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Concentrations of Ground-Level Ozone on Petroleum Filling Stations in Urban West Region- Zanzibar

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Abstract

Ambient concentration of ground-level ozone was quantified from 14 petroleum filling stations in Urban and West districts allocated in urban west region Zanzibar between August and November 2019. In situ measurement was conducted for two separate sessions that involved before noon and afternoon in each day in the field using BH-4S Portable multi-gas detector. The analyzed data revealed both temporary and spatial variations of measured parameters. During phase1, the range of ozone was 4.8- 0.6 ppm. During phase2, the range of ozone was 14.2 - 4.5 ppm. The mean values recorded for ozone ranged from 0.6 ppm to 4.8 ppm for phase1, and from 4.5 ppm to 14.2 ppm for phase2. This study revealed that, ground-level ozone is at a point that calls attention tothe environment and health sectors.
Keywords: Ozone; Health sectors; Gas stations.

1. Introduction

Liquid petroleum has become a dependable energy source, and a major energy supplier used to fuel most transports. Despite the fact that oil composes a major petrochemical feedstock, it is still a primary reliable source of energy to the world [1]. Apart from its great importance, oil industry came with some negative impacts, as it contributes to the productions of some pollutants including VOCs and ozone [2]. GHGs and other pollutants pollute our atmosphere leading to global warming. Therefore, petroleum-filling stations are considered a major contributor to some GHGs emissions and VOCs in urban and remote areas. Fossil fuel, especially petroleum, is a big precursor of air pollutants [3]. Through transportation and petrol filling stations, a large quantity of ozone and even volatile organic compounds are produced [4]. As energy (especially oil) demand increases daily due to the expansion of the transportation sector, there is an increase in the number of petrol stations in Zanzibar, particularly in the urban west region. In Unguja Island, there are 60 petroleum operating stations, 35 out of which are allocated within urban regions[5]. Continuous expansion of petroleum filling stations triggers air pollution due to emission of gases into the air. The gas emissions occur during the petroleum delivery process to the filling stations, tank ventilation, vehicles fuel refilling process, emissions from loosely closed tanks, improper gasoline handling, etc. [6]. The emission is also due to combustion from generators, and vehicle engines present in the stations. VOCs vapor emissions related to gasoline and motor vehicle exhaust are among great environmental concerns air pollutants [7]. Long-term exposure to VOC can even cause cancer problems [8]. Apart from its health problems, VOCs play a crucial role in the formation of ground-level ozone (GLO) through photochemical reactions with nitrogen oxides (NOx) in the presence of sunlight [9]. Ozone is the third-largest source of global warming after carbon dioxide and methane, followed by halocarbons and nitrous oxide [10]. It is believed to generate about one-fourth of carbon dioxide's warming.

1.1. General Objectives

The main objective of this study is to quantify c the concentration of ground-level ozone at petroleum filling stations in the urban west region of Zanzibar. Specifically, the present study aimed at the following objectives:

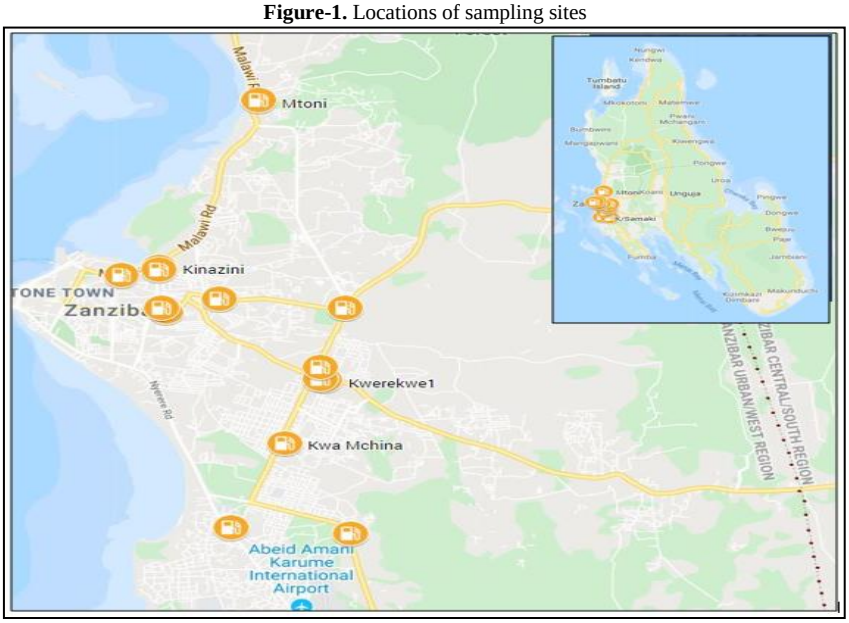
i. To determine the concentration levels of ozone at the petrol filling stations
ii. To assess the influence of gas stations on ground-levelozone

