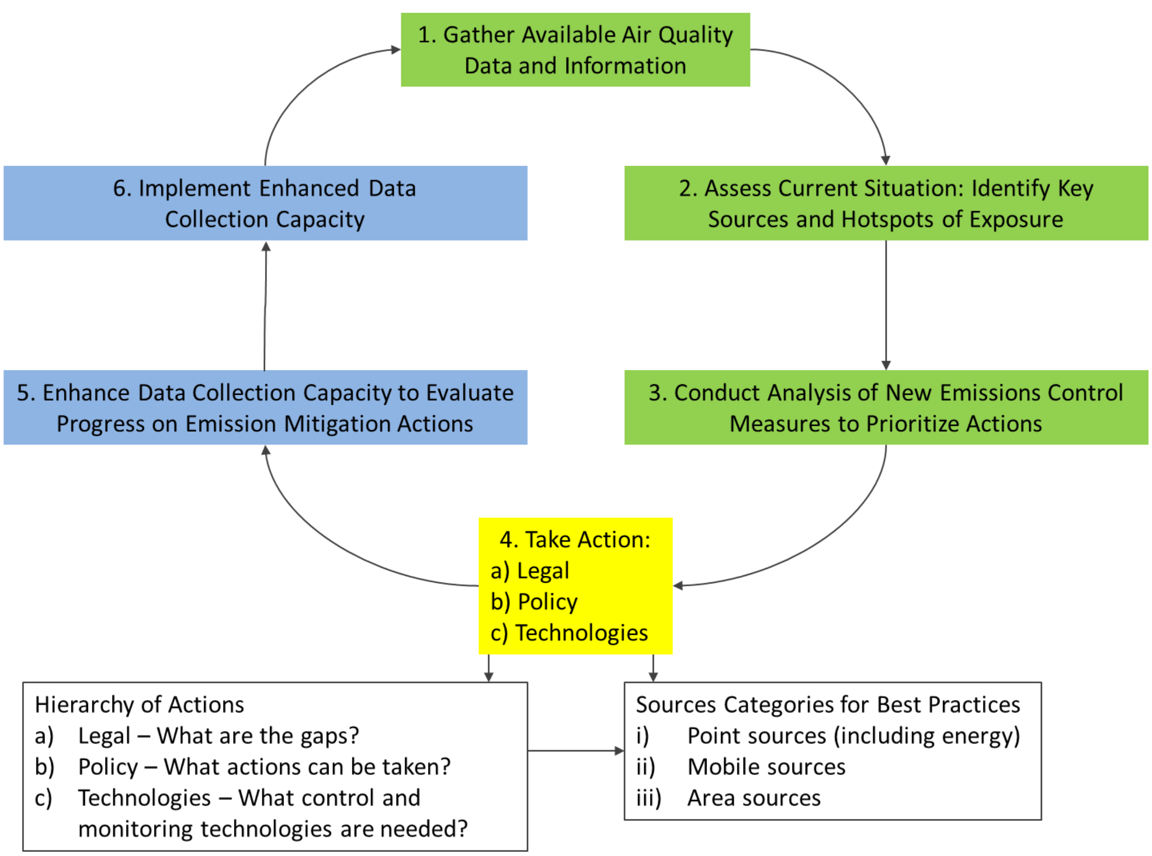
GOAL 5: KNOWLEDGE AND UNDERSTANDING AMONGST DECISION-MAKERS, STAKEHOLDERS, AND THE GENERAL PUBLIC IN THE GREATER ACCRA REGION IS ENHANCED					
OBJECTIVES	**ACTIVITIES**	**MANDATORY RESPONSIBILITY**	**PARTICIPATORY RESPONSIBILITY**	**TIME-FRAMES**	**INDICATORS**
Enhance understanding among general public	Develop two page brochure that documents EPA Ghana's air quality management success stories	EPA Ghana	USEPA, GHS, GAMA	June 2018	Complete, approved, and published brochure
	Update website				
Inform decision makers to take action on the key activities in the GAMA AQMP and air quality policy decision making	Awareness creation for EPA Ghana staff on the dimensions of the AQMP and how it might affect the work of all employees. Create awareness for other GoG stakeholders on the AQMP	EPA Ghana (led by communications team)	Mo Energy, MoT, MoH /Ghana Health Services, MoLGRD, NDPC, DVLA, Road Safety Commission, MTTD, NPA, Ghana Standards Authority	June 2018	Meetings scheduled and completed with all relevant stakeholders
Assist stakeholders and the regulated community to understand and comply with regulations under the AQMP	Develop, publish, and disseminate written materials Allocate a portion of EPA website to compliance promotion	EPA Ghana	AGI, PEF, Petroleum Importers Association, Bulk Distribution Companies etc.	January 2019	Completed, approved, and published written materials Completed, approved, and updated website pages for compliance promotion

