Monitoring and Evaluation of Air Quality: A Case Study of Mogadishu, Somalia

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***Abstract*: The long lasting civil war in Somalia and the limited functionality of the Mogadishu based government for over the last 20 years have had negative implications on both the environment and public health majorly through air pollution. The absence of strong laws or legislations concerning access and use of different natural resources has severe consequences on the entire Somalia population as a whole. This study was aimed at assessing the level of air quality in Mogadishu, Somalia. The focus of the assessment was to carefully document the prevailing environmental health situation or air quality in the selected districts of Mogadishu mostly concerning the areas of sanitation and hygiene, industrial pollution and energy as well as air quality as a whole. A descriptive observational study was undertaken in the seven selected Mogadishu of districts to assess the level of air quality and the overall environmental health situation in the area.**

A sample of 10 commercial areas was used for each district, and both $PM_{2.5}$ and PM_{10} devices were installed, and each areawas ch ecked three times (7:00Am.) (12:00PM) and (3:00PM) values wer e entered in Excel 2019. The level of pollution in all areas of the study are very healthy state. Except the Hodan district in which there is moderate to high level of pollution followed by Yaqshid and Heliwa. However; in Somalia the air pollution is not a national issues as compared the Neighboring countries. Although our study season may have impact on overall study results due to the winter season we suggest that need for further study in the different seasons to expose the hidden factors that minimize the level of pollution.

***Key words*: Air quality, $PM_{2.5}$, PM_{10}, District, Mogadishu, Somalia**

I. INTRODUCTION

Air quality has continued to deteriorate globally due to the different environmental or climatic changes influenced by both natural and human factors. The impact of polluted air quality is simply clear as it remains one of the greatest environmental risk for today's health. Annually around 7 million premature death have been linked to polluted air quality, moreover; air pollution is the 4th leading causes of early death worldwide (Gatari, 2019).

Air Pollution means presence of substances (Particulates, Sulphur oxides, Ozone and other photochemical oxidants, Carbon monoxide, Nitrogen oxides, Air toxics, Lead and other heavy metals) in air at concentrations, durations and frequencies that adversely affect human health, human welfare or the environment. The phenomena of air pollution and deaths related to it is an old one dating back in medieval times in 1873 a number of deaths ranging from 200-700 were reported in London. Similarly, in 1880-1892 a number of 2000 death had occurred in the in London due to air pollution in 1900s the burden of air pollution have increased due to urbanization climate changes and industrialization-emissions however; in 1990s subsequent reduction of emission related pollutants were observed in beginning of 21st century data from 31 European environmental agency members stated that substantial reduction from acidifying emission 40 %, and from fine particulate and gasses 34 % and 29% in and ozone Gasses has been achieved, however; ground level pollutants reduction was less achieved by all 31 EU members except four countries. A report by European environmental agency (2019) revealed a high prevalence of air quality problems in most European countries, and described air pollution as still local pan European and hemispheric issue. In Asian countries, china, Bangladesh, India, Pakistan for example have higher concentration of $PM_{2.5}/PM_{10}$. Although many African countries lack real time data of Air quality, many studies believe that African countries, had higher particulate matter that exceeds the International air quality guidelines (Viebahn, 2002).

In recent years the ambient air pollution both outdoor and Indoor remains serious problem in many countries around the world, The association of poor healthy outcome and air pollution have been areas of research, in recent years, and many have demonstrated concrete link between air pollution and poor health outcome and even deaths. According to a World Health Organization (WHO, 2006) assessment of the burden of disease due to air pollution, more than two million premature deaths each year can be attributed to the effects of urban outdoor air pollution and indoor air pollution. WHO (2013) found that approximately 531,000 children under the age of 5 died from household air pollution in 2012, and around 127,000 children under the age of 5 died from outdoor air pollution in 2012.

A constant finding is that air pollutants contribute to increased mortality and hospital admissions. The different composition of air pollutants, the dose and time of exposure and the fact that humans are usually exposed to pollutant mixtures than to single substances, can lead to diverse influences on human health. Human health effects can range from nausea and difficulty in breathing or skin irritation, to cancer. They also

include birth defects, serious developmental delays in children, and reduced activity of the immune system, leading to a number of diseases. The effects of air pollutants on different organs and systems on human health especially the respiratory system, cardiovascular system, nervous system, urinary system, and digestive system (Huang, 2014).

