AIR QUALITY CONCERNS IN AFRICA: A LITERATURE REVIEW

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DOI: 10.29322/IJSRP.8.5.2018.p7776
http://dx.doi.org/10.29322/IJSRP.8.5.2018.p7776

Abstract- Air Quality; both indoor and ambient is a worldwide concern. It estimated by The World Health Organisation that Air pollution caused up to 7 million premature deaths every year owing to mainly heart disease, stroke, respiratory diseases and cancers.[1] Many developed and developing countries such as USA and China are investing heavily in controlling and fighting Air Pollution. However, there seem to be little sign of concern in African countries on Air Quality issues. There is simply strong evidence in study papers that air pollution in Africa has reached worrisome levels and that this problem is being ignored by authorities in many corners of the continent. Results of Studies carried out all over Africa show unprecedented levels of Pollutants; PM2.5, PM10, NOx, SO2, CO2 and many others in the air. The studies also show catastrophic effects of such pollution on health and the socio-economic lives of people. As the countries in Africa are making effort to grow their Economies, the Air Pollution concerns are similarly increasing. This paper summarizes significant finding in literature on the air quality in Africa; including air pollutants, related sources, levels and concertation, mitigation measures and potential health effects. There are also recommendation that may help to change present picture of Air Quality management in Africa.

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Index Terms- Air pollutants, Heath Assessment, Mitigation Measures, Africa

I. INTRODUCTION

Air Pollution is currently a worldwide problem. It is regarded as one of the main contributors to morbidity and mortality worldwide.[2] To date, both outdoor and indoor air pollution, is arguably one of the biggest environmental risk to health, it is estimated to be responsible for about one in every nine deaths per year. It is estimated that outdoor air pollution on its own caused around 3 million deaths each year, as a result of non-communicable diseases.[3] Air pollution is also taunted as a cause of many other health problems such as chronic obstructive pulmonary disease (COPD) linked to enhanced ozone (O3), and acute lower respiratory illness (ALRI), cerebrovascular disease (CEV), ischaemic heart disease (IHD), COPD and lung cancer (LC) which is linked to PM2.5.[4] As Air pollution continues to rise at a high rate due to increased human activities, it is in turn affecting economies and people's quality of life; it is in fact a public health emergency[3]. While it has been a popular phenomenon in Asia, Europe and America in the past decades, Air Pollution is rapidly becoming of a vital concern in Africa. Both indoor and outdoor pollution is presumed to be on the rise; there is increased burning of rubbish and cooking indoors with inefficient solid fuel cook stoves, enormous number of small diesel generators, cars which have had the catalytic converters removed and other petrochemical plants, all emitting pollutants into the continent's atmosphere. Ambient air pollution from traffic, fuel power generation and industries is increasing at a rapid rate, especially in fast-developing countries such as Egypt, South Africa, Ethiopia and Nigeria. This makes Air pollution a serious and worsening health problem in all the growing cities in Africa[5]. The deterioration of air quality in Africa is attributed to enhance by rapid population growth and increased vehicle ownership, accelerated use of solid fuels and poor waste management practices. Industrial expansion is also repeatedly mentioned as a major contributor to the worsening air pollution[6]. Dating back to the time the initial measurements of high concentrations of CO over tropical Asia, Africa, and South America were made available by the MAPS instrument launched in 1981 on the space shuttle Columbia, it became clear that air pollution was a global issue. The images showed not only that industrial air pollution from fossil fuel combustion could affect regional and global air quality, but that emissions from biomass burning were important as well, confirming the hypothesis of Crutzen et al. This meant that communities in less developed regions, as well as residents of industrialized and rapidly developing countries, could suffer from air pollution generated elsewhere.[7]

Studies conducted throughout Africa have shown that air pollution from all the sources adversely affects people's respiratory health. Despite this realization however, little attention has been paid to the issue and in so doing, the control of this man-made hazard very difficult. [8] In order to woe foreign investments into their mining sectors, many countries in Africa have been and are willing to overlook instances of mining company non-compliance with environmental standards and regulations. Such acts have led to high levels of pollution in many mining areas.[9] This however is causing big problems on both the African people's health and the continent's economy. It is estimated by scientific studies that almost 600'000 people in Africa alone each year due to air pollution related sicknesses.[10] Economically, it was estimated that as at 2013, the African continent incurred costs up to USD 215 billion as a result of outdoor air pollution related premature deaths. While USD 232 billion was the estimated cost of premature deaths from household air pollution [11]