7.0 MONITORING AND EVALUATION

EPA Ghana has a long-term plan to maintain the air quality monitoring plan that is currently in place, which will be a central focus in evaluating progress toward air quality goals in the GAMA. Using these data, and the planned expansion of capacity in the area of emissions inventory development, EPA Ghana will perform a mid-term review of progress in two years (at the end of 2020), and a formal evaluation of the plan's progress after 5 years. Any portion of the plan may be updated as a result of the review.

Figure 4 below provides a summary of the ongoing process of air quality management envisioned. Steps 1 through 3 have been used to formulate this first draft of the plan. Available air quality data and information has been used to assess the current situation and identify key sources. These results have in turn been used to prioritize actions for the key industrial point sources and for continued progress in reducing emissions from mobile sources (using both tailpipe controls and fuels content regulation). This plan represents the first step in taking action (Step 4, FIG.5).

.**Figure 5: Schematic of the Air Quality Management Planning Process**



The monitoring and evaluation process will include planned enhancements to the monitor network to expand monitoring in the Tema Metropolitan area, and to add a continuous monitoring capability. The data collected will be evaluated at the 5-year formal review to further assess whether the actions taken will be sufficient to meet the key goal of meeting the $PM_{2.5}$ standard.

Note that the review will also evaluate the state of emissions drivers, including faster or slower growth in emissions rates, air pollutant exposures, and the economy. The 5-year formal evaluation will also include an update on the availability of financing for implementation of the plan and to support meaningful changes in emissions rates and transition to new technologies, particular for point sources but also for the turnover of the mobile source fleet to cleaner technologies and the availability in retail settings of cleaner, low sulfur diesel and gasoline.

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FINAL DRAFT GHANA STANDARD **FDGS 1219: 2018**

Environment and Health protection – Requirements for motor vehicle emissions

0. Introduction

0.1 Air pollution is both a national and a trans-boundary problem caused by the emission of certain substances which either alone, or through chemical reaction may lead to adverse environmental and public health impacts. Diseases and disorders associated with exposure to air pollution tend to have wider scope of distribution usually across the entire urban areas exposed to substantial amounts of air pollutants.

0.2 Clean-air policies, standards and regulations are very important instruments for protecting the environment and public health. The evidence that controlling air pollution has the concomitant result of protecting the environment and public health is based on a broad range of interdisciplinary research findings.

0.3 The World Health Organization (WHO) air quality guidelines were initially developed in 1987 and designed as an addition to preceding initiatives to provide direction and guidance to policy-makers. The purpose of the guidelines were to assist in devising measures for reducing the health impacts of air pollution from motor vehicle emissions based on expert evaluation and contemporary scientific evidence.

0.4 The European Union (EU) and countries like the USA, Japan etc. took inspiration from WHO and put in place air pollution policies that control vehicular emissions in the US and in the European Union..