Most developing countries such as Somalia face several challenges of climate change which majorly attributed to the prolonged civil conflicts and poor governance mechanisms in the area (Huang, 2014). These factors have enabled different people to engage in illegal act8vtotes that contribute greatly to environmental degradation, climate change and air pollution. This study discusses the burden of air pollution in Mogadishu and focuses on the health effects associated with two most prevalent air pollutants, ozone (O_3) and particulate matter (PM). The study is intended to benefit clinicians and anyone who is interested in the clinical aspect of air pollution.

II. LITERATURE REVIEW

Overview of air pollution

Air pollution is among the leading environmental risk factors or threats that normally results into death or permanent disability of people in the diufferent parts of world. Estimates by WHO in 2012 indicated that over 3.7 million people died as a result of exposure to ambient air pollution. Worldwide ambient air pollution contributes to 6.7% of all deaths. Low and middle-income countries in the Southeast Asia and Western Pacific regions where the air pollution is most severe had the largest air pollution-related disease burden. The disease burden remains significant even in the developed countries where the levels of air pollutants are generally much lower because of the constant exposure of the large number of people to the air pollutants.

Ali (1993) reported instances of visible injury on clover/berseem (Trifolium repens) and Egypt Mallow (Malva parviflora) plants growing close to the industrial complex at Shoubra El-Khaima. Mean pollution concentrations between November 1987 and January 1988 reached 160 µg m-3 SO_2, 88 µg m-3 NOx and 680 µg m-3 of total suspended particles. Hourly mean O3 concentrations ware also recorded of greater than 100 ppb. Visible injuries included necrosis, red spots and chlorides with 60% and 54% of clover and Egyptian Mallow leaves injured respectively.

Hassan et al. (1995) assessed the impact of O_3 on the growth and yield of local varieties of radish (Raphanus sativus L.cv. Balady) and turnip (Brassica rapa L.cv. Sultani) at sub-urban and rural sites of Alexandria using EDU to protect control plants from O_3 effects. At the site mean 6 hour O_3 concentrations over the experimental period were 55 ppb in the sub-urban site and 67 ppb at the rural site. O_3 Impacts include the formation of chlorotic spots on the upper leaf surface and reductions in plant biomass. These effects were recorded for the radish at the both sites and for turnip only at rural site. The study proved that levels of ambient in O_3 in Egypt are high enough to have significant impacts on the growth and yield of local varieties of vegetable crops, even at the time of year when O_3 levels are relatively low.

The increase in air pollution that have occurred around the urban industrial centers of Cairo and Alexandria in Egypt are particularly problematical since these in the same locations as the primary agrarian region, which is limited to the Nile river basin as the primary source of irrigation water. Studies of the effects of air pollution on vegetation have been carried out in the last 20 years in the greater Cairo area and around the main roads within Nile delta region (Huang, 2014).

In South Africa there are number of locations where air pollution is perceived to be a problem. Industrial plants located on the high veld using coal as primary fuel source result in emissions of SO_2 (Siversten et al., 1995) SPM emissions from household coal and wood burning are also a concern in urban areas. Due to the high SO_2 emissions, the commercial forests located downwind of the high highveld have been most extensively studied for air pollution impacts to the vegetation in South Africa. Two years old plants of three commercially important forest species (Pinus patula, Pinus elliotii and Eucalyptus grandis) were exposed to SO_2 at 4 different concentrations: 133,226,1300, and 2660 µg m-3 For 1` or 2 hours a day over 26 days (Kelly,1986). Visual damage to E. grandis was evident at short duration exposures to concentrations of 1300 and 2660 µg m-3 whereas P. patula was unaffected. The problems of pollution are not limited to the borders of a country. The harmful effects extend beyond the borders of the originator of the pollution. That is why development of policy frameworks for Pollution Control and Waste Management is a priority for the Environment and Natural Resources Sector of the EAC Secretariat (Huang, 2014).

All Partner States are parties to the Eastern African Regional Framework Agreement on Air Pollution (Nairobi Agreement, 2008). The States agreed to develop actionable targets to address air pollution in the following key areas: Transport, Industry and Mining, Energy, Waste, Vegetation Fires, Indoor Air pollution, Urban Planning and Management. The EAC is working on development and harmonization of standards and regulations on pollution control and waste management. The EAC Secretariat is working on the implementation of the provisions of the Eastern African Framework Agreement on Air Pollution, and developing the EAC Electronic Waste Management Framework and Management of Plastic and Plastic Waste Disposal (Huang, 2014). Cities and rural areas worldwide are affected by air pollution. When planning a trip, consider health status, age, destination, length of trip and season to mitigate the effects of air pollution. In accordance with the World Health Organization's guidelines, the air quality in Somalia is considered moderately unsafe - the most recent data indicates the country's annual mean concentration of PM2.5 is 32 µg/m3, exceeding the recommended maximum of 10 µg/m3.

