(RESEARCH ARTICLE)

Assessment of air quality within Maiganga coal mining area in Akko Local Government Area, Gombe State, Nigeria

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Abstract

Anthropogenic activity especially coal mining contributes immensely to environmental pollution within coalmine and the host community especially if not well managed. This study is on the assessment of air quality in and around Maiganga coalmine, with the objectives of finding out the ambient concentration levels of criteria air pollutants within the coalmine, the Maiganga community and the four control sites 2km north, south, east and west of the coalmine, as well as compare the findings with the concentration levels of pollutants recommended as acceptable safety limits set by Federal Ministry of Environment, FMEnv. Six sampling locations were selected for detail assessment, with one point in each of the sites mentioned. Measurement of concentrations of criteria air pollutants; sulphur dioxide (SO_2), nitrogen dioxide (NO_2) volatile organic compounds (VOCs), carbon monoxide (CO), ammonia (NH_3), and ozone (O_3) were taken in-situ using Personal Toxic Gas Monitor (Tango TXI single gas monitor). Fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}), were collected using a Portable Counter HT – 9601 ($PM_{2.5}$ and PM_{10}) personal dust meter high volume gravity sampler. Volatile organic compounds (VOCs) were also measured using a Portable Hand Held Gas Detector (Porcheck+). The study was done during the dry season and the results revealed that, coarse paticulate matter (PM_{10}) was above the stipulated safety limit of $250\mu g/m^3$ set by the FMEnv for the coal mine area and Maiganga community but all other parameters were within the safety limits of the FMEnv. CO, NO_2, SO_2, and NH_3 in coalmine area had concentrations lower than in that in control areas because of other anthropogenic activities like burning, heating, waste disposal, agricultural practices and a host of others taking place in the control area and which are not available in the coalmine area. However, the concentrations of the aforementioned parameters were higher in Maiganga community than in the control areas due to higher rate of anthropogenic activities in the community than in the control areas. The hypothesis were tested using student t – test, and the alternative hypothesis was accepted which showed there was no significant variations in the values of fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), volatile organic compounds (VOCs), carbon monoxide (CO), ammonia (NH_3), and ozone (O_3) obtain from the coalmine, Maiganga community and the Control (N.S.E.W) with safety limits set by FMEnv. It is however, recommended that the Federal Ministry of Environment and National Environmental Standards and Regulations Enforcement Agency (NESREA) should ensure strict compliance with safety and environmental standards agreed upon during Environmental Impact Assessment (EIA).

Keywords: Assessment, Air Quality, Community, Pollutants, Particulate Matter

1. Introduction

Air pollution can make breathing difficult with children and the aged being the most vulnerable. Air pollution can cause thousands of illnesses, in extreme cases heart attack, stroke and irregular heartbeat can occur, which could lead to death. Air pollution also damages the environment as toxic pollutants and chemicals could form acid rain as well as ground level ozone that can damage trees, crops, wildlife, lakes and water bodies [1, 2]. It was observed that environmental

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pollution arises from economic and industrial activities, and that "industrial activities are the major contributors to pollution through thermal power generation, burning of fossil fuel and moving vehicles which emit harmful pollutants such as sulphur dioxide, nitrogen dioxide and carbon dioxide" [3]. According to National Collaborating Centre for Environmental health "Air quality impact both on the environment and health of the citizens, and air quality management aims to limit negative impact through a variety of activities, including legislations, policies and plans to manage emissions and monitor ambient air quality" [4]. Air pollutants are gases or particles in the atmosphere which have been linked to being harmful to human health or the environment. Pollutants can be categorized according to their formation (primary or secondary), their sources and their chemical composition and characteristics. Primary pollutants are released directly into the atmosphere while secondary pollutants are formed through reactions between pollutants already present in the atmosphere, also known as precursors. Fine particulate matter (particles smaller than 2.5 μm in aerodynamic diameter) is an example of both primary and secondary pollutants. These Particles can be formed directly through combustion processes, including activities involving wood burning or vehicle engines, and also formed through reaction between pollutants, such as oxides of nitrogen (N_xO_y), volatile organic compounds (VOCs) and oxide of sulphur (S_xO_y). Ground level Ozone is a secondary pollutant that is formed through a reaction between N_xO_y and VOCs in the presence of sunlight.