Several studies that provide evidence to the fact that Air Quality is of great concern in Africa resulting from the increase in the emission of Pollutants and expansion Pollutant sources, were reviewed. The studies also reveal the extent to which Air pollution is affecting the health of people in Africa as well as their social and economic lives. Despite the overwhelming evidence of increased Air pollution in Africa, there are also revelations in some studies that the problem is being ignored in the continent and only a few countries are implementing Mitigation measures. This is supported by lack of data which make the estimates limited both by the lack of air measurements and the lack of medical studies linking pollution to deaths in Africa.

II. Air Pollutants and Sources in Africa

In developing countries, sources of air pollution range from transportation and industrial pollution, biomass burning and coal fuel use, to suspended soil particles from unpaved roads[12] These sources are to some extent different from those in many other regions. The literature from different studies show different pollutants from varying sources across the whole continent. Air pollution in Africa appears to be rising with respect to key pollutants.[13]. Many studies revealed the main cause of urban air pollution as the use of fossil fuels in almost all industrial and domestic sectors. The pollutant concentrations are presumed high over the industrialized regions (Morocco, North Algeria, Tunisia and Eastern Algeria), where they account for about 60–70 % of the total sulphate. Concentrations of NAS are also high over Western Algeria and Eastern Algeria.[14] The burning of fuelwood and agricultural wastes also contributes to high pollution levels.[13] It is estimated by one of the reviewed studies that about 700 million people depend on solid biomass fuel and use simple cook stoves located in poorly ventilated kitchens in Sub Saharan Africa. This results in high concentration indoor air pollutants. The access to less polluting types fuels is very limited for the majority of people in SSA (Rao and Pachauri, 2017) as such people resort to obtaining energy from biomass fuels, such like wood, agricultural wastes and animal dung (Amegah and Agyei-Mensah, 2017; Sulaiman et al., 2017).[15] Scientific studies show that approximately 90% of African households depend on biomass fuels.[16]. Another noticeable source of Air pollutants in Africa are the Deserts. Studies reveal that winds transport large amounts of dust from Sahara desert to the Americas, North Africa, and ven Europe. It is estimated by one of the studies that the Sahara and its margins inject between 600 and 900 106 tons of dust into the atmosphere each year (D'Almeida, 1986; Marticorena et al., 1997; Callot et al., 2000).[17] Other studies reviewed have included the use of heavy machinery as another major source of air pollutants in Africa. The use of heavy machinery in extractions and constructions in many countries in Africa, generates a lot of dust which contribute of respiratory disorders (Ayine, 2001; ILO, 2005; Kumah, 2006). However, such damages are not really carefully looked carefully as a hazard. Some practitioners argue that the desire by many African nations to earn foreign exchange weakens their resolve to pass and enforce, mining-related environmental regulations (McMahon, 2011).[9]

The high concentrations of dust for long periods of time, and the interaction between dust and other man-made air pollution, raise eyebrows about negative health effects and a need for appropriate interventions by health authorities.[18] Air pollution in Africa thus has many causes; purely anthropogenic factors like industrial, road traffic and biomass fuel use. All these are releasing pollutants into the atmosphere and contributing to the deterioration of the air quality. In addition, dust particles, whether of natural origin or manmade, from bush fires or practices that lead to desertification, affect air quality (O'Hara et al., 2000; Sunnu et al., 2008; Zender et al., 2004).[19] Another study conducted in Africa concluded that Air pollution in urban areas in Africa comes from many and different sources. One of the most important source of the classical pollutants; sulfur dioxide (SO_2), nitrogen oxide (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs) and particulate matter (PM) is fossil fuels; particularly the burning of fuels. While yet another study went a step further and classified the pollution sources in Africa into three; namely mobile sources, stationary sources, and open burning sources. The sources can further be categorized into groups like motor traffic, industry, power plants, trade and domestic fuel.[20] Southern Africa is globally regarded as a significant source region of atmospheric pollutants, for instance a prominent NO_2 hotspot is seen on global maps of NO_2 satellite retrievals over the South Africa. [21] Biomass burning is a relatively small source category with a contribution of 5% globally; its areal range is large. It is presumed as the main source of air pollution in Canada, Siberia, Africa, South America and Australia. The annual mean PM2.5 in these countries is below the concentration–response threshold. In the Southern Hemisphere biomass burning is categorized as the leading contributor of PM2.5. In Brazil it is estimated to contribute about 70%, and in some African countries its impact can go as high as 90%. For example in Angola[4] .Emissions from solid fuel use in households are detrimental to health, especially in households where there is no proper ventilation or improperly designed cook stoves that do not have flues to evacuate the smoke resulting from incomplete combustion. Inefficient burning of fuels produces toxic products such as particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), oxides of nitrogen (NO_x) and sulphur dioxide (SO_2).[22] This is the same in crude oil refineries, fertilizer industries and power plants; some of which are located in the Atlantic coast of Morocco, Northern Algeria, Easter Algeria and Tunisia; these greatly contribute to mixing desert dust with particulate pollutants such as nitrate, sulphate and ammonium.[14]