Contributors to poor air quality in Somalia include factories and production industries, inefficient fuel use, vehicle

emissions, and forest fires. City-specific air quality data is not available at this time. (Kamra et al., 1997). A total of 2.36 million people (1.84 million students and 520 000 staff) learn, lecture, research and work at 334 different universities, colleges and polytechnics in Germany. With regard to their consumption of energy and materials, universities are therefore comparable to large commercial concerns. Environmental pollution not only occurs in lecture halls and research laboratories, but also in the area of administration. This air pollution could be reduced considerably by the systematic implementation of organizational and technical measures. For example, a third of all energy consumed in public institutions could be saved with the introduction of such measures. If the University of Osnabruck were to reduce its energy consumption by just 20% it could save 500 000 DM in energy costs every year. However, the necessity to become more involved in environmental protection should not be guided by financial arguments alone: universities make a significant contribution to the development of our society, and therefore have a special societal responsibility, in particular with regard to the sustainable protection of the environment and the use of resources. University environmental protection projects can encourage other public institutions to act, thus making the universities role models (Viebahn, 2002).

As the world gets hotter and more crowded, our engines continue to pump out dirty emissions, and half the world has no access to clean fuels or technologies (e.g. stoves, lamps), the very air we breathe is growing dangerously polluted: nine out of ten people now breathe polluted air, which kills 7 million people every year. The health effects of air pollution are serious – one third of deaths from stroke, lung cancer and heart disease are due to air pollution. This is having an equivalent effect to that of smoking tobacco, and much higher than, say, the effects of eating too much salt.

According to WHO (2013) Air pollution is hard to escape, no matter how rich an area you live in. It is all around us. Microscopic pollutants in the air can slip past our body's defense, penetrating deep into our respiratory and circulatory system, damaging our lungs, heart and brain. Air pollution is closely linked to climate change - the main driver of climate change is fossil fuel combustion which is also a major contributor to air pollution - and efforts to mitigate one can improve the other. This month, the UN Intergovernmental Panel on Climate Change warned that coal-fired electricity must end by 2050 if we are to limit global warming rises to 1.5C. If not, we may see a major climate crisis in just 20 years.

Meeting the goals of the Paris Agreement to combat climate change could save about a million lives a year worldwide by 2050 through reductions in air pollution alone. The economic benefits from tackling air pollution are significant: in the 15 countries that emit the most greenhouse gas emissions, the health impacts of air pollution are estimated to cost more than 4% of their GDP. "The true cost of climate change is felt in hospitals and in our lungs. The health burden of polluting energy sources is now so high, that moving to cleaner and more sustainable choices for energy supply, transport and food systems effectively pays for itself. The lack of visible smog is no indication that the air is healthy. Across the world, both cities and villages are seeing toxic pollutants in the air exceed the average annual values recommended by WHO air quality guidelines. To help people better understand just how polluted the air is where they live, the WHO, UN Environment and the Climate and Clean Air Coalition's Breathe Life campaign developed an online pollution meter.

Components of air pollution

There are two main types of air pollution ambient air pollution (outdoor pollution) and household (or indoor) air pollution refers to pollution generated by household combustion of fuels (caused by burning fuel such as coal, wood or kerosene) using open fires or basic stoves in poorly ventilated spaces. Both indoor and outdoor air pollution can contribute to each other, as air moves from inside buildings to the outside, and vice versa.

This type of pollution is also known as Indoor pollution and it kills 4 million people a year and tends to affect countries in Africa and Asia, where polluting fuels and technologies are used every day particularly at home for cooking, heating and lighting. Women and children, who tend to spend more time indoors, are affected the most. This type of air pollution is also known as ambient air pollution and it has more effects than the first one when a comparison arrived.

The main pollutants include; articulate matter, a mix of solid and liquid droplets arising mainly from fuel combustion and road traffic; nitrogen dioxide from road traffic or indoor gas cookers; sulphur dioxide from burning fossil fuels; and ozone at ground level, caused by the reaction of sunlight with pollutants from vehicle emissions. The pollutant that affects people the most is particulate matter (often abbreviated to PM and used as a measure for air pollution.)

