Advances in Research
4(4): 247-254, 2015, Article no.AIR.2015.079
ISSN: 2348-0394

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Assessment of Particulate Air Quality in Ho Municipality, Ghana

B. B. K. Keteku[1], N. Bakobie[1*], R. Adongo[1], A. B. Duwiejuah[1] and S. Sovoe[2]

[1]Department of Ecotourism and Environmental Management, Faculty of Renewable Natural Resources, University for Development Studies, Ghana.
[2]Environmental Protection Agency, Volta Region, Ho, Ghana.

Authors' contributions

This work was carried out in collaboration between all authors. Authors NB and RA designed the study. Author ABD performed the statistical analysis. Authors BBKK, NB and ABD wrote the protocol, and wrote the first draft of the manuscript. Authors BBKK, NB, ABD and SS managed the analyses of the study. Authors RA and BBKK managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AIR/2015/16031
Editor(s):
(1) Marco Trevisan, Faculty of Agricultural Sciences, Institute of Agricultural and Environmental Chemistry, Catholic University of the Sacred Heart, Italy.
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(3) Anonymous, Brazil.
(4) Anonymous, Greece.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=970&id=31&aid=8463

Original Research Article

Received 1st January 2015
Accepted 11th February 2015
Published 14th March 2015

ABSTRACT

Aims: The study was to assess particulate air quality in some selected areas in the Ho municipality.
Study Design: Thirty (30) samples were collected from ten (10) different sites in the Ho municipality using Mini Vol air sampler.
Place and Duration of Study: Samples were collected from ten (10) different sites in the Ho municipality in the months of October, January and February, 2013 and 2014 respectively.
Methodology: Samples collected were taken to Ho Environmental Protection Agency's laboratory for the analysis of the PM_{10} concentration levels.
Results: Most of the PM_{10} concentration values from the study were within the World Health

**Corresponding author: E-mail: nbakobie@gmail.com;*

Organization's standard. However, some values which were higher than 50 μg/m^3 and 70 μg/m^3 for WHO and Ghana EPA guidelines respectively. Based on Ministry of Population and Environment (MOPE) classification in Nepal, sample sites VRH and URB falls in "moderate" category (60 to 120 μg/m^3), sample sites EPA, HP, HK, GH, SB and L falls in "unhealthy" category (121 μg/m^3 to 350 μg/m^3) and sample sites CC and CP fall in "hazardous" category (< 450 μg/m^3) in the month of February.

Conclusion: The residents in some of the sampling sites could be at risk of the particulate air pollution.

Keywords: Air quality; Ghana; mortality; particulate matter.

1. INTRODUCTION

Most West African big cities are nowadays facing one of the biggest challenges of the millennium: to reduce air pollution in cities for improved quality of the living environment for citizens [1]. It is reported that indoor air pollution from solid fuel use and urban outdoor air pollution have caused about 3.1 million premature deaths every year worldwide and constitutes 3.2% of the global burden of disease [2]. In developing countries more than half of the global burden of disease from air pollution is borne by people. Air pollutants have been linked to some number of adverse health effects that include heart disease, respiratory infections and lung cancer [3]. Reduction of air pollution levels is expected to decrease the global health burden related to these illnesses. Efforts to significantly reduce concentrations of air contaminants will also lead to decrease in greenhouse gas emissions and mitigate the effects of global warming [3].

In most countries in Europe, ambient air quality has improved significantly in the last few decades. However, it is evident that exposure to air pollution, even at the levels commonly achieved nowadays in European countries, leads to adverse health effects. In particular, exposure to pollutants such as particulate matter and ozone has been found to be associated with increases in hospital admissions for cardiovascular and respiratory disease and mortality in many cities in Europe and other continents [4]. A well-established body of literature documents strong linkages between respiratory health and air pollution in both developed and undeveloped countries [5,6,7]. Greenstone and Gayer [8] suggest that pre-existing differences in mortality between high air quality attainment and non-attainment areas make inference less compelling. It is also not clear how well results from the developed world carry over to the developing world, given background differences in economic circumstance, access to health services and overall exposure to adverse environmental conditions.