Several studies conducted in various countries in Africa revealed different types of pollutants with different levels. For instance a study carried out in Algeria found the annual average concentration of PM_1, $PM_{2.5}$ and PM_{10} to be 18.24, 32.23 and 60.01 $\mu g\ m^{-3}$ respectively. While PM_1, $PM_{2.5}$ and PM_{10} concentrations in roadside varied from 13.46 to 25.59 $\mu g\ m^{-3}$, 20.82–49.85 $\mu g\ m^{-3}$ and 45.90–77.23 $\mu g\ m^{-3}$ respectively. In an urban station, the PM_1, $PM_{2.5}$ and PM_{10}concentrations were found to be varying from 10.45 to 26.24 $\mu g\ m^{-3}$, 18.53–47.58 $\mu g\ m^{-3}$ and 43.8–91.62 $\mu g\ m^{-3}$.[23] The magnitude of air pollution is attributed to the poor combustion of the ever increasing fleet of cars. The fleet of cars to another disadvantage is that it is has a higher proportion of diesel cars which some of them are too old and even poorly maintained. It is also important to note that in the areas under discussion, the use of unleaded gasoline is still very low. In a study conducted in Burkina Faso, large spatial and temporal variations were found that showed a poor air quality situation, with very high levels of PM_{10}, exceeding WHO air quality guidelines.[24] Important sources are said to be transported dust and re-suspension of dust from unpaved roads, not forgetting vehicular emissions and biomass burning.[24] While in another study in the same country, Cl, K, Ca, Ti, Mn, Fe, Cu, Zn, Br, Rb, Sr, and Pb were also found in the samples. The particle mass concentration was found to be 27–164 μg/m^3 while BC varied between 1.3 and 8.2 μg/m^3 [25]. A study conducted in Kenya, positive matrix factorization analysis identified up to five source factors of PM2.5 in the capital city Nairobi. These are; traffic, mineral dust, industry, combustion and a mixed factor (composed of biomass burning, secondary aerosol and aged sea salt). The study estimated that Mineral dust and traffic factors contribute to about 74% of PM2.5.[26] This is similar to the results of a pilot study conducted in the same country which found that roadway concentrations of PM2.5 were estimated to be about 20-fold higher than those from the urban background site, while black carbon concentrations differed by 10-fold.[5] In Cameroon, the comparison of the roadside concentrations in Douala and the guidelines of the WHO showed a great exceedance of up to approximately 300%, specific to the scenario.[27] In a separate study carried out in Ghana, $PM_{2.5}$ and PM_{10} were estimated to be as high as 200 and 400 μg/m^3, respectively, in some parts of the path.[12] There is evidence of the contributions from biomass and traffic sources, as well as from geological and marine non-combustion sources to particle pollution.[28] Results of a comprehensive study carried out in Tanzania showed that hourly average sulphur dioxide concentration range from about 127 to about 1385 μ g/m^3. The measured values of sulphur dioxide were well above the WHO recommended guidelines with an hourly objective value of 350 μ g/m^3 at 87%. The hourly average suspended particulate matter ranged from about 98 to about 1161 μ g/m^3, which also exceeded the 230 μ g/m^3 WHO recommended value at 87% of the sampling sites.[29] In a study done in South Africa, the average annual outdoor concentration of PM10, NO2 and SO2 captured was 48.3 +/- 43.4, 11.50 +/- 11.6 and 18.68 +/- 25.4 mu g/m(3), respectively, whereas the South African National Outdoor Air Quality recommend 40, 40 and 50 mu g/m(3) for PM10, NO2 and SO2, respectively.[30] However, some areas in the same country, the levels are much higher as a result of the economic activities taking place, for example in the city of Durban ; this is a city with Africa's busiest port and a key hub for crude oil and exported refined petroleum and petrochemical products, as such it experiences a mixture of pollutants that reflects emissions from such sources as , traffic, industry and biomass burning.[31] The trend is also the same in several other African countries. In Kenya, the urban concentrations observed by a study raised some concerns as regards public health and policy. Looked at it together with survey data on commuting patterns within Nairobi, the results suggested that many people in Nairobi are exposed to high concentrations of fine particle air pollution on a regular basis. These have the potential of causing serious long-term health implications.[32] This is also the case in Egypt, where PM and lead are presumed the major pollutants. The average $PM_{2.5}/PM_{10}$ ratio for all paired measurements made during the baseline year and the consecutive three years was 0.51.[20]A comparison study carried out in three countries; Tanzania, Burkina Faso and Botswana on Particulate Matter also revealed similar results; the spatial and temporal variations of PM2.5, PM10 and TSP in these three countries were investigated with portable particle counters. Soil derived dust was found to be the main source of particles in three studied cities of the three counties. PM2.5/PM10 ratios were low (0.1–0.3). Relatively high levels of TSP and PM10 were also observed within the urban areas of Dar es Salaam in Tanzania and Gaborone in Botswana. [33] A separate study showed that whether based on daily, monthly, seasonal, or annual PM10 concentrations measured in the four West African stations, the dust concentrations were extremely higher compared to the air quality standards defined by the WHO, the European Union and the United States of America.[34]