Major pollutants are classified into four main groups; criteria air pollutants, persistent organic pollutants, heavy metals and toxic pollutants [4]. Criteria air pollutants are typically the focus of air quality management activities, including pollutants monitoring and objective setting. Criteria air pollutants include: fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), volatile organic compounds (VOCs), carbon monoxide (CO), ammonia (NH_3), and ozone (O_3). It is a well-known fact that, coal mining activity or its operations from exploitation, mining, transportation and usage affects the environment and health negatively and can also be seen to contribute to the buildup of some, if not all, of the criteria air contaminants. Anthropogenic aerosols have a range of impacts on the climate and on human health for example, 'Smog' formed by an amalgam of 'smoke' and 'fog' generally affects the climate and human health [5]. The constitution of smog is as diverse as the sources that create them. In early cities, high densities of coal burning were a feature of smog. This was created from a mixture of smoke, sulphur dioxide and other components, which tend to react with other pollutants, in a kind of "toxic soup". A similar type of smog can be formed by erupting volcanoes, which emit high concentration of sulphur dioxide and particulate matter; which is generally referred to as 'smog' to distinguish it from a natural and generally more short- lived occurrence. It was asserted that, "the smog in our modern cities particularly in 1950's derived substantially from vehicular emissions and industrial fumes as well as from coal fires which combines and react with sunlight to form a range of secondary pollutants known as ' photochemical smog' which today affect nearly every large city on earth" [6]. Each year for example, air pollutant from coal burning kill between 5,000 and 200,000 people in the United States and causes at least 50,000 cases of respiratory diseases and several billion dollars property damage. Human exposure to air pollutants may result in a variety of health effect depending on the type of pollutants. Air quality assessment or monitoring is often used, to determine the pollution levels in urban or rural environments. A monitoring network produces concentration measurement that can be used to compare between the national and international guideline values.

The activities of human society, the economy, and production of goods, transportation and consumption, all affect the environment, directly or indirectly creating air pollution and host of other environmental problems. Since the advent of industrial revolution, over 200,000 chemicals have been introduced into our lives. Community studies of air pollution have a number of different types of adverse health effect from exposure to ambient pollution. World Health organization air quality guideline comprehensively reviewed health effect and it depends on the type of pollution, the level of exposure and personal susceptibility of an individual [7]. Typical health effects observed by studies include; reduced lungs functioning, asthma attacks, respiratory system failure, restricted activity, increased medication use, increased hospital admission, increased emergency room visit, development of respiratory diseases and premature death. The WHO guideline is based on experts' evaluation of current scientific evidence for particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) [7]

In all people living in polluted areas often get sick for a longer period of time than people in areas with less pollution, elevated levels of pollution has been linked to premature mortality. The higher mortality or morbidity rate requires public and private expenditure and creates human suffering that can be avoided in the future by directing societal development in cleaner air and especially reducing exposure levels. This can only be determined through proper scientific approach, hence the need for this study, air quality assessment of Maiganga coalmine community. Coal is said to be the dirties of all fuels, from mining to coal cleaning, from transportation to electricity generations to disposal, coal releases toxic pollutants into the air and land [8]. These disrupt ecosystem and endangered human health.

Air quality is an indication of the healthfulness of the quality of substances and particulate (liquid droplets or tiny solid particles suspended in the air), worldwide, more than 1.1 billion people live in urban areas with unhealthy air and