Duflo et al. [9] provide a short survey on the recent literature that uses natural variation in ambient air quality to examine the effects of air quality on health, of particular interest are studies of the effects of 1997 forest fires in Indonesia, which were found to lead to higher infant mortality, higher respiratory-related hospitalizations [10] and lower in terms of measures of health status that are shown to correlate with lung capacity [11]. Particulate matter compounds respiratory and cardiovascular conditions and research shows that these particles are likely to be inhaled deep into the respiratory tract. Evidence relating to the possible effects of long term exposure to other common air pollutants (such as sulphur dioxide, nitrogen dioxide and ozone) is less well developed [12]. Airborne particulates are among the unhealthiest components of air pollution to humans. Particulate matter of aerodynamic diameter of less than 2.5 um can lodge deep inside lung tissue where they can stay throughout the life of a person. The sources of particulate matter can be natural as well as anthropogenic. Airborne dust, pollen grains, soil, or particles from the smoke and exhaust of automobiles, factories, and power plants all contribute to the total amount of particulates in the air. Fine particles are easily inhaled deep into the lungs where they may accumulate, react, be cleared or absorbed.

Transportation-related air pollution, which is a significant contributor to total urban air pollution, increases the risks of cardiopulmonary-related deaths and non-allergic respiratory disease. Some evidence supports an association of transportation-related air pollution with increased risks of lung cancer, myocardial infarction, increased inflammatory response and adverse pregnancy outcomes (for example premature

birth and low birth weight) [13]. Some scientific studies have linked particulate pollution exposure to a several of problems that include premature death of people suffering from heart or lung diseases, heart attacks that are nonfatal, aggravated asthma, irregular heartbeat, decreased lung function and increased respiratory symptoms (such as irritation of the airways, coughing or difficulty breathing). People suffering from heart or lung diseases, children and aged people are the most vulnerable to particle pollution exposure. Hence, the study was to assess particulate air quality and its related issues in the Ho municipality.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Ho in the Volta Region of Ghana (Fig. 1). The Ho municipality lies between latitude 6º20'1"N and 60º55'1"N and longitudes 0º12'1"E and 0º53'1"E and covers an area of 11.65 square kilometres. Monthly mean temperatures range between 22ºC to 32ºC whilst annual mean temperature range from 16.5ºC to 37.8ºC. The municipality shares boundaries with the Adaklu-Anyigbe District to the South, Hohoe Municipal to the North, South-Dayi District to the West and the Republic of Togo to the East. The total population of Ho municipality is about 271,881 [14]. The Region is located at latitude 3º45' N and longitude 8º45' N and covers a total land area of 20,572 km^2. Geographically, it lies at the eastern side of Ghana and shares boundaries with four major regions of Ghana namely, Greater Accra, Eastern, Brong Ahafo and Northern regions. It stretches from coast of gulf of guinea running through all the vegetation zones found in the country.

2.2 Experimental Design and Data Analysis

Air samples were collected from ten different sites in the Ho municipality. The samples were collected from different locations: Ho South, North, East, West and Central constituencies to ensure uniformity and avoid bias using a purposive sampling. Sampling was done within three months (October 2013, January 2014 and February 2014). A total of 30 samples were collected and the filters taken to the laboratory for analysis during the study period. Air Sampler (MiniVol) was carefully transported to the study site, verified and installed in the mounting cradle with the intake positioned upward in an unobstructed area of 30 cm from any obstacle to air flow and was placed on a firm level surface.

Fig. 1. Map of Volta region

The clean pre-separator/ filter holder assembly was removed from the plastic transport bag, the protective plastic bag under the rain cap removed, and the assembly quickly connected to the sampler at the top. The following information were recorded on the PM Field Data Sheet: number of the filter, the battery ID, ambient temperature, and barometric pressure, flow meter reading and elapsed time reading. Whilst depressing the snap buttons the pump and time assembly were lifted out by the top cap and rested on the edge of the sampler casing using the triangular pump mount stand. Care was taken not to pull the connecting wire loose or jar the pump hose fitting. The top of the cap was held preventing the grasped of the centre of the circuit board. The values taken were inserted into the formula below to derive the concentration mean. The data was subjected to Pearson's correlation analysis using Statistical Package for Social Scientists (SPSS) version 16 to determine the mutual relationship that exists between the sampling sites.