It is interesting that most of the reviewed studies tend to agree on the type and levels of pollutants in the atmosphere in the African region. Furthermore the studies are attributing the rise in air pollution to the same or similar causes, the studies suggest that pollution levels may be rising in Africa as a result of the ever increasing car fleet on the continent which is building on already high concentrations of PM in many locations resulting from climatic and geographic conditions. Biomass burning and industrial activities, located in cities, further accelerate the levels of PM in the air.[35] The Pollution from biomass burning however does not only feature in Cities but also in rural areas with the poor masses where it poses the greatest health concern. Unvented burning of biomass for fuel is currently taunted as one of the main killers in the world.[36] In developing countries throughout the world, it is obvious that burning of biomass produces a very hazardous mixture of air pollutants. More than 2,000,000 people, mainly women and children, are estimated to be dying annually from such pollution (Smith, 2003). This is one of the main environmental and health problem of the world, which is vividly not recognized enough by authorities.[36] The use of crop residues, animal dung, crop waste, and other solid wastes for cooking, lighting and heating is an important source of air pollutants in Africa. It is estimated that 82% of people in Africa primarily depend on solid fuels for cooking. The majority of these people live in rural areas where they do not even have access to any of the modern forms of energy such as gas or solar. Inefficient burning of such solid fuels with traditional cook stoves or in a popular African three-stone place in open, generates smoke with significant amounts of toxic air pollutants which include carbon monoxide (CO), particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen oxide (NO_x) and sulphur dioxide (SO_2), which a huge health hazard, especially to women and children who spend most of their time in the household where exposure to concentrations of air pollutants from such emissions is considerably high.[22] In addition to household and crop residue burning, anthropogenic savanna fires in sub-Saharan Africa is also presumed to be emitting a lot of smoke that affects cloudiness in the African region.[37]

The table below summarizes the Air Pollutant sources in Africa;

Air Pollutant Sources	**Air Pollutants form the Sources**
Industries	NAS, Sulphate, PM10, PM2.5, VOCs
Biomass Burning	($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), oxides of nitrogen (NO_x) and sulphur dioxide (SO_2)sulfur dioxide (SO_2), nitrogen oxide (NO_x),

	carbon monoxide (CO), volatile organic compounds (VOCs) and particulate matter (PM)
Oil Extraction	sulfur dioxide (SO_2), nitrogen oxide (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs) and particulate matter (PM) is fossil fuels
Transportation (Vehicles)	(NO_x), carbon monoxide (CO), volatile organic compounds (VOCs)
Construction	Fine dust particles
Deserts	Fine dust particles
Power Generation	PM_1, $PM_{2.5}$ PM10, VOCs

Table 1: Air pollutant and their sources in Africa.

