

Evaluation of Air Pollutant Levels in Dire-Dawa City, Ethiopia



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Abstract

Our planet earth is enclosed by a blanket of gaseous mixtures that can cause a harmful effect on life when present in excess of the natural abundance limit. These gaseous substances in the air we breathe, depending on their properties, magnitude and composition could benefit and/or risk the health of humans, animals and aquatic organisms. The existences of unwanted gases in the air we breathe are referred as air pollution, which implies the presence of harmful substances in the ambient air and have an outdoor and indoor sources. Air pollution has a wide array of negative health effects which are believed to be associated with air pollution exposure, among of which are respiratory diseases, cardiovascular diseases, adverse pregnancy outcomes, poor visibility, reproductive and neurological disorders. Air pollution is one of the most dangerous environmental problems, causing many adverse health effects and responsible for the death of many people each year worldwide. The objective of this study was to evaluate the levels of air [CO₂, NO₂, SO₂, CO, VOC] pollutants around the sampling spots (commercial, residential, mixed and industrial) of the City and initiate the city administration to take mitigation measures on time.

The methodology used to collect and measure the selected air pollutants was site selection on field visit and use of Aeroquip series 500 that is employed for quick and short-time measuring of air pollutant levels. The results of the study showed that the levels of nitrogen dioxide (0.0446 ppm), carbon dioxide (459 ppm) and volatile organic compounds (514 ppm) was high in commercial and mixed spots respectively. In residential and industrial spots the values of NO₂ and CO₂ were close to each other with some differences for volatile organic compounds. But carbon monoxide (CO) and sulphur dioxide (SO₂) were below the measuring capacity of the sensor and no value was obtained. Thus improper land use, low awareness, and inadequate enforcement of laws are considered as the main contributors for ambient air pollution in the city.

Keywords: Pollutant; Air Pollution; Standard Limit; Effects; Exposure; Values

Abbreviations: CO: Carbon Monoxide; SO₂: Sulphur dioxide; COPD: Chronic Obstructive Pulmonary Disease; NOX: Nitrogen Oxides; CO₂: Carbon dioxide; VOC: Volatile Organic Compounds; AAQS: Ambient Air Quality Standard; WHO: World Health Organization

Introduction

Air pollution is one of the most dangerous environmental problems that affect people's health in a variety of ways [1]. Long term exposure to high levels of air pollution results in cardiovascular, respiratory, reproductive and neurological health problems and cause to the death of many people worldwide, particularly children [2,3]. The emission of gaseous pollutants into the atmosphere degrades the quality of ambient air resulting in haze, poor visibility and damages of culturally valuable materials such as statues and monuments and this degradation in the quality of the air we breathe is described as pollution, meaning the presence of harmful gases in the atmosphere in excess of their natural limit [4]. Air pollutants come from natural and anthropogenic sources and affect the composition of air and eventually cause harm to human health, ecosystems, agricultural crops and the built environment. Air pollution can be understood as a deviation from the unpolluted composition of air under the circumstances of no human intervention.

Air pollution is a widespread health problem associated with respiratory symptoms and can contribute to the development of chronic obstructive pulmonary disease (COPD) with enhanced susceptibility in children, older adults and people with heart and lung diseases [5,6]. Air pollution negatively affects human and ecosystem safety, depending on the exposure dose and time and it is caused by stationary and mobile sources from multiple sectors of human activity such as industry, residential sector, transport, agriculture and can manifest itself via the presence of sulphur dioxide (SO₂), nitrogen oxides (NOX) and volatile organic compounds [7,8]. The fast growing trend in infrastructure, industries and transportation network in populous cities are potential contributors for air pollution and their negative impact on public health and environment is a serious issue that cannot be underestimated. Dire-Dawa is one of the fast growing cities in Ethiopia. It is a center for several industries and markets, a place for an International Airport and railway line [9] and the

community nearby can be highly susceptible to the hazardous impacts of atmospheric air pollution generated by both natural and anthropogenic activities.