3. RESULTS AND DISCUSSION

The PM_{10} concentration levels recorded in the month of October ranged from 2 $\mu g/m^3$ to 32 $\mu g/m^3$ (Table 1). The minimum was obtained from Volta regional hospital whilst the maximum concentration was obtained from car park. The concentration levels of the various sites in October were within the World Health Organizational PM_{10} air quality standards of 50 $\mu g/m^3$ (24 hrs). This could be due to factors such as rain and wind which could have frequently reduced particulate concentration of the atmosphere at the various sites. Based on the classification of the MOPE's in Nepal's standards, it was realized that the values falls in the classification of "Good" (0 $\mu g/m^3$ to 60 $\mu g/m^3$) hence the particulate air was clean and risk free for residents in the month of October.

PM_{10} concentration levels recorded in the month of January ranged from 9 $\mu g/m^3$ to 89 $\mu g/m^3$ (Table 1). The minimum concentration in the month of January was recorded from Volta regional hospital whilst the maximum from car park. In the January, it was realized that 6 out of 10 sites were within the World Health Organization (WHO) standard of 50 $\mu g/m^3$ (24 hrs). However, only four of the sites namely Lokoe (53 $\mu g/m^3$), Soldier Barracks (60 $\mu g/m^3$), Civic Centre (83 $\mu g/m^3$) and car park (89 $\mu g/m^3$) were above the standards (Table 1). In Nepal classification the four sites above the WHO's standard were found in the range of 60 $\mu g/m^3$ to 120 $\mu g/m^3$ as "Moderate" under the MOPE's categories [15]. Hence, there is cause for concern since residents within those areas will not be risk free from air health related diseases. Particulate material of less than 10 microns in size may be inhaled into the respiratory system resulting in adverse health effects. Acute exposure to inhalable particulates can result in loss of lung function, onset of respiratory symptoms, aggravation of existing respiratory conditions and increased susceptibility to infection. These problems may occur to a greater degree in asthmatics, small children and the elderly with chronic respiratory and cardiovascular disease [16,17].

PM10 concentration levels recorded in the month of February ranged from 67 µg/m3 to 460 µg/m3 (Table 1). The minimum was obtained from Volta regional hospital whilst the maximum concentration was obtained from car park. Based on MOPE's classification in Nepal, sample sites VRH and URB falls in "moderate" category (60 $\mu g/m^3$ to 120 $\mu g/m^3$), sample sites EPA, HP, HK, GH, SB and L falls in "unhealthy" category (121 $\mu g/m^3$ to 350 $\mu g/m^3$) and sample sites CC and CP fall in "Hazardous" category (< 450 $\mu g/m^3$). Generally, results from the various sampling sites in the month of February indicated that residents are not risk free from polluted air which could be immediate or long term. The PM_{10} concentration levels generally increased in the last month of the study. However, there was a gradual increased in the PM_{10} concentration levels of air samples from the beginning of the study to the last month of the study.

The study observed that sampling site car park experienced persistent movement of vehicles that might have contributed to the high PM_{10} concentration levels through the exhaust from the vehicles. The proximity of the car park to the regional market which is also a source of dust for air pollution resulting from activities of the market buyers and sellers. These factors contributed to particulate air pollution. Since Burnett [18] reported that rapid urbanization, high influx of population, ever increasing automobiles and industrialization amidst urban areas are among the chief sources to increase air pollution. Hotels could also not be left out in considering some of those factors. This is because, hotels and other guest houses seldom around the sampling site use fossil fuels to generate power during an outage which in this case release exhaust into the air aiding strongly air pollution of which this

area is no exception in terms of some of those hospitality industries. As explained by Derwent [19] and Holman [20] combustion of fossil fuels for transportation, power generation and other human activities produce a complex mixture of pollutants comprising literally thousands of chemical constituents among the contributing factors.

Most cities are moving rapidly from peasant ways of production to real industrialization stage which Ho is not in exception. This exposes the town to many dangers associated with air pollution from industrial sectors where machines release exhaust and other toxic chemicals into the air. From observation, these two areas have the large population of people, the busiest side of Ho and are closer to some mountainous arena where fire is always rampant especially during dry seasons which by aid of wind could blow ashes and other available pollutants into those areas contributing to the high concentration levels of particulate matter. All these factors contributed to high PM_{10} concentration levels in the study. These findings are consistent with WHO [21] that reported that outdoor sources of air pollutants include vehicles, combustion of fossil fuels in stationary sources, such as power generating stations, and a variety of industries.