III. Air Pollution and Health Assessment in Africa

Compared to the air pollutant and sources studies above, air quality research related to health assessment is much less in Africa. This is another indication that this field is being ignored somehow. It is vivid from many studies that the greatest health impacts from air pollution worldwide occur among the poorest and most vulnerable populations. The amount of exposure in terms of, exposure intensity, the number of people and time spent exposed is said to be far greater in the developing countries (Smith, 1993); it is estimated that 76% of all global particulate matter air pollution occurs indoors in the developing countries.[2] Indoor air pollution from biomass fuels disproportionately affects children and women and is said to be one of the causes of significant global mortality and morbidity. According to the reviewed literature, this is a neglected area of global disease that affects a large number of people throughout the world.[2] According to the reviewed studies, The main health effects associated with the exposure to concentrations of air pollutants from emissions are lung cancer, chronic bronchitis, heart disease, stroke, lower respiratory infections, cataracts, premature mortality and low birth weight among many others.[22] All over Africa, studies have also shown that air pollution from all the sources negatively affects people's respiratory health. Air pollution either due to gases (carbon monoxide, sulphur dioxide, nitrogen dioxide, or dust particulates. These, one by one or in combination cause respiratory impairment if inhaled at certain concentrations and over a long enough period of time.[8] Respiratory impairment: in rural as well as urban areas of Africa in which industries are located have been scientifically proven to have a high prevalence of respiratory diseases symptoms and reduced lung functioning. For example, one author demonstrated a high frequency of occurrence of cough alone, cough with sputum, nasal catarrh, morning phlegm, reduced lung function and chest pain among the residents of Bacita, Kwara State in Nigeria owing to their exposure to air pollutants from the sugar factory; and Fatusi et al. also drew similar conclusions from sawmill workers in the same country. In eastern Africa, Mengesha et al. studying the respiratory effects of dust in different sections of yarn, cigarette and cement factories found a higher prevalence of chronic cough, bronchial asthma and chronic bronchitis, among the workers than other people. Results of the studies from southern Africa and northern Africa are similar to those mentioned above from West and eastern Africa. Rees et al. found that an uncontrolled dust hazard in all the nine foundries surveyed in South Africa in a nine year period.[8] A study carried out in Sub Saharan Africa concluded that Exposure to ambient air pollution is a major threat to health in SSA with an estimated 176,000 deaths every day in the region attributable to outdoor air pollution exposure.[6] While another study also concluded that Respiratory malfunctioning from the four main sources of air pollution is a major but highly neglected issue in African.[38] A study on the effects of exposure to certain concentration of pollutants revealed that Exposure to an hour's concentration of NO2, SO2, CO and O3, an 8-hour concentration of CO and O-3, and a 24-hour concentration of PM10, NO2 and SO2 will less likely lead to adverse effects to sensitive exposed groups. However, children are more likely to be affected than adults. Furthermore, for chronic annual exposure, NO2, SO2 and PM10 posed a health risk to sensitive groups of people, with the severity of risk varying across the exposed groups.[30] In Several other studies in Africa, outdoor air pollution has been associated with adverse respiratory effects, more especially among infants with asthma.[31]

A number of studies dealing with the health effects of Biomass Burning in Africa were also reviewed. The results in one of the studies demonstrated that biomass $PM_{2.5}$ has increased the death rate of under-five infants in Western and Central Africa, each by 2%, and maternal mortality in Central Africa by 19%. While anthropogenic $PM_{2.5}$ increased maternal and under-five deaths in Northern Africa by 10% and 5%, respectively, and maternal deaths by 4% in Eastern Africa. Dust $PM_{2.5}$ increased under-five deaths in Northern, Western, and Central Africa by 3%, 1%, and 10%, respectively. Mixture $PM_{2.5}$ only increased under-five deaths and maternal deaths in Western (incidence rate ratio = 1.01, $p < 0.10$) and Eastern Africa (incidence rate ratio = 1.06, $p < 0.01$), respectively.[39] Whereas a study conducted in Malawi (The warm heart of Africa) found that reliance on high-or low-quality fuelwood or crop residue (vs. charcoal) was associated with considerably higher odds of shortness of breath, chest pains, night phlegm, forgetfulness, dizziness, difficulty breathing and dry irritated eyes.[16] Biomass Burning (BB) contributes mainly to indoor pollution in Africa which has been cited by many studies that it contributes to respiratory related illnesses and deaths.