exposed to a number of pollutants [9]. The air quality problem date back to the industrial revolution which began in England in the mid – 1700s and spread to the United States in the 1800s. It was observed that, "the availability of coal led to the invention of steam engine to pump water and perform other task, and eventually an array of new machines powered by coal and later by oil and natural gas" [10]. In the industrial cities, coal smoke belching from a profusion of chimneys was so heavy which resulted to the death of many people mainly from lung ailments. Ash and soot covered everything, and some days the smoke was so thick that it blotted out the sun. Most air pollutants originate from anthropogenic activities [11]. Human exposure to air pollutants may result in a variety of health effect depending on the type of pollutants; the magnitude, duration and frequency of exposure; and the associated toxicity of the specific pollutants, numerous epidemiological studies have already shown or proved that, exposure to elevated levels of various pollutants affect human health. Air pollution is particularly severe in mega cities Such as Beijing, Seoul, Mexico city, Cairo, and a host of others. In each of these cities air pollutants exceeded World health Organization guidelines, at least for two of the pollutants monitored. In Mexico City, suspended particulate matter from vehicles and other sources contribute to about 6,000 deaths each year and 29 percent of all children have unhealthy blood lead levels. The World Bank estimated that if particulate matters levels alone were reduced to WHO guidelines, between 300,000 and 700,000 premature death per year would have been avoided globally. That is the equivalence of roughly 2 to 5 percent of all deaths in urban areas that have excessive level of particulates. In addition, chronic coughing in urban children under the age of 14 years could be reduced by half or about 50 million cases annually, reducing the chance that these children would face permanent respiratory damage. This can be considered as manmade environmental degradation and is illustrated (Figure 1).
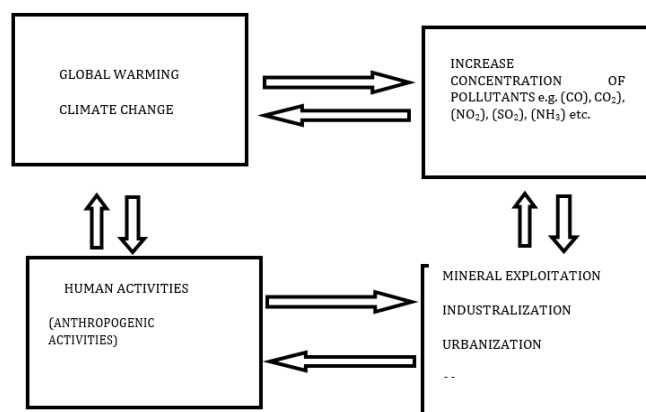
Figure 1 Diagram of Conceptual Framework of Causes and Effects of Environmental Degradation. Authors field work, 2019.

Table 1 Eight Major Air pollutants

Pollutant	Health and Environmental Concern	Environmental Source
Particulates	Respiratory and Visual Irritant	Dust Combustions And minerals Processes
Sulphur dioxide	Respiratory irritant, Vegetation damage	Combustion and minerals processes
Carbon Monoxide	Cardiovascular illness and Pulmonary System	Automobile Combustion mineral Processes, natural Sources
Nitrogen Dioxide	Respiratory illness and Lungs Damage	High Temperature Combustion And Natural Sources
Ozone	Respiratory Irritant, vegetation damage	Atmospheric Reaction
Lead	Retardation and Brain Damage	Combustions Minerals Processes And natural Sources
Hydrocarbons	Respiratory and Visual Irritant	Automobile Combustion And Natural Sources
Photochemical Oxidants	Respiratory and visual Irritant	Atmospheric Reaction, Vegetation Damage

Source: [12]

Table 1 shows the identified eight major pollutants that are particularly hazardous to public health and welfare under the Clean Air Act [13]

1.1. Air Pollution and Human Health

Air pollution is a major environmental health problem affecting everyone in developed and developing countries alike, during the Victorian era, London was known as "pea soupers". Concerns about London's air pollution date back to 1306, when fears about air pollution was sufficient for King Edward (1) to institute a ban on the burning of sea Coal. WHO estimates, that some 72% of outdoor air pollution – related premature deaths was due to ischemic heart disease and stroke while 14% of deaths were due to chronic obstructive pulmonary disease or acute lower respiratory infection, and 14% of deaths were due to lung cancer [14]. The assessment by WHO's International Agency for Research on Cancer concluded that, outdoor air pollution is carcinogenic to humans with the particulate component of air pollution which are more closely associated with increased cancer incidence, especially cancer of the lung [15. An association also has been observed between air pollution and increased in cancer of urinary tract/bladder. It has been asserted that "smog and other pollution problems have changed in nature with technological progress, giving rise to contemporary issues associated with petrochemical smog, which comprises of a complex mixture of nitrogen oxides and wide range of volatile organic compounds, both types emitted largely as result of the burning of fossil fuels and once released into the atmosphere, these substances in the presence of ultra violet rays of the sunlight lead to the formation of many noxious compounds including carbon monoxide, particulate matter, ground level ozone, sulphur dioxide and nitrogen dioxide" [6]