Current situation in Mogadishu Somalia

Following the 20 years of violence and civil conflicts in most areas of Somalia with Mogadishu inclusive, most of the valuable infrastructure, the environment and other forms of development have been severely destroyed. Somalia as a whole is currently experiencing the worst environmental abuses and climate changes that ever before. Air pollution is on the rise majorly as a result of the encroachment on the environment and from the different dangerous GHG emissions released by the different industries around Mogadishu. The current environment in Mogadishu has been neglected and greatly damaged which has led to increased levels of air pollution and negative climate change in the country (Gatari, 2019).

The prevailing environmental health situation in Mogadishu that is associated with high levels of household air pollution is greatly linked to absence of a very strong government to enforce or implement different legislations aimed at

mitigating the different causes of air pollution or climate change. Studies reveal that continued neglect of the environmental and other associated natural resources in most developing countries such as Somalia has continued to disproportionately affect the environment and public health status of most highly populated regions in developing countries.

Most people in Somalia and Mogadishu in particular face several challenges in trying to meet the different household needs or requirements. Research also indicates that lack of comprehensive awareness among the general public concerning he effect of climate change or air pollution has led to the increased prevalence of severe climate change conditions and high levels of pollution in the area (Friedrich, 2017). Similarly the tendency of individuals and industries taking advantage of poor governance in Somalia to exploit or exhaust the environment has to a greater catalyzed the already fragile situation of poor environmental and natural resources management in Mogadishu. Most of the perpetrators of environmental or air pollution in Somalia are always concerned with their personal and monetary gains hence do not consider the risk or threats imposed on the general public as a result of air pollution.

Consequences of air pollution

Air pollution has a disastrous effect on children. Worldwide, up to 14% of children aged 5 – 18 years have asthma relating to factors including air pollution. Every year, 543 000 children younger than 5 years die of respiratory disease linked to air pollution. Air pollution is also linked to childhood cancers (Jeong, 2013). Pregnant women are exposed to air pollution; it can affect fetal brain growth. Air pollution is also linked to cognitive impairment in both children and adults

Along with harming human health, air pollution can cause a variety of environmental effects including:

Acid rain is precipitation containing harmful amounts of nitric and sulfuric acids. These acids are formed primarily by nitrogen oxides and sulfur oxides released into the atmosphere when fossil fuels are burned. These acids fall to the Earth either as wet precipitation (rain, snow, or fog) or dry precipitation (gas and particulates). Some are carried by the wind, sometimes hundreds of miles. In the environment, acid rain damages trees and causes soils and water bodies to acidify, making the water unsuitable for some fish and other wildlife. It also speeds the decay of buildings, statues, and sculptures that are part of our national heritage. Acid rain has damaged Massachusetts lakes, ponds, rivers, and soils, leading to damaged wildlife and forests. For more information on acid rain (Friedrich, 2017).

Eutrophication is a condition in a water body where high concentrations of nutrients (such as nitrogen) stimulate blooms of algae, which in turn can cause fish kills and loss of plant and animal diversity. Although eutrophication is a natural process in the aging of lakes and some estuaries, human activities can greatly accelerate eutrophication by increasing the rate at which nutrients enter aquatic ecosystems. Air emissions of nitrogen oxides from power plants, cars, trucks, and other sources contribute to the amount of nitrogen entering aquatic ecosystems (Jeong, 2013).

Crop and forest damage. Air pollution can damage crops and trees in a variety of ways. Ground-level ozone can lead to reductions in agricultural crop and commercial forest yields, reduced growth and survivability of tree seedlings, and increased plant susceptibility to disease, pests and other environmental stresses. As described above, crop and forest damage can also result from acid rain and from increased UV radiation caused by ozone depletion (Jeong, 2013).

Global climate change. The Earth's atmosphere contains a delicate balance of naturally occurring gases that trap some of the sun's heat near the Earth's surface. This "greenhouse effect" keeps the Earth's temperature stable. Unfortunately, evidence is mounting that humans have disturbed this natural balance by producing large amounts of some of these greenhouse gases, including carbon dioxide and methane. As a result, the Earth's atmosphere appears to be trapping more of the sun's heat, causing the Earth's average temperature to rise - a phenomenon known as global warming. Many scientists believe that global warming could have significant impacts on human health, agriculture, water resources, forests, wildlife, and coastal areas (Jeong, 2013).