A comprehensive study on the health and cost of air pollution in Africa found that the total of annual deaths from outdoor air pollution across the continent increased by 36% from 1990 to 2013, from a then relatively low base of ≈ 180 000 in 1990 to ≈ 250 000 in 2013. Over this period, deaths from indoor air pollution also continued to an increase, by 18%, from an already high base of ≈ 400 000 in 1990 to well over 450 000 in 2013.[11] It is also important to note that another study highlighted that there is a lot of unreported or unmeasured emissions in the African region. The study concluded that when these underrepresented emissions sources are combined with the current estimates of emissions, ambient particulate matter concentrations from present-day anthropogenic activity contribute to approximately 13 210 premature deaths per year, with the largest contributions (about 38%) coming from residential emissions.[40] The studies reviewed also agree that airborne dust particles also affect human health, through their effects on local and regional air qualities (Anuforom et al., 2007; Sassen et al., 2003). From all the studies cited so far, several mention the potential effects of dust particles on human health (e.g. Anuforom et al., 2007; Engelstaedter et al., 2006; Kellogg et al., 2004; Mahowald et al., 2007; Sassen et al., 2003), but very few of them present quantitative results.[19] It is of particular importance to note that only a few studies on Saharan dust have been published, although the Sahara desert is cited as one of the major sources of air pollutants in African; and of major concern is the fact those studies that are available indicate that Saharan dust has a significant impact on human health, further studies could therefore be necessary.[41]

IV. Mitigation and Control Measures

A far as air pollution is concerned, the worldwide tendency is to reduce the concentrations of pollutants owing to the increasingly strong restrictions which local governments and international organizations unanimously impose. Several guidelines and regulations have been adopted to define air quality levels. The WHO considers the Guideline Values (GD); the EU labels the Limits Values for Air Quality (LVAQ), while the US Environmental Protection Agency defines the National Ambient Air Quality Standards (NAAQS). Guidance on indoor air quality and concentrations of $PM_{2.5}$ and CO is provided by the World Health Organisation (WHO) (World Health Organization, 2016). To prevent harmful health consequences, the WHO recommends keeping $PM_{2.5}$ concentrations at less than 25 $\mu g\ m^{-3}$ when averaged over a 24 h period, with the guidance also recommending CO should not exceed 6 ppm over 24 h (World Health Organization, 2016).[15] However, in poor countries like the majority of African countries and those with generally low average incomes, concentrations of air pollutants remain high and the tendency will be to increase their emission levels as they develop, making the problem even worse than it is at the moment. In many African countries, Pollution control falls within the context of competing priorities for basic service provision and economic development. Further challenges include the lack of political will, the limited use of planning tools, and a non-strategic approach to Air Quality Management. [42] Developed countries are building up strategies in order to reduce air pollution while most African countries have neither air quality regulations, nor the tools for monitoring the same.[17] Despite the health risks this situation presents, air quality programs, particularly in sub-Saharan Africa, have stalled or completely stopped in recent years.[35] Studies have concluded that minimal attention is given to air quality and air pollution control related programmes. For example one study revealed that out of about 27 countries, only 7 have operational routine monitoring systems: these are Botswana, Ethiopia, Ghana, Madagascar, Tanzania, Zambia, and Zimbabwe.[13] While in South Africa air quality management has focused on industrial, domestic coal burning and vehicles as emission sources of air pollutants.[43] A few studies have revealed mitigation measures being implemented in Africa. The interesting part is that the few measures that haves been implemented in the few areas have revealed very positive and encouraging results. A study in South Africa, for example showed that household $PM_{2.5}$ concentrations greatly decreased when households in Kikati areas switched from use of firewood to biogas for cooking.[15] It has been suggested by another study that advanced stoves, which burn fuel more efficiently and reduce smoke emissions, could help to reduce indoor air pollution in poor, rural areas.[44] The results from other studies also suggest that economic growth and rising incomes may matter in African countries in order to curb pollution, but more stringent policy measures, especially at the industrial level would be required to curb environmental degradation. [45] Some Courtiers such as South Africa have already set up targets for mitigation strategies. It is estimated that these targeted potential mitigation strategies can avoid up to about 37% of the estimated annual premature deaths by 2030 with the largest opportunity being a reduction of 10 868 annual deaths from switching half of the energy generation in South Africa to renewable technologies.[40] However, another study revealed that South African face several challenges in implementing AQA. as pollution control falls within the context of competing priorities for basic service provision and economic development.[46] Exploring the effects of different types of PM2.5 is necessary to reduce associated deaths, especially in developing African countries.[39]