Air pollution is linked to a multitude of health impacts according to National Centre for Environmental Health [16], everyone is exposed to air pollution and for important pollutants like $PM_{2.5}$ and ozone, thresholds of exposure do not exist. For this reason, health impacts are expected at all levels of air pollution exposure. In general greater health impacts are seen for vulnerable groups, including children, the elderly and those with preexisting respiratory or cardiovascular diseases; this is true for both short – term and long - term exposures. From a public health perspective, $PM_{2.5}$ is considered the important ambient air pollutant, due to its numerous sources of emissions as well as its links with health impacts; therefore, it is most often studied by researchers. Short-term exposure (over hours, days, or weeks) to $PM_{2.5}$ is associated with several acute effects, including; respiratory inflammation and irritation, reduced lungs function and exacerbation of asthma and other pre –existing lungs diseases. Cardiovascular effects of short-term $PM_{2.5}$ exposure include; increased rates of myocardial infections, increased risk of cardiac arrhythmia, and increased rate of death due cardiovascular issues. Similarly, exposure to ozone and nitrogen dioxide (NO_2) have been linked to acute changes in lungs functions, during intermittent episodes of poor outdoor air quality such as those created by forest fires. Research shows that aside from regional impact, specific sources have an important local impact on air pollution and health. Localized sources such as traffic and wood smoke have been observed as sources of pollution hot spots and important contributors to community health impacts. Exposure to most air pollutants follows a gradient; those living closer to hot spot experience higher exposure compared to those living further away. For example, research indicates that living close to roads may be an independent risk factor for the onset of childhood asthma and may increase the risk of cardiovascular mortality.

1.2. Coal Mining and Impacts on the Environment

Coal mining is an activity of man that has been associated with some hazards and a list of historical coal mining disasters is a long one. Underground mining hazards include; suffocation, gas poisoning, roof collapse and gas explosion. According to a report by WHO, coal particulate pollution is estimated to shorten approximately 1,000,000 lives annually worldwide [17]. According to Tim Flannery Atmosphere coal and coal waste products (including fly ash, bottom ash, and boiler sludge) release approximately 20 toxic chemicals including arsenic, lead, nickel, vanadium, beryllium, cadmium, barium, chromium, copper, molybdenum, zinc, selenium, and radium which are dangerous if released into the environment, while these substances are trace impurities, when enough coal is been burned, significant amount of these substances are released [18]. Mercury is bio-concentrate in the food chain, as it is converted into methyl mercury, a toxic compound which harms both wildlife and people who consume fresh water fish. Coal mining releases methane, a potent greenhouse gas. Methane is the naturally occurring gas product released when coal deposits are formed from the decaying organic matter which is buried at an increased depth under increased temperatures and pressures over geological time. A portion of the methane produced is absorbed by the coal and later released from the coal seam (land surrounding disturbed strata) during the mixing process. Methane account for 10.5 percent of greenhouse gas emission created through human activity. According to Intergovernmental Panel on Climate Change (IPCC), methane has a global warming potential 21 times greater than, that of carbon dioxide over a 100 year time line. The process of mining can release pockets of methane. These gases may pose a threat to coal miners as well as a source of air pollution. Coal fired power and heat production is the largest single source of atmospheric mercury emissions [8]. According to United Nation Environmental Programme (UNEP), mercury and its compounds pose threats to human and wildlife, mercury is

toxic to the developing brain and exposure in the womb can cause learning disabilities, developmental delays and other serious health problem in children. According to Environmental Monitoring Group in Cape Town, South Africa and "Both ENDS", Amsterdam (2010), "Mpumalanga province is amongst the places with the worst air quality in the world due to coal mining activities". The Mpumalanga has long been seen as an area of bad air quality. Environmental Journalist, once compared Mpumalanga to Eastern Germany in extents of air pollution [19], and quoted studies showing stunted growth in children. A research was carried out in University of Pretoria which shows that respiratory infection in children less than 5 years of age in Mpumalanga province were higher in winter months, and peak in month of March and August, the year 2006 [20]. The most recent and the most comprehensive study of air pollution in Mpumalanga noted that elevated pollutants are SO_2, particulates (PM_{10} and $PM_{2.5}$) nitrogen oxides (NO_2) Ozone (O_3) benzene and H_2S. The study anticipated that the threshold for SO_2, and PM_{10}, NO_2, O_3 and benzene exceeded power generation fuel combustion by industries and institutions, domestic fuel burning and vehicle emissions contributed to all these. There is the assertion that "Coal is dirty and its mining and transport generates a great deal of dust, in the atmosphere, the loading and unloading site causing local air pollution problems" [11]. Since coal is a fossil fuel and it is formed from plant remnant, it contains sulphur, which was present in the proteins of the original plant. According to them, many miners suffer from black lungs diseases, a respiratory condition that result from the accumulations of fine coal dust particles in the miners' lungs. The coal particles inhibit the exchange of gases between the lungs and the blood. It was also observed that, " mining in the United States, has killed more than 100,000 miners and 250,000 or more retired US miners, suffer from black lungs disease, a form of emphysema caused by prolong breathing of coal dust and other particulate matter" [10]. It was also noticed that miners faced problem of death from a host of perils, including the formation of gases such as methane, carbon dioxide, hydrogen sulphide, and carbon monoxide, which is potentially a deadly gas devoid of color, taste and odor, the gas is extremely flammable and unlike carbon dioxide it sink as levels rise, carbon mono oxide is lighter than air and subsequently more dangerous [21]. Carbon monoxide competitively and reversely binds to heamoglobin, even more than oxygen, and even low levels of carbon monoxide can build up in the body causing death. Pollution resulting from carbon dioxide and suspended particulate matter may cause undue burden on the respiratory system and contribute to increased morbidity and mortality especially among susceptible individual in the general population [22].