0.5 In September 2014, the EU released Euro VI standards for motor vehicle emissions. Current motor vehicles produced and used in the EU shall meet these new standards. Despite the release of newer and higher standard vehicles, vehicles with lower standards are still allowed to ply the roads. They however pay higher levies to remain on the road.

0.6 Vehicles emissions are affected by driving patterns, the vehicle type and age, fuel type and quality, road conditions, axel load, traffic speed and congestion etc.,as well as altitude and other ambient conditions. .

0.7 Ghana stand to benefit by embracing resource-efficient, less polluting technologies, policies and standards developed and already in use. This first Ghana Standard has been set at (Euro II) so as not to put too many vehicles off the road on introducing motor vehicle emission requirements in the country.

0.8 Because of the potential adverse environmental and public health implication of air pollution, Ghana intends in the immediate long term, to improve the quality of ambient air for all Ghanaians.

0.9 This first Ghana vehicle emissions standard is derived from the EURO II vehicle exhaust emission standard with some modifications to reflect local data collected by the Ghana Environmental Protection Agency (EPA) and research institutions. This Ghana Standard shall be reviewed on regular basis to meet best international practice.

0.10 The structure of this standard is such that the requirements have been classified under two categories by vehicle year of manufacture and technology. These are:

- 1995 and earlier: This refers to vehicles manufactured before 1995 and prior to the use of catalytic converter technologies that aid in the reduction of emissions.

- Post 1995: This refers to vehicles manufactured after 1995 and after the introduction of catalytic converter technologies that aid in the reduction of emissions.

0.11 This Standard covers exhaust emission requirements of vehicles fuelled by petrol, diesel and gas.

1. Scope

1.1 This Ghana Standard specifies the requirements for exhaust emissions of motor vehicles as well as tractors, farm equipment (such as combine harvester, etc.), mobile industrial / construction machines (such as excavators).

1.2 These requirements do not apply to engines used on water bodies such as boats, air boats, jet skis and canoes using an outboard motor. It also does not apply to aviation including helicopters and airplanes or stationary motors such as generators and corn mills.

2. Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.1 GS ISO 3929**,** Road vehicles -- Measurement methods for exhaust gas emissions during inspection or maintenance.

2.2 GS ISO 11614, Reciprocating internal combustion compression-ignition engines -- Apparatus for measurement of the opacity and for determination of the light absorption coefficient of exhaust gas

3. Definitions

For the purposes of this standard, the following definitions apply:
3.1
emissions
the products produced other than heat in a combustion reaction

3.2
motor vehicle
a vehicle powered by an internal-combustion engine

3.3
opacity
the amount of light obscured by particulate matter

3.4
regulator
statutory body responsible for environmental protection

3.5
authority
statutory body responsible for the issuance of road worthy certificate

4. Classification

Vehicles by this specification are classified by Category A, Category B (based on the year of manufacture) and Motor cycles. These classifications are described in detail below:

4.1 Category A

This category shall represent vehicles that were manufactured before and during 1995.

4.2 Category B

This category shall represent vehicles that were manufactured after 1995.

4.3 Motor Cycles

All motor cycles and tricycles

5. Requirements

5.1 General requirements

5.1.1 Monitoring of emission levels of vehicles shall be every year for a private motor vehicle or every six months for a commercial vehicle.

5.1.2 Reports of motor emission levels of vehicles shall be presented to the appropriate authority as part of the requirements for issuance of road worthy certificate.

5.2 Emission Levels

The following parameters shall be evaluated for emissions of vehicles plying our roads. The requirements shall be based on the fuel type being used.