V. Conclusions and Recommendations

This review summarizes major findings reported in literature on air quality in Africa including air pollutant, related sources, levels and concertation, mitigation measures and potential health effects. In different African countries, research interests and focus varied, which may have led to different reporting and more difficult to compare results across the continent. Data from sub-Sahara Africa is said to be scarce and virtually absent especially among populations residing in informal residential settlement.[47] Again, despite the proximity of the Sahara, very few studies about dust impact on air quality and human health have been conducted in West Africa. The lack of data therefore is one of the major constraints on our understanding of the impacts on human health.[34] Findings also suggest a lack of clear and/or practical policy intervention to restore household air quality, while single policy intervention have been proven inadequate in many studies.[48] In addition, the studies revealed that different countries are at different levels a far as air pollution control and regulation is concerned. For example, as of July 2017, there was no network for the continuous measurement of air quality or data on the levels of air pollution in Algiers (APW, 2017). However, such data is essential for implementing, monitoring and evaluating policies that can help to deal with air pollution while also protecting human health. At present, only some occasional data collected by scientists and researchers are available to give an idea of the air quality in Algiers (Kerbachi et al., 2006; Moussaoui et al., 2010; Kerchich and Kerbachi, 2013, 2016). These data though are still insufficient and need to be improved further.[23] Another study also concluded that there is a clear lack of urgency from SSA countries in addressing air quality issues. This is clear when we look at the scarcity of reliable data on air pollution levels.[6]

Our review, just like other reviews on air quality related studies in Africa, reveals that, although few studies have reported annual mean levels of coarse and fine particles, collective evidence from short- and long-term air monitoring studies across Africa demonstrate that pollution levels often exceed WHO and other international guidelines.[35] There is strong evidence from the studies that air quality is a big concern in Africa; and that air pollution is posing detrimental impact on human health especially children and women. However, there is very little attention to it from many African Governments. Notably, the air quality in many African cities is almost completely unmonitored.

Overall, from the reviewed studies we can conclude that the pollution caused by fine particles is of a great concern in Africa because of its high magnitude and its physicochemical characteristics.[23] I is also clear from the studies that air pollution in Africa is on the rise; the number of fatalities from air pollution related illnesses is also tremendously increasing as development efforts are accelerating in almost all African countries. On this basis, this review agrees with many other studies and review in proving recommendations that will help to reduce, control and manage air pollution in Africa. There is need for concentrated efforts on the part of African governments, health administrators and health workers to ensure that necessary attention is given to research on the subject so that meaningful control measures can be formulated, thereby ensuring clean air for the people to breathe and live healthily.[38] Implementation of systematic PM data collection would enable air pollution related health impact assessments, the development of strategies to reduce the air pollution health burden, and facilitate urban planning and transportation policy as it relates to air quality and health. There is need to identify and implement effective and equitable transportation regulations and policies that reduce the impacts of traffic pollution, and technological and policy innovations that can reduce air pollution from biomass fuels without restricting what may be the only energy source available to poor households.[12] Countries EPAs should set higher emission standards for factories located in urban settlements by strictly enforcing the installation of scrubbers to ensure cleaner emissions and to also curb the concentration of industries in cities.[6]

Above all, air quality is a serious concern in Africa and the reviewed studies have proved that it is a killer and a cause of economic losses. Air pollution in Sub Saharan cities appears to be on the rise with respect to many key pollutants.[49] However there I strong indication from some studies that air pollution is being greatly ignored by many the countries largely due to its conflicts with economic development. Just like one study suggested, if nothing is done to reduce emissions and to better plan for urbanization, this trend can be expected to further exacerbate already serious air quality problems in sub-Saharan African cities as well as the health impacts that accompany them.[32] This sadly applies to the whole African continent a well as other parts of the world.

ACKNOWLEDGMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

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