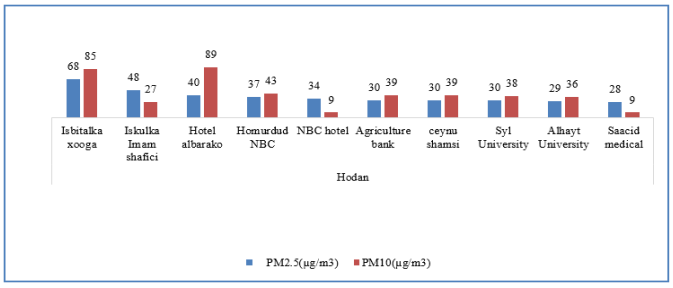
III. METHODS

This study sought to Evaluate and Monitoring Air quality in Mogadishu, Somalia. To find out the Air quality in Mogadishu, a descriptive observational study was carried to 7 districts of Mogadishu. Each district a sample of 10 commercial areas were selected and both MP.25 and PM 10 devices were installed and each area three times were tested (7:00Am.) (12:00 PM) And (3:00PM) the values were entered in Excel 2019. The real time data form the monitoring device will be analyzed, according WHO guideline of air quality standard, A PM2.5 of > 50 (µg/m3) will be considered as normal air quality, and PM 2.5 of 51-100 (µg/m3) will be interpreted as Moderate air quality, PM2.5 index of 101-150 (µg/m3) will be analyzed as unhealthy Air quality, PM 2.5 display of (201-300, 301-400, and above) will be assumed as unhealthy, very unhealthy, and hazardous respectively.

IV. RESULTS

Our study aimed to evaluate the level of air pollution in Mogadishu city, a descriptive observational study was carried to 7 districts of Mogadishu. Each district a sample of 10 commercial areas were selected and both MP.25 and PM 10 devices were installed and each area three times were tested (7:00Am.) (12:00 PM) And (3:00PM) the values were entered in Excel 2019. The data were analyzed using excel software as shown in the result, the level of pollution in all areas of the study are very healthy state. Except the Hodan district in which there is moderate to high level of pollution followed by Yaqshid and Heliwa. This study indicates that the level of air pollution in Mogadishu commercial area is very healthy.

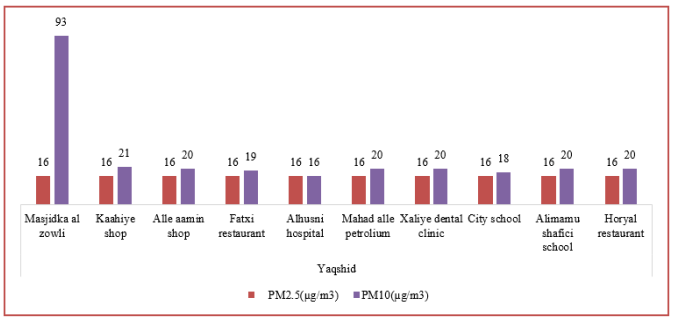
Figure 1: The Level of Commercial Area Pollution



Source: Primary data (2020)

The above Bar graph indicates the level of commercial pollution in Hodan district. As shown in the graph the level of PM10 (µg/m3) pollution is higher in all areas of the study than $PM_{2.5}$ (µg/m3). The level of pollution in Hodan district suggests very unhealthy air quality. With higher concentration of both PM $_{2.5}$ and PM_{10} is observed, in Isbitalka xooga and hotel albarako.

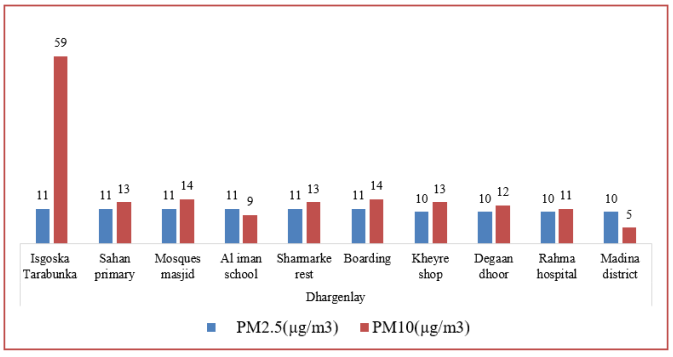
Figure 2: Commercial area pollution level



Source: Primary data (2020)

The Above Bar graph indicated the distribution of PM2.5 among selected areas of Yaqshiid District. This graph indicates moderate air quality, with concentration of $PM._{2.5}$ of 16 ug/M3 and PM_{10} concentration of 20 ug/M3. Except al zowli mosque which indicates higher pollution of PM_{10} 93 ug/M3.