Table 1: Emission requirements for vehicles based on fuel type

Fuel type	Category	Parameter	Requirements	Test Method
Petrol/CNG/LPG	A	CO (%),max.	3.5	ISO 3929
	B		2.5	
	A	HC (ppm),max.	800	ISO 3929
	B		300	
Diesel	A	Opacity (%), max.	55	ISO 11614
	B		40	

Note: 1) CNG – Compressed Natural Gas
2) LPG – Liquefied Petroleum Gas

Table 2: Emission requirements for motor cycles and Tricycles

Fuel type	Parameter	Requirements	Test method
Petrol	CO (%), max	4.5	ISO 3929
	HC (ppm), max	1200	
Diesel	Opacity (%), max	55	ISO 11614

6. Testing

6.1 Emission testing of vehicles shall be carried out by a regulator or a third party contracted by the regulator.

6.2 Equipment used for testing shall be approved by the regulator.

7. Compliance

A vehicle shall be deemed to have conformed to the requirements of this Standard if it fulfils all the requirements in this standard.

WORKING DRAFT **DGS 1236: 2018**

Environment and Health Protection – Requirements for Ambient Air quality and Point Source/Stack Emissions

1. Introduction

0.1 Ghana recognizes the need to reduce air pollution from stationary, aerial, mobile and non-point sources to levels which minimize harmful effects on public health, paying particular attention to sensitive populations, and the environment as a whole, to protect the environment and improve public health.

0.2 In order to protect public health and the environment as a whole, it is particularly important to control emissions of pollutants at source and to identify and implement the most effective emission reduction measures at national, regional and local levels. Therefore, emissions of harmful air pollutants should be prevented, minimized or controlled and appropriate objectives set for pollutants in ambient and point source, taking into account relevant Standards, guidelines and programmes. Such Standards, guidelines and programmes provide direction and guidance to policy-makers in devising measures for reducing the health impacts of air pollution based on expert evaluation and contemporary scientific evidence.

0.3 Ghana stand to benefit by embracing resource-efficient, less polluting technologies, policies and standards developed and already in use.

0.4 Clean air is essential to maintaining the delicate balance of life on this planet. Poor air quality is a result of a number of factors, including emissions from various sources, both natural and anthropogenic. Poor air quality occurs when pollutants reach high concentrations which may endanger public health and/or the environment. Our everyday choices, such as transportation, open burning of waste, source of energy for industrial, domestic and commercial activities etc. can have significant impacts on air quality.

0.5 This first Ghana Ambient Air Quality, Point Source or Stack Emission standard is derived from data collected by the Ghana Environmental Protection Agency and research institutions in Ghana.

0.6 Clean air policies are very important instruments for protecting public health. The evidence that regulation of air-quality has the concomitant result of protecting public health is based on a broad range of interdisciplinary research findings. Diseases and disorders associated with exposure to air pollution tend to have wider scope of distribution usually across populations.

0.7 Because of the potential adverse environmental and public health implication of air pollution, Ghana intends in the immediate long term, to improve the quality of ambient air for all Ghanaians.

1. Scope

1.1 This Ghana standard specifies the requirements and test methods for ambient air quality.
1.2 It also specifies the requirements and test methods for point source or stack emissions based on energy source.

2. Normative References

The following standards contain provisions which through reference in this text, constitute provisions of this standard.

All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

2.1 AS 3580.4.1, Methods of sampling and analysis of ambient air – Determination of Sulphur Dioxide – Direct reading instrumental method

2.2 ASTM D4096 – 17, Standard Test Method for Determination of Total Suspended Particulate Matter in the Atmosphere (High–Volume Sampler Method)

2.3 ASTM D6602 -13 , Standard practice for sampling and testing of possible carbon black fugtive emissions or other environmental particulate, or both

2.4 ASTM D3162-12, Standard method for carbon monoxide in the atmosphere (continuous measurement by nondispersive infrared spectrometry)

2.5 ASTM D5466 – 15, Standard test method for determination of volatile organic compounds in the atmospheres (canister sampling methodology)

2.6 ASTM D4323 – 15, Standard test method for hydrogen sulphide in the atmosphere by rate of change of reflectance

2.7 ASTM D7773-12, Standard test method for determination of volatile inorganic acids (HCl, HBr and HNO_3) using filter sampling and suppressed ion chromatography