Material and Method

Site Description

This survey study was conducted in Dire Dawa city, which is located in the eastern part of the country, at the foot of Dengego mountain between 9027' and 9049'N Latitude and 41038' and 42019'E Longitude. The city is bordered by Oromia and Somali National Regional States and is located 515 kilometers east of Addis Ababa, situated in the Awash River Basin. The area of the city is 133,043 hectare. The city is a preferred strategic location for both agricultural and industrial activities. It serves as the main

gate way for the country's trade line and is one of the largest and modern cities of Ethiopia. The city is divided into commercial, industrial, mixed and industrial zones but not fully implemented as planned. The industrial zone is not well developed and factories are not available as expected. The city experiences a warm and dry climate with low level of precipitation. The mean annual temperature is 25.9°C and the average maximum temperature 32.8°C. The region has two rain seasons; a small rain season and a more pronounced rain season that extends from August to September. The average annual rainfall that the region gets from these two seasons is about 583 mm. Air sample for the survey study was collected from each of the 18 sampling spots (commercial, industrial, mixed, residential) selected by field observation. The survey study was conducted in the first week of June, 2017 G.C (Figure 1).



Figure 1: Map of ambient air sampling areas.

Data Collection

The sites for data collection were first identified by inspecting the zones by field visit observation. 18 ambient air sampling spots from the four separate zones were selected based on their vicinity to the public and the types of activities done around the sampling spots/sites. Aeuoqual series 500, a portable air quality sensor, was used to measure the levels of ambient air

pollutants in parts per million (ppm) (Table 1). Evaluation of the values of nitrogen dioxide (NO₂), carbon dioxide (CO₂) and volatile organic compounds (VOC) was the prior interest of the researcher but gases such as sulphur dioxide (SO₂) and carbon monoxide (Co) were included in the valuation. Prior to taking air samples for measurement, the sensor was warmed up to burn off contaminants that could be present in the device.

Table 1: Values of Ambient air pollutants in Dire Dawa City (in ppm).

No	Ambient air Pollutants	Commercial spot	Industrial spot	Mixed spot	Residential spot
1	Nitrogen dioxide	0.044611	0.0435	0.0435	0.0426
2	Carbon dioxide	459	425	435	426
3	Volatile organic cpds	480	429	514	506
4	Sulphur dioxide	Nil	Nil	Nil	Nil
5	Carbon monoxide	Nil	Nil	Nil	Nil

By first switching on the monitor, the sensor was made to warm for 3 minutes. The reading was then flashed for the next 7 minutes to make sure that the sensor is still in the warm state. Air sample was taken twice a day, in the morning and afternoon, for three minutes each and the two results average was recorded as the final values of the pollutant gases (NO₂, CO₂, VOC). The measurement was conducted at different days of the week and may lead to discrepancies in the final results of nitrogen dioxide (NO₂), carbon dioxide (CO₂) and volatile organic compounds (VOC) in the ambient air.

Result and Discussion

Nitrogen dioxide (NO₂) level in the ambient air

Nitrogen dioxide (NO₂) was one of the ambient air pollutants surveyed in the study areas. Its level was measured at industrial, commercial, mixed and residential spots in the city. Commercial and Industrial spots showed a higher values of nitrogen dioxide (NO₂) compared to the values recorded for mixed and residential spots. Commercial and industrial spots indicate nitrogen dioxide (NO₂) values of 0.044611 ppm and 0.0435 ppm respectively. The level of nitrogen dioxide (NO₂) in mixed and residential spots was found to be 0.0435 and 0.042167 ppm. In all cases the recoded values of nitrogen dioxide was less than the hourly

average of ambient air quality standard (AAQS) that is 0.106 ppm. The result of the survey also indicated that the difference in the values of nitrogen dioxide (NO₂) among industrial, commercial, mixed and residential spots was statically insignificant. Though it was difficult to obtain an ambient air quality standard (AAQS) for a three minute measured value of nitrogen dioxide (NO₂), the present value could soon reach or exceed the annual average (0.021 ppm) level set in the ambient air quality standard (AAQS).

As shown in Figure 2, Mariam and Garage sefer have the highest nitrogen dioxide (0.056 ppm) level while Aftesa has the lowest (0.035ppm) level. Measurement of nitrogen dioxide from the collected air sample was carried out twice, in the morning and afternoon and the difference in nitrogen dioxide value was insignificant (p>0.05) in all air sampling spots. Natural sources such as, bacterial and volcanic action, and lightning are considered not to have significant influences on the measured values of nitrogen dioxide as they may be equally distributed in all the study sites of the city. But the high value of nitrogen dioxide in Mariam and Garage sefer (Figure 2) might be contributed to the use of fossil fuels at household levels and vehicle service stations which can use several fuel byproducts and solvents for energy, lubrication, greasing and washing reasons.