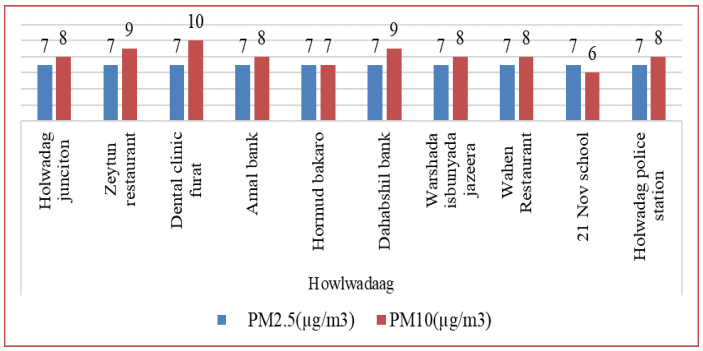
Figure 3: Concentration of commercial are pollution



Source: Primary data (2020)

In the above Histography shows good air quality in all areas of dhargenlay except Tarbuunka junction which shows high level of PM_{10} concentration of 59 ug/M3.

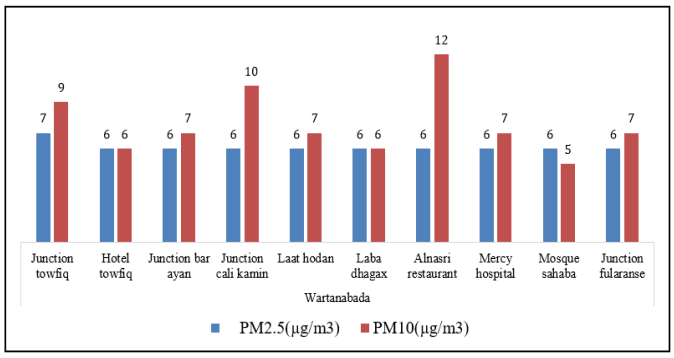
Figure 4: Howlwadaag Air Pollution



Source: Primary data (2020)

As indicated in the above data the howlwadaag district have very healthy air quality with zero pollution of both particulate matter concentration the above data shows no sign of air pollution, in all commercial areas of heliwa district.

Figure 5: Wartanabada pollution level

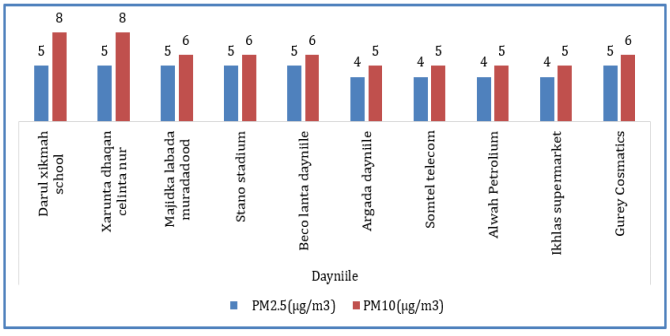


Source: Primary data (2020)

The data suggests very healthy air quality, with average concentration between 10 to 9 and 16 to 6ug/M3 of PM 2.5 and PM 10 respectively.

As in the above graph the level of air pollution concentration, indicates very healthy air quality, with no pollution indicated on both concentration.

Figure 6: Air Pollution level among Dayniile District



Source: Primary data (2020)

As indicated the data above the dayniile district have very healthy air pollution than any other district of the study

V. CONCLUSION

Air Pollution means presence of substances (Particulates, Sulphur oxides, Ozone and other photochemical oxidants, Carbon monoxide, Nitrogen oxides, Air toxics, Lead and other heavy metals) in air at concentrations, it's a global issues that affects human and planet; it have major impact on health may studies have shown concrete correlation between poor air quality and mortality, while other study revealed the annual death due to Air pollution, however; in Somalia the air pollution is not a national issues as compared the Neighboring countries. Although our study season may have impact on overall study results due to the winter season our study suggest the need for further study in the different seasons to expose the hidden factors that minimize the level of pollution if any.

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