2.8 ASTM D3266-91,Standard test method for automated separation and collection of particulate and acidic gaseous fluoride in the atmosphere (double paper tape sampler method)

2.9 ASTM D6209 – 13, Standard test method for determination of gaseous and particulate polycyclic aromatic hydrocarbons in ambient air (collection on sorbent-backed filters with gas chromatographic/ mass spectrometric analysis)

2.10 ISO 13964, Air Quality – Determination of ozone in ambient air – ultarvoilet photometric method

2.11 ISO 7996 , Ambient air -- Determination of the mass concentration of nitrogen oxides -- Chemiluminescence method

2.12 ISO 10849, Stationary source emissions -- Determination of the mass concentration of nitrogen oxides -- Performance characteristics of automated measuring systems

2.13 ISO 9096, Stationary source emissions – Manual determination of mass concentration of particulate matter

2.14 ISO 7996, Ambient Air – Determination of the mass concentration of nitrogen oxides – chemiluminescence method

2.15 ISO 21438-2, Workplace atmospheres -- Determination of inorganic acids by ion chromatography -- Part 2: Volatile acids, except hydrofluoric acid (hydrochloric acid, hydrobromic acid and nitric acid)

2.16 ISO 9855, Ambient Air – Determination of the particulate lead content of aerosols collected on filters – Atomic absorption method

2.18 ISO 17733, Workplace air — Determination of mercury and inorganic mercury compounds — Method by cold-vapour atomic absorption spectrometry or atomic fluorescence spectrometry

2.19 ISO 13964, Air quality – Determination of ozone in ambient air – Ultraviolet photometric method

2.20 USEPA Method 23, Determination of Polychlorinated dibenzo–p–Dioxins and Polychlorinated dibenzofurans from stationary sources

2.21 USEPA Method 29, Determination of metals emission from stationary sources

2.23 USEPA Method 0050, Isokinetic HCl/Cl_2

2.24 USEPA Method 10, Determination of carbon monoxide emissions from stationary sources (instrumental analyzer procedure)

3 Definitions

For the purpose of this Ghana standard, the following definitions apply:

3.1

air pollution

contamination of indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere.

3.2

ambient air

ambient air refers to outdoor air in our surrounding environment

3.3

ambient air quality

ambient air quality refers to the quality of outdoor air in our surrounding environment.

3.4

atmospheric emission

any release that changes the composition of the air emanating from a point, non-point or mobile source

3.6

gaseous fuels

refers to any one of a number of fuels that under ordinary conditions are gaseous. example LPG and Natural Gas.

3.8

incinerator

an enclosed device that uses controlled temperature for burning waste materials including industrial waste until it is reduced to ash.

3.10

liquid fuels

all petroleum including crude oil and products of petroleum refining, natural gas liquids, bio fuels, and liquids derived from other hydrocarbons sources (including coal to liquids and gas to liquids)

3.11

mobile source

a single identifiable source of air emissions which does not emanate from a fixed location

3.12

non-point source

a source of air emissions which cannot be identified as having emanated from a single identifiable source or fixed location, and includes bush, forest and open fires, mining activities, agricultural activities and kraals.

3.15

point source

a single identifiable source and fixed location of air emission and includes stacks chimneys, hoods among others.

3.16

PM_{10}

particulate matter with aerodynamic diameter of less than 10 micro metre

3.17

$PM_{2.5}$

particulate matter with aerodynamic diameter of less than 2.5 micro metre

3.18

agency

statutory body mandated to deal with environmental protection, pesticides control and regulation of environmental issues and it's related purposes

3.19

particulate matter

are microscopic solid or liquid matter suspended in Earth's atmosphere

3.20

oxides of nitrogen

is nitric oxide and nitrogen dioxide

3.21

chimney

stack or final exit duct on a stationary process used for the dispersion of residual process gases

4 Requirements

4.1 Requirements for point source/stack emissions

When point source/stack emissions are measured in accordance with the relevant test methods specified in column 3 of table 1, results shall not exceed the maximum limits for the corresponding pollutant based on source of fuel/type of energy used as given in column 2 of Table 1.