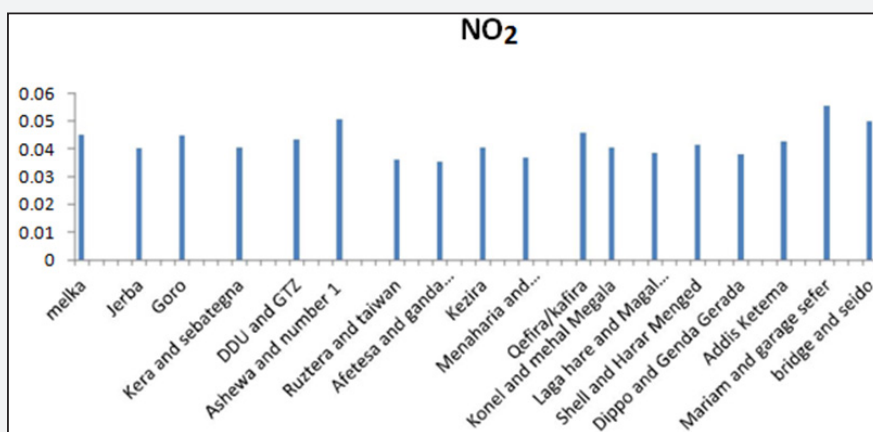


Figure 2: Ambient air sampling areas.

Carbon dioxide Level

The method used to determine carbon dioxide (CO₂) level in the sampling spots was similar to that of nitrogen dioxide. The effect of carbon dioxide (CO₂) as ambient air pollutant is not its impact on human health but in causing climate change. Carbon dioxide concentration at Ashewa and number 1 spot was the highest (493.5 ppm) and Afetesa and Ganda Grada the lowest (407.83 ppm). Measurement of ambient air pollutants (NO₂, CO₂, VOC) indicated a significant difference in the four selected sampling spots of the city (p<0.05). Similar to nitrogen dioxide (NO₂), commercial spots have the highest reading value of carbon dioxide (459 ppm) and the remaining sampling spots have closer ppm values with industrial 425 ppm, mixed 435 ppm and residential 426 ppm values respectively (Figure 3).

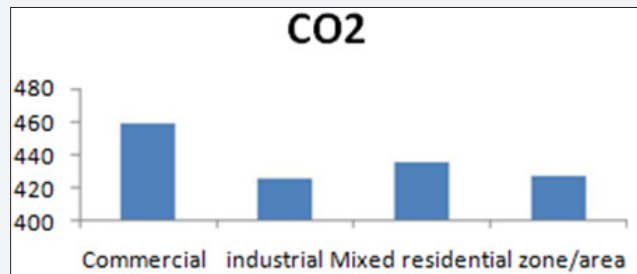


Figure 3: Carbon dioxide levels at four sampling spots/areas.

Volatile Organic Compounds (VOC)

Volatile Organic Compounds (VOCs) are organic compounds with a boiling point of below 260 degree Celsius. They are easily

released into the ambient air from various sources and cause air pollution. Hence, many organic compounds fall into this category according to the world health organization (WHO) definition. The value obtained for volatile organic compounds in Mariam and garage sefer was high (728 ppm) compared to carbon dioxide (CO₂) and nitrogen dioxide (NO₂) and this significant difference is accounted for the daily activates in the garages which release volatile substances used daily for vehicle greasing, lubricating and cleansing reasons. The lowest value was recorded at kera and sebategna (300 ppm). To judge whether these areas are polluted or not by volatile organic compounds was difficult due to lack of a

set standard but can give a general idea about the status of volatile organic compounds (VOC) in the area. Statically the VOC values between commercial, residential and mixed spots did not show a significant difference except for industrial which read 429 ppm. Commercial, mixed and residential areas have VOC values of 480, 514 and 506 ppm respectively with the mixed areas showing a relatively higher value (514ppm). Air pollutants such as carbon monoxide and sulphur dioxide were included in the survey but non-of them have recorded a value by the measuring sensor used to measure carbon dioxide (CO₂) and nitrogen dioxide (NO₂) (Figures 4 & 5).

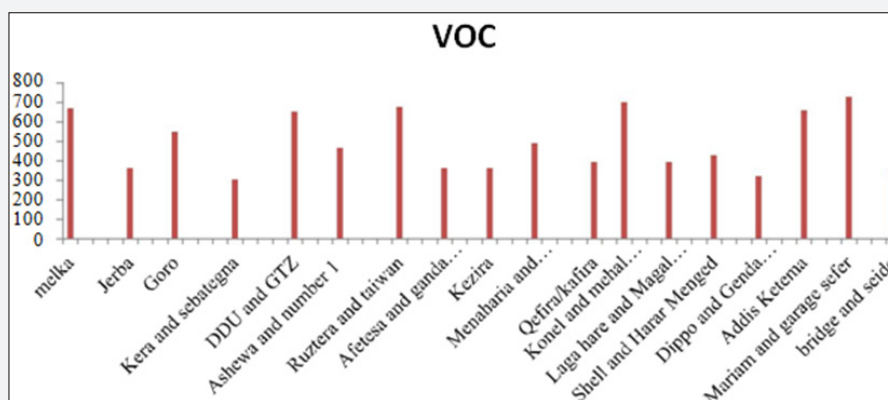


Figure 4: volatile organic compounds sampling areas.