2. Materials and Methods

The study was conducted in Unguja –urban west Region of Zanzibar. It included all the region's three districts, namely Urban, West A, and West B. As pointed earlier, the site was selected due to the abundance of the petroleum operating stations in the study area**.**

*Corresponding Author

Figure-1. Locations of sampling sites



2.1. Gas Stations Sampling

Fourteen (14) gas stations were involved in this study in which, 7 stations were taken from urban district and the remaining stations from the west district. The stations included united petroleum, Gapco, Zanzibar petroleum and one private station.

2.2. Sampling Procedures

A simple random sampling technique was used to select gas filling stations. This is a convenient technique since every member has the same probability chance of being selected (Table 1).

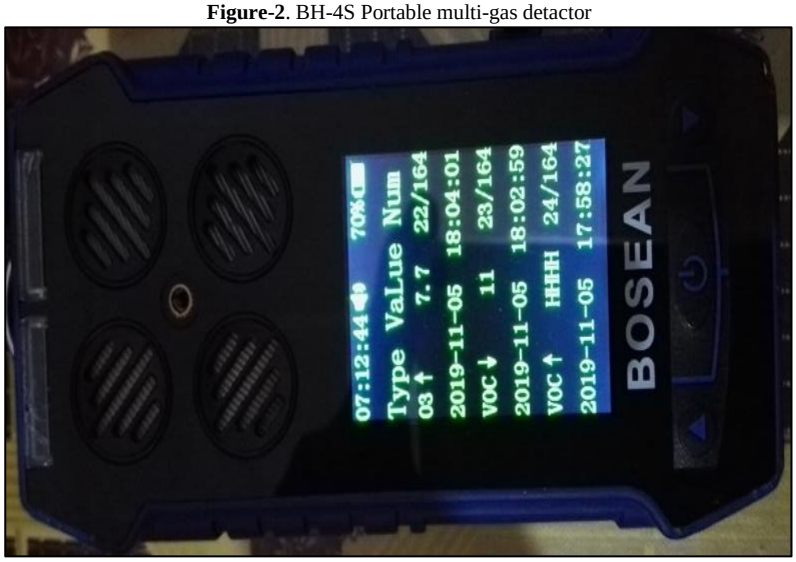
Table-1. Petroleum filling sites in the study area

Urban West Petroleum Filling Stations Sampling Sites	
WEST DISTRICT	URBAN DISTRICT
Kiembe Samaki	Amani
Kisauni	Mikunguni
Kwa Mchina	Kijangwani1
Kwerekwe1	Kijangwani2
Kwerekwe2	Gulioni
Kwerekwe3	Kinazini
Mtoni	Mlandege

2.3. Data Collection

The present study used quantitative research method. The concentration of ozone was quantified insitu using BH4-S portable multi- gas detector (Figure2). Ozone was measured three times for data reliability before statistical data analysis.

Figure-2. BH-4S Portable multi-gas detactor



3. Results and Discussion

The results from the study showed that there is a noticeable variation of the levels of ozone.

3.1. Variation of Ozone Concentration

Variation of ozone concentration was witnessed from day to day as well as from site to site. This indicates that concentration of ozone levels is a dynamic parameter.

3.2. Temporal Ozone Concentration in Urban District

3.2.1. Before Noon

During the first phase, ozone lowest concentration of 0.20 ppm was recorded in day 1 at Mlandege, Gulioni, Kinazini and Kijangwani2, day2 at Amani, Mikunguni and kijangwani2 and day3 at Amani, Kijangwani1 and Gulioni. While the highest ozone concentration of 21.0 ppm was recorded at Amani (range =20.8 ppm).