TABLE 1: Requirements for point source/stack emission

Note: Electrical Energy usage include induction/electric arc furnaces, dryers, oven, kilns, Alumina & iron smelting among others.

4.2 Requirements for Point Source Air quality

POLLUTANTS	MAXIMUM LIMITS	TEST METHOD
SOLID FUELS		
Sulphur Dioxide (mg/Nm^3)	200	
Oxides of Nitrogen (mgN/m^3)	200	ISO 10849
Particulate Matter (mg/m^3)	50	ISO 9096
LIQUID FUELS		
Sulphur Dioxide (mg/Nm^3)	500	
Oxides of Nitrogen (mgN/m^3)	400	ISO 10849
Particulate Matter (mg/m^3)	50	ISO 9096
GASEOUS FUELS		
Sulphur Dioxide (mg/m^3)	100	
Oxides of Nitrogen (mg/m^3)	320	ISO 10849
Particulate Matter (mg/m^3)	20	ISO 9096
ELECTRICAL ENERGY		
Sulphur Dioxide (mg/m^3)	200	
Oxides of Nitrogen (mg/m^3)	200	ISO 10849
Particulate Matter (mg/m^3)	50	ISO 9096
INCINERATORS		
Sulphur Dioxide (mg/m^3)	200	
Oxides of Nitrogen (mg/m^3)	400	ISO 10849
Particulate Matter (mg/m^3)	70	ISO 9096
OTHER PARAMETERS (that may apply)		
Carbon Monoxide (mg/Nm^3)	100	USEPA Method 10
Hydrochloric Acid (HCl) (mg/Nm^3)	60	USEPA Method 0050
Hydrogen Fluoride (mg/Nm^3)	4	ISO 15713

Mercury and mercury compounds (mg/Nm^3)	0.03	USEPA Method 29
Particulate Lead (mg/Nm^3)	0.5 (expressed as lead)	USEPA Method 29
Chromium 6$^+$		USEPA Method 0061 California EPA Method 425
cadmium		USEPA Method 29

For requirements for ambient concentrations of air pollutants see Table 2.

Table 2 – Maximum time weighted averages for monitoring Ambient air pollutants

#	Substance	Maximum Time Weighted Average(TWA)	Average Time	Test Method
1	Sulphur Dioxide (SO_2)	520 µg/m^3	1 hour	AS 3580.4
		50 µg/m^3	24 hours	
2	Nitrogen Oxides (measured as NO_2)	250 µg/m^3	1 hour	ISO 7996
		150 µg/m^3	24 hours	
3	Total Suspended Particulate	150 µg/m^3	24 hours	ASTM D4096 - 17
		80 µg/m^3	1 year	
4	PM_{10}	20 µg/m^3	24 hours	ASTM D4096 - 17
		20 µg/m^3	1 year	
5	$PM_{2.5}$	Primary =12 µg/m^3 Secondary=15 µg/m^3	24 hours	ASTM D4096 - 17
6	Black Carbon	18 µg/m^3	24 hours	ASTM D6602 -13
7	Benzene	5 µg/m^3	1 year	ASTM D5466 – 15 Exhibit 2-43
8	Lead	1 µg/m^3	24 hours	ISO 9855