1.3. Study Area

The study area is located within Akko L.G.A of Gombe State and lies between longitude 09°54'24.1°N and 09°54' 24.1°N, latitude 11° 8' 31.29° E and 11° 9' 44.63° E. The study area is located on this coordinates N 9° 59' 09.3'', E 11° 09' 03. 76'' (coalmine) and the community is on this coordinates N9° 58' 48.8'', E11° 08' 57.9'. The community covers a land area of about 2. 129.47 acres (48.165 Kmsq). Coal mining was discovered in the area in the year 2005 but operations began in the year 2007. The coal reserve is expected to serve Ashaka cement for the next 40 years, as present Ashaka cement is using this coal as alternative fuel.
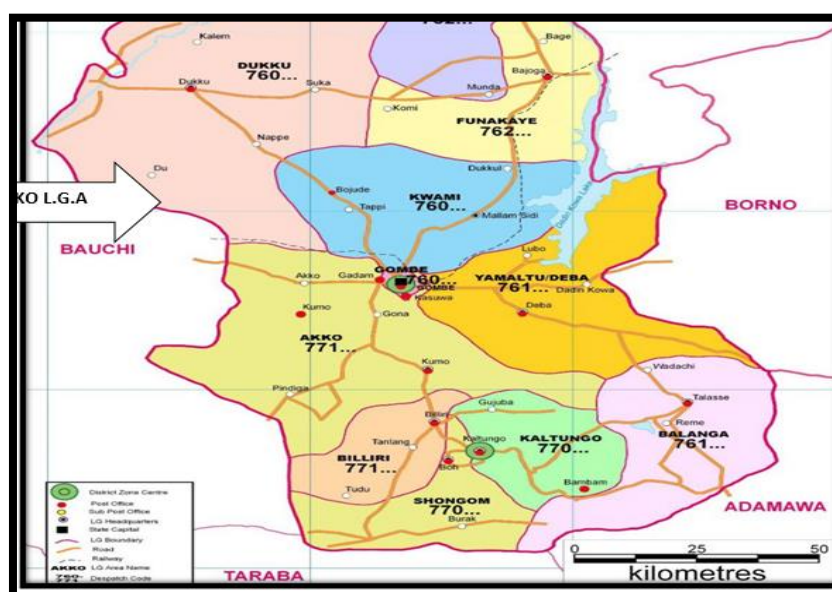

Figure 2 Gombe State Showing Akko Local Government Area

Figure 3 Google Earth of Maiganga Coalmine Showing Sample Points Indicated In Yellow Spot