The highest pick of the area was recorded in day 4 and 5 at Amani where by ozone concentration increased to 21.0ppm but then dropped to 0.2 ppm in day 2 (range = 20.8 ppm).

For the second phase, the least ozone concentration of 0.1ppm was recorded on day1at Mikunguni. While the highest pick of 21.0 ppm at the same site (range=20.9 ppm).The highest record of21.0ppm Obtained on day1 at kijangwani2 and Gulioni, day2 at Mikunguni and kijangwani2 and on day 3 at kijangwani1 and kijangwani2 (range=20.9 ppm)

Generally, variations of ozone could probably due to the level of VOC at the sites during data collection, sunlight and the presence of nitrous oxide as suggested by Sillman [11]. In addition, wind direction and atmospheric temperature and pressure could probably be some of the factors.

The study revealed that the ozone level was most of the time to the levels of VOCs present at the stations.

Figure-3a. Levels of ozone in west district (afternoon phase1)

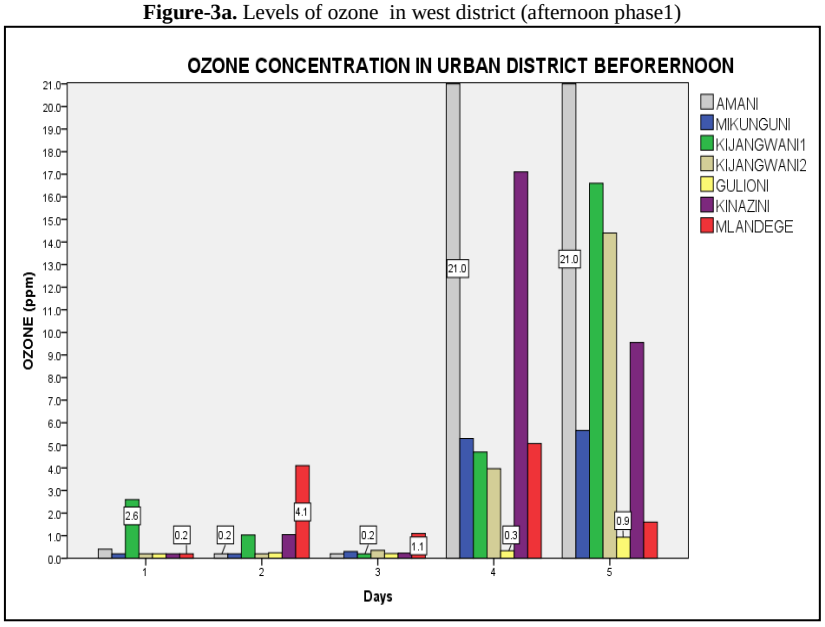
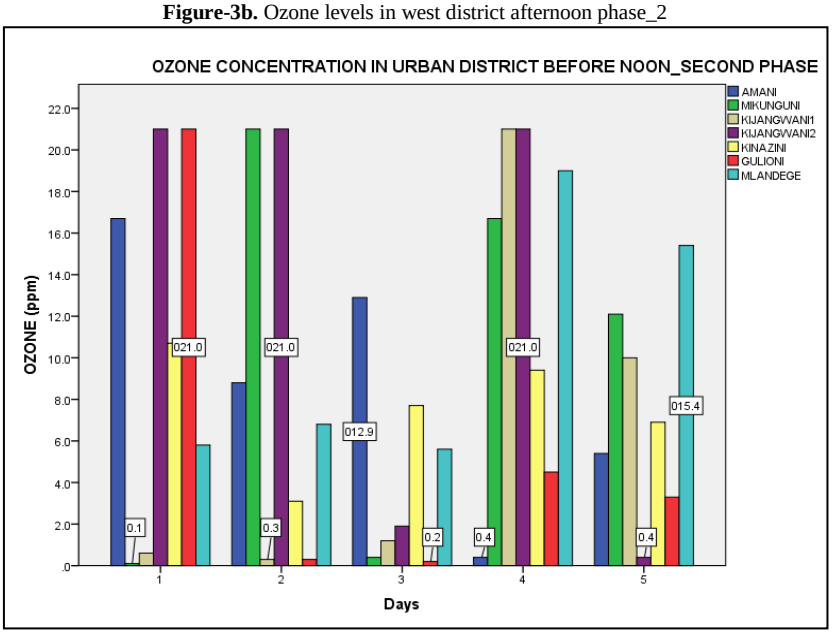