Forest fires and deliberate biomass burning, although intermittent sources of air pollution represent major sources of combustion pollution globally. Nature including volatile organic compounds released from trees, wind-blown soil, dust storms and sea spray can also be an important source of many trace gases and particles within the atmosphere. Exposure to particulate matter, including metals, has been linked to a range of adverse health outcomes, including modest transient changes in the respiratory tract and impaired pulmonary function, increased risk of symptoms requiring emergency room or hospital treatment, and increased risk of death from cardiovascular and respiratory diseases or lung cancer. Particulate matter is estimated to cause about 8% of deaths from lung cancer, 5% of deaths from cardiopulmonary disease and about 3% of deaths from respiratory infections [2]. There were strong positive correlations between the various sites at both 1% and 5% significant levels (Table 2). Hence, indicating common source of particulate air pollution in the Ho municipality.

Table 1. Shows PM_{10} concentration levels of air samples in the Ho municipality

Site	Oct	Jan	Feb
	Conc (μg/m^3) (24 hrs)	Conc (μg/m^3) (24 hrs)	Conc (μg/m^3) (24 hrs)
EPA	13	26	163
URB	6	16	94
VRH	2	9	67
HK	15	35	230
HP	12	36	202
CP	32	89	460
CC	28	83	433
GH	10	37	228
SB	17	60	346
L	12	53	261

Table 2. Correlation matrix of the sites

Site	EPA	URB	VRH	HK	HP	CP	CC	GH	SB	L
EPA	1									
URB	1.0*	1								
VRH	1.0*	1.0**	1							
HK	1.0**	1.0*	1.0**							
HP	1.0*	1.00**	1.0*	1.0*	1					
CP	1.0*	1.0*	1.0*	1.0*	1.0**	1				
CC	1.0*	1.0*	1.0*	1.0*	1.0**	1.0**	1			
GH	1.0*	1.0**	1.0**	1.0*	1.0**	1.0**	1.0**	1		
SB	1.0*	1.0*	1.0*	1.0*	1.0**	1.0**	1.0**	1.0**	1	
L	1.0*	1.0*	1.0*	1.0*	1.0*	1.0*	1.0*	1.0*	1.0*	1

**. Correlation is significant at the 0.05 level (2-tailed)*

***. Correlation is significant at the 0.01 level (2-tailed)*

3.1 Diseases and Their Respective Morbidity Returns from Ho Hospital

From Fig. 1 below, the outpatients' returns in October for males were 19 and that of females 5 for Asthma disease. Asthmatics according to Pope et al. [16] appear to be more susceptible to the impact of particulate and SO_2 exposure causing increase in respiratory symptoms and a decrease in lung function related to exposure to PM_{10}. In addition, diesel particulate has been shown to increase allergic response and might be a risk factor for the development of allergy and asthma. Particulate air pollution according to Romero-Placeres et al. [22] plays a major role in the incidence of acute / upper respiratory tract infections.

It was realized that there has been reduction in the number in the month of January for males to 10 whilst that of female increased to 11. The females reduced to 7 in the month of February whilst 4 were also recorded for the males and reduced by 6 as compared to January. However, the males recorded total of 79 persons and 68 females in the month of October for the upper respiratory tract infections. In January, there was reduction in the number of males to 67 whilst the female also reduced by 4 to 64. Finally, the number of males dropped to 60 with an increment of 70 females. The secondary data indicate residents in Ho municipality experiences particulate air pollution related diseases. However, this study cannot conclude by linking outpatients' returns to the monthly study since particulate air pollution have immediate and long term effect.

According to WHO [23] exposure to pollutants such as particulate matter and ozone has been found to be associated with increase in hospital admissions for cardiovascular and respiratory diseases and mortality in many cities across the globe. It has been estimated that about 6.4 million years of healthy lives are lost due to long-term exposure to ambient particulate matter [23]. Many diseases are linked up with particulate air pollution such as ischemia, upper respiratory tract infections, lung cancer and asthma. However, the data collected from the Volta regional hospital indicated that, there have been admissions on some of those diseases of which two were considered that is asthma and upper respiratory tract infections.