2. Material and methods

The method adopted for this study was a universally acceptable procedure for data collection, sampling and analysis. Ambient air quality parameters (CO, NO_2, NH_3, SO_2, O_3) were measured using Personal Toxic Gas Monitor (Tango TXI Single Gas Monitor,), that uses electrochemical sensors. Total Suspended Particulate (TSP) that is airborne particulate matter were collected using a portable particle counter HT -9601($PM_{2.5}$ and PM_{10}) Personal Dust Meter High Volume Gravimetric Sampler. The sampling unit consists of a gas pump, a filter holder manifold connected to the sampling pump by a Teflon Tuber. And VOCs were measured with a portable hand held gas detector, Phocheck+, which is suitable for the detection of a verge range of volatile organic compounds (VOCs). The Phocheck+ uses a PID (Photo Ionization Detector) technology. The test gas is drawn into the chamber from Phocheck+ probe. It is caused by the chamber design to move across the face of a lamp window, emitting light particles, or photons of high UV energy. The Phocheck+ has two electrodes for the detection of organic compounds. The instrument has dynamic detection range spanning 1ppb up to 10000 ppm accuracy of ±5%. In this study, six monitoring sites were selected for the air quality assessment, the points were distributed around the project site, and four of the points were located 5km away from the project site, at remote location along the four cardinal points of the site North, South, East and West to act as control points. Samples were collected at high levels of between 1.5 to 2.0 meters above the ground level at each of the sampling points.

- Maiganga coalmine
- Maiganga community
- The four control sites located 2km away N, E, W, S of the Coal mine.

This is aimed at determining the concentration levels of pollutants mentioned and compared with safety limits set by the Federal Ministry of Environment (FMEnv) (Table 2).

Table 2 Air Quality Monitoring Equipment Used

Parameters	Equipment	Detection limit	Unit	Model Number
CO	CO Metre	0 – 25	$\mu g/m^3$	Tango TX1 Single Gas Monitor (CO)
NO_2	NO_2 Metre	0 – 20	$\mu g/m^3$	Tango TX1 Single Gas Monitor (NO_2)
NH_3	NH_3 Metre	0 – 50	$\mu g/m^3$	Tango TX1 Single Gas Monitor (NH_3)
SO_2	SO_2 Metre	0 – 20	$\mu g/m^3$	Tango TX1 Single Gas Monitor (SO_2)
O_3	O_3 Metre	0 – 20	$\mu g/m^3$	Tango TX1 Single Gas Monitor (O_3)
SPM	Dust Monitor	0 – 250	$\mu g/m^3$	Particles Counter HT 9601 ($PM_{2.5}$ and PM_{10}) Personal Dust Metre
VOCs	VOC Metre	0 -50	$\mu g/m^3$	CROWOON single Gas Monitor VOCs)

Source: [23]

Figure 4A   A cross section of Air Quality Monitoring Equipment,Field work, 2019

Figure 4B Air Quality Assessment at Maiganga Coalmine, Field work, 2019

Figure 4C Photograph of houses bordering the Coalmine, with open space exposed already to the impact of Particulate Matter on Maiganga Community, Field work, 2019

Figure 4C Photograph showing houses and vegetation in Maiganga Community

2.1. Sources and types of Data

Sources of data for this study were from primary and secondary sources collection procedure. The primary sources include field survey which involves in-situ measurement or assessment of air quality in the coalmine area, the Maiganga community, and the four control sites 2km away N.E .W .S of the coalmine area. The secondary source also includes information from journals, textbooks, thesis, Newspapers, encyclopedia and internet. The population of Maiganga community was 355 according to 2006 census and about 105 worked at the coalmine. The technique for analysis focused on presenting the data and testing of hypothesis so as to infer variance or otherwise. The statistical methods used for this study were descriptive statistics such as mean, standard deviation and coefficient of variation, the data was subjected to student t – test for comparison of mean difference between the survey values and the standard value Federal Ministry of Environment Safety Limit.

2.2. Statistical Analysis

This focuses on presenting the data and testing of hypothesis so as to infer variance or otherwise. The statistical method that was employed in this research, is the descriptive statistics such as mean, standard deviation and coefficient of variation, the data was subjected to student t – test for the comparison of mean difference between the survey values and the Federal Ministry of environment safety limit.

The student t- test is a parametric statistical tool used to test hypothesis about the differences between means of groups when sample size are small. Essentially, that t – test is used to determine whether two means $\bar{X}_1$ and $\bar{X}_2$ are significantly different at a chosen level of significance. It also involves the comparison of actual mean difference with the difference that is expected by chance. As long as the population from which sample are drawn can be assumed to be normally distributed, the t – test can be used.

t – Test formula is as given in equation (1) below;

$$t = \frac{\bar{X}_1 + \bar{X}_2}{S} \qquad\qquad (1)$$

Where S_{Dx} = Standard error of difference between means, $\bar{X}_1$ and $\bar{X}_2$ are the mean for survey values and the Federal Ministry of Environment safety limits respectively. S is as given in equation (2) below.