Figure-3b. Ozone levels in west district afternoon phase_2



3.2.2. Afternoon

First phase zone lowest record of 0.10 ppm was recorded in day1 at Mikunguni day2 at kijangwani2 and day5 at Kinazini. In contrast, the highest record of 5.4ppm was obtained on day4 at Kinazini (range = 5.3 ppm).

The highest pick of the area was recorded on day 4 at Kinazini in which ozone rose to 5.4 ppm. Meanwhile the record dropped to 0.1ppm at the same site on day1 as per figure 8a (range=5.3 ppm).

For the second phase taken during October and November, the least record of 0.1ppm was obtained on day1 at Mikunguni, while on the same site on day3, ozone concentration increased to 10.0ppm as illustrated in figure 8b (range=9.9 ppm)

Figure-4a. Variation of ozone in west district (afternoon phase2)

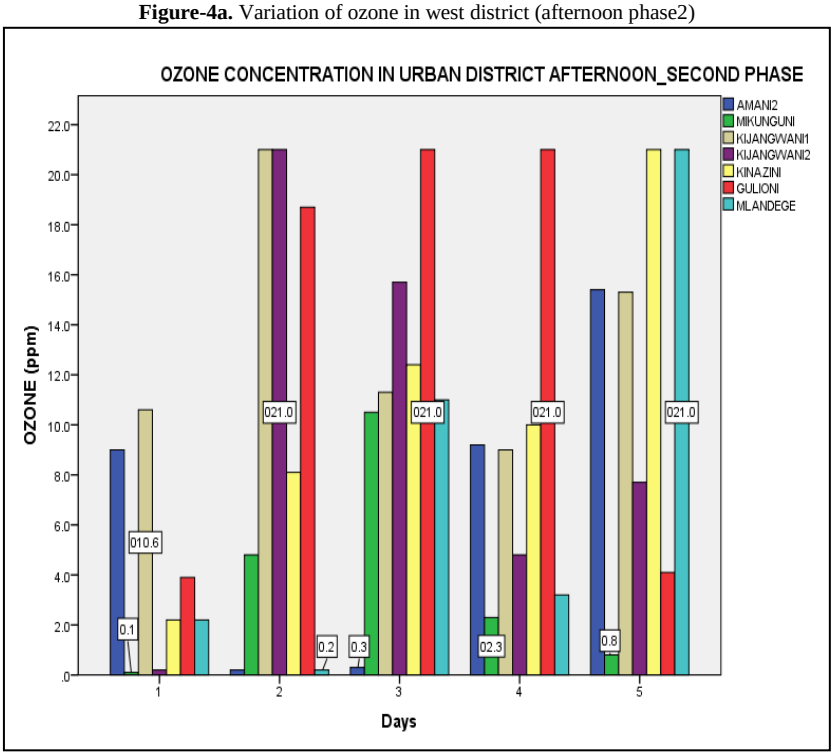
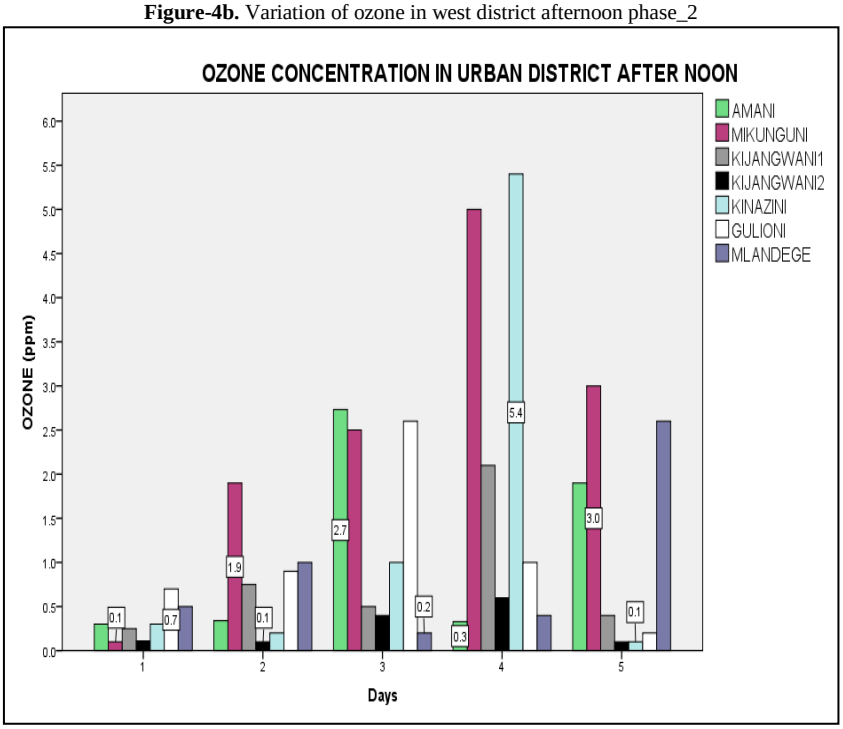