The outpatients' returns for upper respiratory tract infection was higher than that of asthma and mostly among 1-11 months old born babies which could be as a result of poor development of their respiratory system to resist such infections (Fig. 2). In terms of gender distribution, the males recorded the most outpatients of 206 which could be that the male counterparts were more susceptible to the infection as compared to the female side or were more exposed to polluted air than their female counterparts by virtue of their working environment (Fig. 2). For Asthma, the males still recorded the highest outpatients of 33 against 23 for the females (Fig. 2). This disease ranged from one year and above as recorded at the hospital. It was however discovered that, the number of outpatients admitted for upper respiratory tract infections were far above that of asthma.

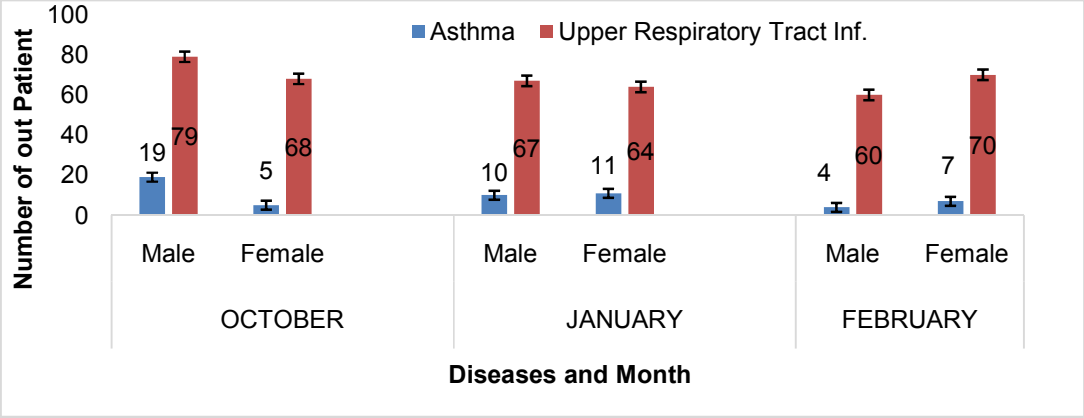

Fig. 2. Shows diseases related to air pollution cases recorded in the Hospital

4. CONCLUSION

Particulate matter (PM_{10}) concentration levels for October was within the WHO standards of air quality guidelines whilst in January and February most of the sampling sites exceeded the limits of 50 $\mu g/m^3$ (24 hrs). Based on MOPE's classification in Nepal, sample sites VRH and URB falls in "moderate" category (60 $\mu g/m^3$ to 120 $\mu g/m^3$), sample sites EPA, HP, HK, GH, SB and L falls in "unhealthy" category (121 $\mu g/m^3$ to 350 $\mu g/m^3$) and sample sites CC and CP fall in "hazardous" category (< 450 $\mu g/m^3$) in the month of February. The high concentration could be attributed to factors such as exhaust released into the atmosphere by automobiles including power generation by plants in mostly the hotels and guest houses. It was also detected that minor factors such as topography (terrain) such as mountains, valleys and weather, such as wind, temperature, air turbulence, air pressure, rainfall, hammarttan and cloud cover could also be contributors for the higher concentrations. The residents in the Ho municipality cannot be risk free from particulate air pollution. Since air pollution could lead to its related challenges such as hospital admissions on cardiovascular and respiratory infections such as asthma, ischaemia, lung cancers, and upper respiratory tract infections. This could finally lead to mortality on severe cases as a result of long and short term exposure to such conditions. Based on the findings of the study, the public should be informed of effective air particulate pollution reduction activities and associated health benefits. There should also be regular assessment of the air quality by EPA in order to put in measures to either mitigate or curb air pollution if feasible.

ACKNOWLEDGEMENTS

We wish to thank the staff of Environmental Protection Agency, Ho, for the analysis of the samples. Our profound gratitude also goes to all medical doctors and staff of the Volta Regional Hospital especially Mr. Benjamin Amedume (A.C.H.I.O) and Mrs. Rejoice Blebu for the release of secondary data on outpatients' morbidity returns of certain diseases.

CONFLICT OF INTERESTS

Authors have no conflict of interests regarding the publication of this article.

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Peer-review history:
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