But
$$S = \sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}} \qquad\qquad (2)$$

Where S^2 = Variance of group given by equation (3) below;

$$S^2 = \frac{\sum X_2{}^2 - \frac{(\sum X_2)^2}{n}}{n - 1} \qquad\qquad (3)$$

Where n is the number of observations.

Therefore S in equation into equation, t will be as given in equation 4 below;

$$t = \frac{\bar{X}_1 + \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \qquad (4)$$

Descriptive statistical analysis deal with methods and techniques of summarizing and describing information, it tends to describe incidences, events, qualities in the elements.

3. Results and discussion

Table 3 Air pollutant concentrations ($\mu g/m^3$) at the coalmine, Maiganga community and the control sites

Sample Location	GPS Point	Pm$_{2.5}$	Pm$_{10}$	CO	NO$_2$	NH$_3$	SO$_2$	VOC	O$_3$
Coal Mine (AQ1)	N9°59' 09.3'' E11° 9'03.76''	79.00	359.00	0.00	0.00	0.00	0.00	0.00	0.00
Maiganga Com. (AQ2)	N9°58' 48.8'' E11° 8'57.9''	78.00	358.00	2.30	0.01	0.01	0.01	0.00	0.00
Control - N (AQ4)	N9°59' 47.9'' E11° 08'41.1''	67.00	177.00	0.00	0.02	0.00	0.00	0.00	0.00
Control – S (AQ6)	N9°59' 58'.36'' E11° 08'49.3''	49.00	153.00	1.50	0.0	0.01	0.10	0.00	0.00
Control – E (AQ3)	N9°59' 19'.9'' E11° 09' 39.9''	53.00	163.00	0.70	0.02	0.01	0.01	0.00	0.00
Control – W (AQ5)	N9°59' 11'.3'' E11° 08' 10 .3''	46.00	180.00	0.50	0.00	0.00	0.01	0.00	0.00

Table 3 shows the concentration of air pollutants measured for fine particulate matter PM$_{2.5}$ and coarse particulate matter PM$_{10}$, CO, NO$_2$, NH$_3$, SO$_2$, O$_3$ and VOCs at various sampling points, the coalmine (AQ1) and Maiganga community (AQ2). Sites AQ4, AQ6, AQ3, and AQ5 shows the concentrations of the parameters of air quality mentioned above as the control values.

Table 4 Ambient air quality parameters from the coalmine, Maiganga Community, control with safety limits set by FMEnv.

Parameters	Coal Mine (AQ1) ($\mu g/m^3$)	Maiganga Comm. (AQ2), ($\mu g/m^3$)	Mean Control Value (AQ4, AQ6, AQ3, AQ5) ($\mu g/m^3$)	FMEnv, (1991) ($\mu g/m^3$)
CO	0.00	2.30	0.675	10.00
NO$_2$	0.00	0.01	0.055	0.04
NH$_3$	0.00	0.01	0.00525	0.20
SO$_2$	0.00	0.01	0.003	0.01
VOCs	0.00	0.00	0.00	0.10
O$_3$	0.00	0.00	0.00	0.10
PM$_{2.5}$	79.00	78.00	53.75	250.00
PM$_{10}$	359.00	358.00	168.25	250.00

3.1. Source Field Work 2017, FMEnv [24]

Table 4 shows the comparison of measured ambient air quality parameters at the coalmine and Maiganga community with mean control values and ambient air quality standards set by FMEnv. The results revealed that at the coalmine the mean concentrations for the parameters were CO (0.00), NO_2 (0.00), NH_3 (0.00), SO_2 (0.00), VOCs (0.00), Ozone (0.00), $PM_{2.5}$ (79.00) and PM_{10} (359.00) $\mu g/m^3$. All these values are below or within the standards stipulated by FMEnv for ambient air quality standards of CO (10.00), NO_2 (0.04), NH_3 (0.20), SO_2 (0.01), VOCs (0.10), O_3 (0.10) and $PM_{2.5}$ (250.00) $\mu g/m^3$ but the concentration of suspended particulate matter is 359.00 ug/m^3 which exceeded the FMEnv ambient air quality standard of 250.00 $\mu g/m^3$. At the Maiganga community the ambient air quality had concentrations CO (2.30), NO_2 (0.10), NH_3 (0.01), SO_2 (0.01), VOCs (0.00), and Ozone (0.00) $\mu g/m^3$ which are below the stipulated FMEnv ambient air quality standards. The concentration of Fine particulate matter ($PM_{2.5}$) in Maiganga community is 78ug/m^3 which is below the stipulated maximum ambient air quality safety limit set by FMEnv while the concentration of suspended particulate matter is at 358ug/m^3 which exceeded the FMEnv ambient air quality standard of 250.00 $\mu g/m^3$. The mean of measured ambient air quality parameters at the control points are all below the standard values recommended by FMEnv.