Figure-4b. Variation of ozone in west district afternoon phase_2



3.2.3. Variation of Ozone Concentration in West District Before Noon and After Noon

3.2.3.1. Before Noon

The lowest ozone concentration of 0.10ppm for the first phase was recorded on day1 at Kwerekwe3.meanwhile, the highest pick of 21.00 ppm for the same site was recorded on day 4.(range = 20.90 ppm). Another highest record of ozone concentration of 21.00 ppm was obtained on day 5 at Kwerekwe2.meanwhile the lowest ozone concentration of 0.26 ppm on day 3 on the same site was recorded (range = 20.74 ppm).

Second phase lowest concentration of 0.2ppm was recorded on day 1, 2 and 5at kwerekwe1 and in day4 at kwerekwe3 while the highest concentration of 17.4ppm among these sites was recorded in day3 at kwerekwe1 (range=17.2 ppm).

Meanwhile, the highest ozone concentration of 21.0 ppm was obtained on day1 at Kisauni, kwerekwe2 and Mtoni, on day2 at Kiembe Samaki and Kwamchina and on day4 at Kisauni and Kwamchina. While the least record of 0.3 ppm among these sites was obtained on day 4 at Mtoni (range=20.7 ppm).

Figure-5a. Variation of ozone in west district afternoon phase_1

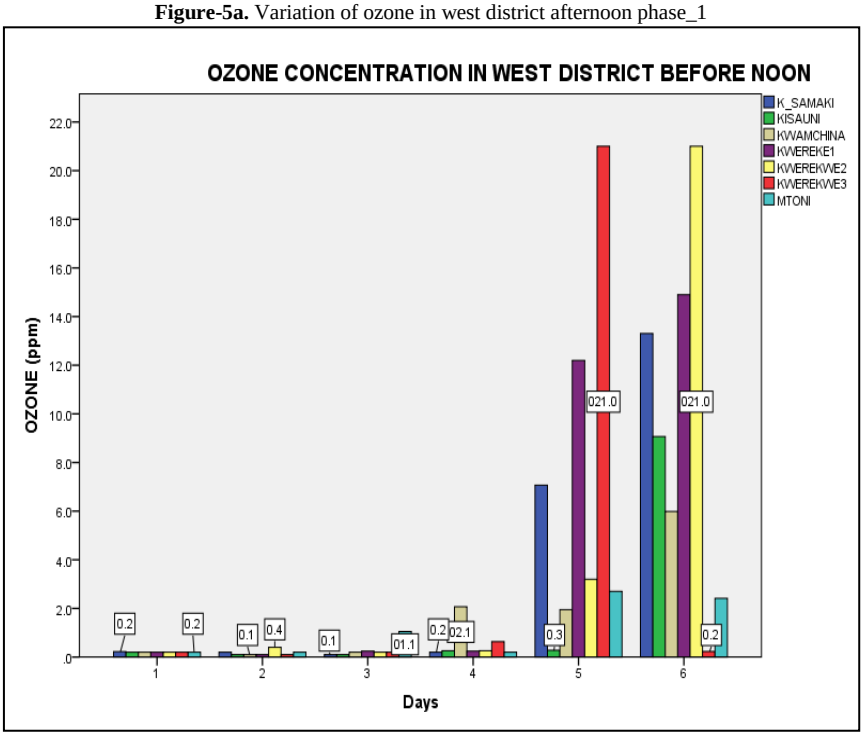
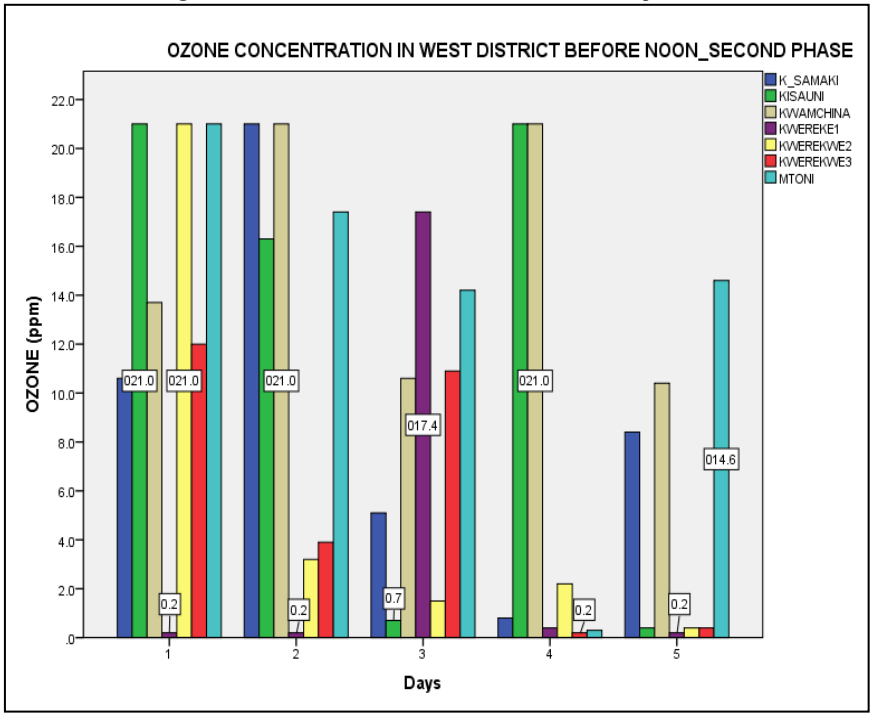


Figure-5b. Variation of ozone in west district afternoon phase_2



3.2.4. Afternoon

The lowest first phase ozone concentration of 0.20 ppm was recorded on day 1 at Mtoni, Kwamchina, Kwerekwe1 and Kwerekwe2 while the same size was recorded on day 5 at Mtoni and kwerekwe3. The highest pick of 21.0 ppm among those sites was recorded in day 5 at Kwerekwe1 (range of 20.8 ppm). Meanwhile, the highest data record of 21.0 ppm was obtained on day5 at Kwerekwe1 and then dropped to 0.2 ppm in day1&3(range=20.8 ppm).

For the second phase, the least data value of 0.1 ppm was taken on day1 at Kwamchina while on the same site on day2,3&4,ozone concentration increased to 21.0 ppm(range=20.9 ppm). Meanwhile, the highest data value was witnessed in the same days on the same site, so the remains at the same as illustrated earlier in this paragraph.