Table 3 – Maximum time weighted averages for monitoring Fenceline Air Pollutants

#	Substance	Maximum Time Weighted Average(TWA)	Average Time	Test Method
1	Carbon Monoxide	100 mg/m^3	15 minutes	ASTM D3162-12
		60 mg/m^3	30 minutes	
		30 mg/m^3	1 hour	
		10 mg/m^3	8 hours	
2	Hydrogen Sulphide	150 µg/m^3	24 hours	ASTM D4323 - 15
3	Hydrogen Cyanide	220 µg/m^3	24 hours	
4	Hydrogen Chloride	20 µg/m^3	24 hours	ASTM D7773-12 ISO 21438-2 Method 410A Test Method 322
5	Cadmium	5 ng/m^3	1 year	ISO 9855
6	Sulphur Dioxide (SO_2)	520 µg/m^3	1 hour	AS 3580.4
		50 µg/m^3	24 hours	
7	Nitrogen Oxides (measured as NO_2)	250 µg/m^3	1 hour	ISO 7996
		150 µg/m^3	24 hours	
8	Total Suspended Particulate	150 µg/m^3	24 hours	ASTM D4096 - 17
		80 µg/m^3	1 year	
9	PM_{10}	20 µg/m^3	24 hours	ASTM D4096 - 17
		20 µg/m^3	1 year	
10	$PM_{2.5}$	Primary =12 µg/m^3 Secondary=15 µg/m^3	24 hours	ASTM D4096 - 17
11	Black Carbon	18 µg/m^3	24 hours	ASTM D6602 -13
12	Benzene	5 µg/m^3	1 year	ASTM D5466 - 15
13	Lead	1 µg/m^3	24 hours	ISO 9855
14	Mercury (and its compounds)	15 ng/m^3	24 hours	ISO 17733
		1 µg/m^3	1 year	
15	Cadmium	5 ng/m^3	1 year	ISO 9855

16	Manganese	1 µg/m³	24 hours	ISO 9855
17	Toluene	8 mg/m³	24 hours	ASTM D5466 – 15 OSHA 108-88-3
18	Arsenic	15 ng/m³	24 hours	
19	Flouride	10 µg/m³	24 hours	ASTM D3266-91
20	Ozone	0.07 ppm	8 hours	ISO 13964
21	Nickel	20 ng/m³	1 year	
22	PAH	1 ng/m³	1 hour	ASTM D6209 - 13
23	Xylene	700 µg/m³	1 year	
24	Dichloromethane (Methylene chloride)	3 mg/m³	24hours	OSHA Method No 80
25	Trichloroethane	0.7 mg/m³	24hours	OSHA Method No 14
26	Dioxins/Furans	0.1 pg TEQ/m³	24 hours	USEPA Method 23
		0.6 pg TEQ/m³	1 year	
27	Total PCB	0.6 pg TEQ/m³	24 hours	
		0.035 pg TEQ/m³	1 year	

Note Mercury and Manganese shall be analyzed for only mining areas/communities.

5 Testing

5.1 Testing of ambient air quality and point source/stack air emission shall be carried out by the agency or a third party contracted by the agency. Equipment used for measurement shall be approved by the agency.

5.2 The testing laboratories shall use the test methods prescribed in this Ghana Standard or any equivalent International Standard test methods or other standard measuring instruments as shall be approved by the agency for air quality monitoring.

5.3 Measuring instruments shall for the purpose of this standard include;

5.3.1 Any standard apparatus for separating any air impurity from the gas or liquid medium in which it is carried; and

5.3.2 Any standard device to indicate or record air pollution or give warning of excessive air pollution.

6 Monitoring

6.1 Measurements of air quality (ambient and point source) shall take place at any facility as determined by the agency.

6.2 The agency shall determine

a. the number of sampling locations

b. the sampling points and

c. frequency of monitoring air quality at any facility.

6.3 Every facility with a point source shall have an orifice on each stack, chimney, hood etc.

6.4 The agency shall establish a network of air quality monitoring stations in all major cities in Ghana to monitor the trends in ambient air quality for policy formulation.

7 Compliance A

A facility shall be deemed to have complied with the requirements of this standard if after measurement and monitoring, the results show that emissions for all parameters as prescribed under clause 4 does not exceed the limits presented.