Values of particulate matter $PM_{2.5}$ (fine) and PM_{10} (coarse) in the coalmine are slightly higher than those recorded in Maiganga community and both are higher than those of the control points and the standards recommended by FMEnv and that could be attributed to the effect of dust from coal mining activity in the area. For CO, NO_2, NH_3 and SO_2 no values were recorded in the coalmine area which implies that these gases may not be associated with the dust from coal mining. But these gases were observed to be present in Maiganga community and slightly in control points but were however below the recommended limits by FMEnv. The presence of these gases in the community could be attributed to other anthropogenic activities of man that generates them such as wood burning or fumes from vehicle exhausts and a host of others and this agrees with the report on the research work done on air pollution monitoring around residential and transportation sector locations in Lagos which was due to urbanization and industrialization [25].

Table 5 Comparison of mean values for coalmine, Maiganga community and control points with standards from FMEnv at 0.05 level of significance, and at degree of freedom (df) = 14

Sample Locations	t- Values
Coalmine (t_c)	– 0.00015011
Maiganga community (t_m)	– 0.00015
Control points (t_{cp})	– 0.0787

Table 5 shows the t-values obtained using equations (1) to (4) for ambient air quality parameters in coalmine area, Maiganga community and control points in comparison with the standard values recommended by FMEnv. In calculating the t-values, the mean values for each location that of the standards are normally used.

3.2. Hypothesis

Ho: there is a significant variation in the values of fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), volatile organic compounds (VOCs), carbon monoxide (CO_2), ammonia (NH_3), and ozone (O_3) obtained from the coalmine, Maiganga community and control points with safety limits set by FMEnv.

H1: there is no significant variation in the values of fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), volatile organic compounds (VOCs), carbon monoxide (CO_2), ammonia (NH_3), and ozone (O_3) obtained from the coalmine, Maiganga community and control points with safety limits set by FMEnv.

The findings of this study shows that, there is no significant variation in the values of fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}), sulphur dioxide (SO_2), nitrogen dioxides (NO_2), volatile organic compounds (VOCs), carbon monoxide (CO), ammonia (NH_3) and ozone (O_3), obtained from the coalmine area, Maiganga community and the control sites with safety limits recommended by FMEnv. This is because at 0.05 level of significance, and at degree of freedom (df) = 14, the t – calculated value exceed the critical or the t – table values. Since the calculated t – values are as follows; t_c = – 0.00015011, t_m = – 0.00015 and t_{cp} = – 0.0787 it shows that, they are all less than the table value of t, which is 1.76 at 0.05 levels of significance and at (df) 14. Hence Ho is rejected and H1 is upheld since it has been shown clearly

that there is no significant variation between ambient air quality parameters at the different locations and the standard values from FMEnv.

4. Conclusion

The research work revealed that there is no significant variation in ambient air quality parameters in the different locations and the standards recommended by FMEnv. However, the values of particulate matter PM_{10} (coarse) at the coalmine and also at the Maiganga community, 359.00 $\mu g/m^3$, and 358.00 $\mu g/m^3$ respectively are higher than the value of 250$\mu g/m^3$ set as safety limit by Federal Ministry of Environment which suggests pollution. This problem of particulate matter (PM_{10}) agrees with the report by Joint Initiative of Environmental Group in Cape Town, South Africa (2010) where "elevated level of pollutants were found to be at Mpumalanga coalmine including PM_{10} which was actually noted to be the reason for a host of health challenges in Mpumalanga Community, South Africa and it was then concluded that particulate matter was really a problem in the area. The implication is that, coalmine workers and residence of Maiganga community are at a risk of exposure to higher concentration level of (PM_{10}) with its associated health problems.

Compliance with ethical standards

Disclosure of conflict of interest

Authors declared that there is no conflict of interest.

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