Figure-6a. Variation of ozone in west district afternoon phase_1

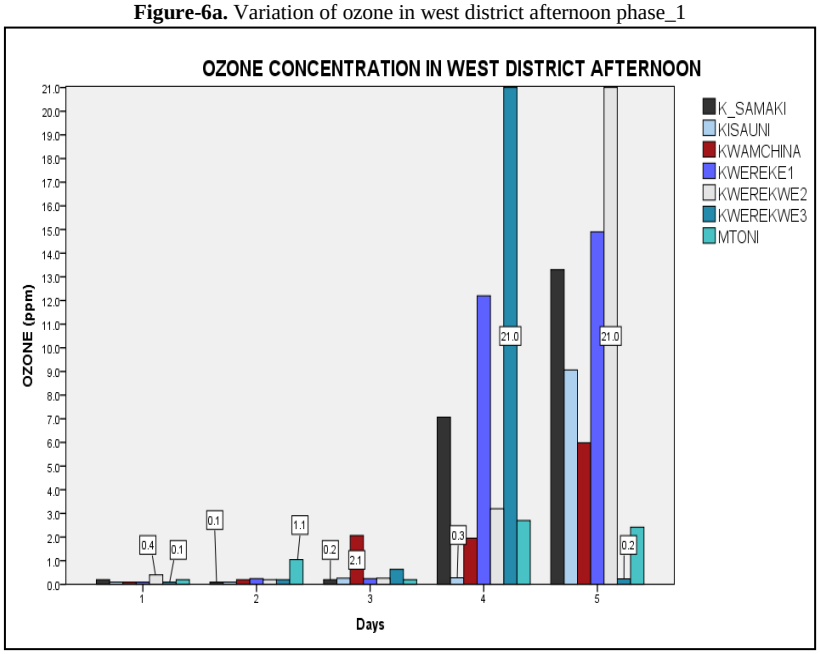
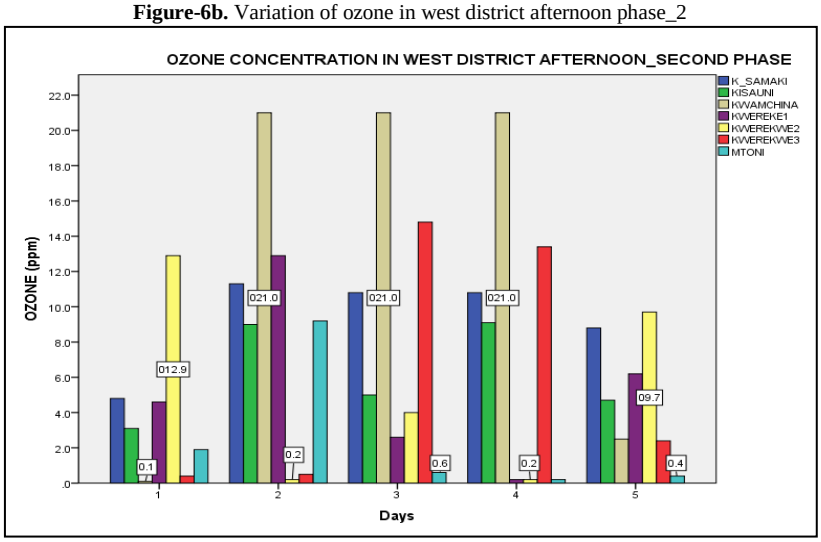


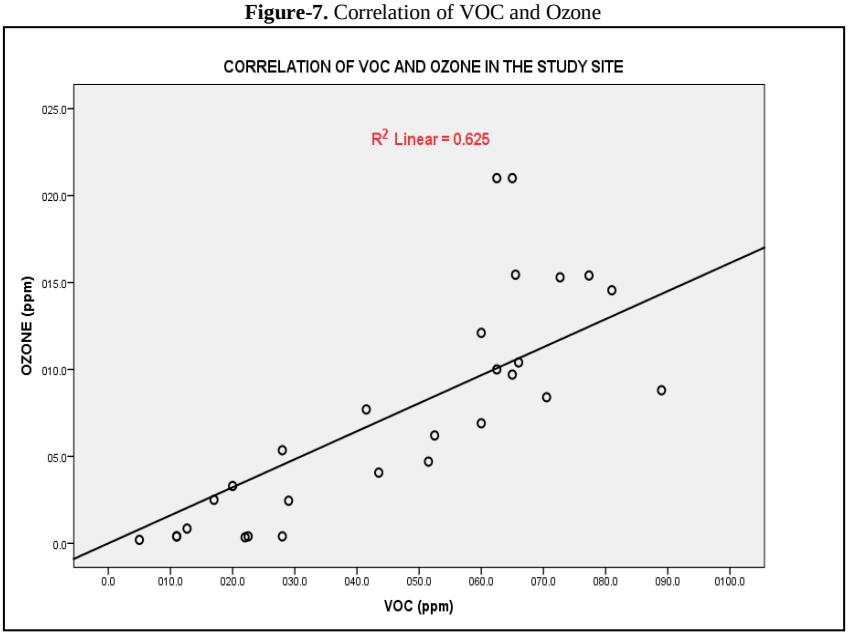
Figure-6b. Variation of ozone in west district afternoon phase_2