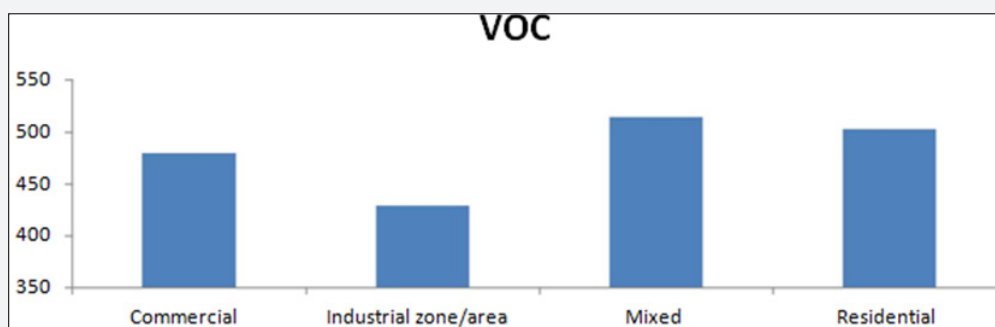


Figure 5: Values of volatile organic compounds (ppm).

Conclusion and Recommendations

Ambient air levels of nitrogen dioxide (NO₂), carbon dioxide (CO₂) and volatile organic compounds (VOCs) was measured at each of the commercial, industrial, mixed and residential sampling spots and the results recorded accordingly. The results showed that the magnitudes of nitrogen dioxide (0.0446 ppm) and carbon dioxide (459 ppm) was higher at commercial spots followed by a relatively similar to each other results at residential (0.0422 ppm and 426 ppm), mixed (0.0435 ppm and 435 ppm) and industrial (0.0435 ppm and 425 ppm) spots but the results of volatile organic compounds at commercial, industrial and residential (480 ppm, 429 ppm, 506 ppm) sampling spots respectively showed high values (mixed 514 ppm) relative to the results obtained for nitrogen dioxide (NO₂) and carbon dioxide (CO₂) at same sampling spots. However, commercial spot at Ashewa and number 1 area

recorded 493.5 ppm value for carbon dioxide which is higher than the average value at all four measuring spots. Similarly, commercial spot at Mariam and Garage Sefer areas had higher magnitudes of both nitrogen dioxide (0.056 ppm) and volatile organic compounds (728 ppm) respectively.

Sulphur dioxide and carbon dioxide level measurement was also conducted at each of the sampling spots at similar conditions but each did not read a value because of either their low level in the ambient air or the sensor failed to measure them. The relatively high values of nitrogen dioxide and carbon dioxide at commercial spots may be attributed to many factors such as the presence of institutions that frequently used fossil fuel products for power and transportation, natural resources activity dependent people (such as agriculture) and the number of people in the area community having limited access to electric power

but dependent on wood and municipal solid garbage for energy sources. Similarly, the magnitude of volatile organic compounds in the mixed spot is also high, 514 ppm. The reason for this can be accounted for the various activities performed around the area of mixed spot. Mixed area by definition consists of industries, commerce and residents of different living standards. Thus, the higher value of volatile organic compound in this particular case may be due to the cumulative effects of the various activities and inputs used at industrial, commercial and household levels. In general, the values obtained for each pollutant gas was based on a three minute sampling average and are lower than the one hour and annual average results set by world health organization (WHO) and ambient air quality standard (AAQS).

However, the higher readings for nitrogen dioxide, carbon dioxide and volatile organic compounds at Ashewa and Number 1 and Mariam and garage Sefer can provide a clear insight on the future pollution status of the city. Rapid urbanization and congested traffic including train and air transport in the city would continually add harmful pollutants into the atmosphere changing the current situation. The low awareness of the people and the leadership together with increasing ambient air pollution could risk public health and the environment. Hence, further detailed research using modern methods of ambient air sample analysis and training through awareness and initiating the leadership to take all possible measures is crucial to alleviate the likely dangers associated with urban air pollution.



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