3.2.5. Correlation of VOC and Ozone in the Study Area

A remarkable relationship between VOC and ozone was observed in this study. The data generally showed a good positive correlation (R^2 =0.625) between the mentioned parameters described in figure 7 below figure 7 below.

Figure-7. Correlation of VOC and Ozone



This correlation reveals that VOC emission in the study area positively influences the production of ground-level ozone.

3.2.6. Ozone Levels in Urban West Region on Selected Sites

With respect to EPA and WHO guidelines for ground level ozone which are 0.075 ppm [12] and 0.05 ppm [13] respectively, the results obtained from the study revealed that ,100% of the selected sites the Urban west region in Zanzibar have highest levels of ozone as illustrated in figure 8a and 8b below.

The least average ozone level during first phase detected was 0.6 ppm at Gulioni and its highest average ozone level of 4.8ppm was observed at kwerekwe1(range=4.ppm). Meanwhile the least ozone level obtained during second phase was 4.5 ppm and its highest level was 14.2 ppm (range=9.7 ppm).The levels obtained from the study are higher than those adopted by WHO. So possible health problems as illustrated in that appendix may take place

Figure-8a. Ozone levels in urban west region phase 1

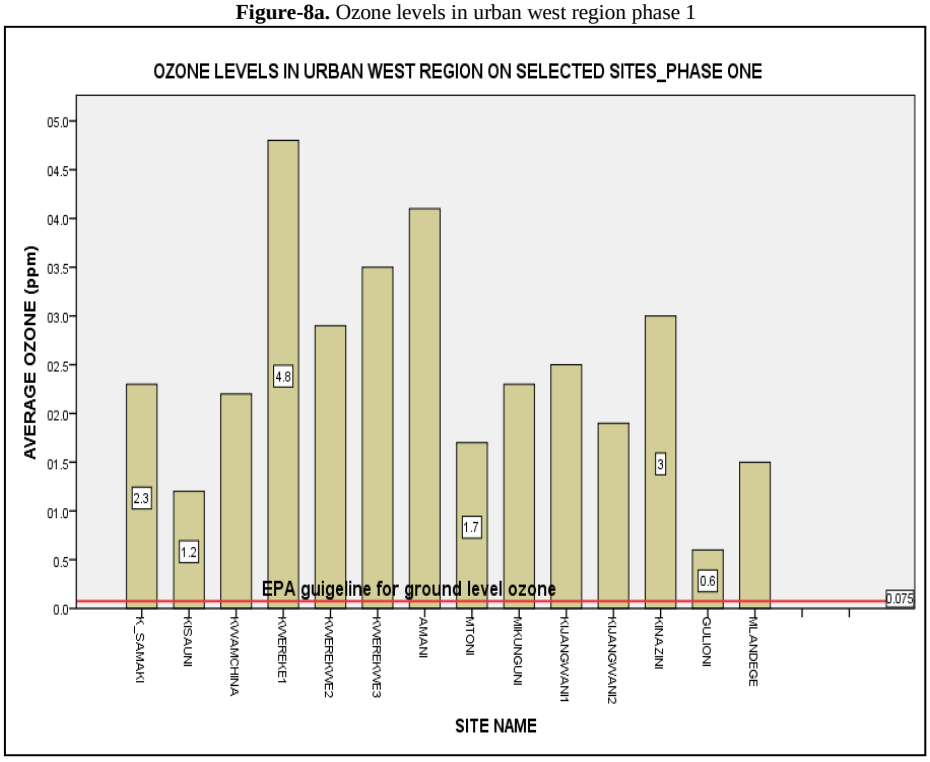
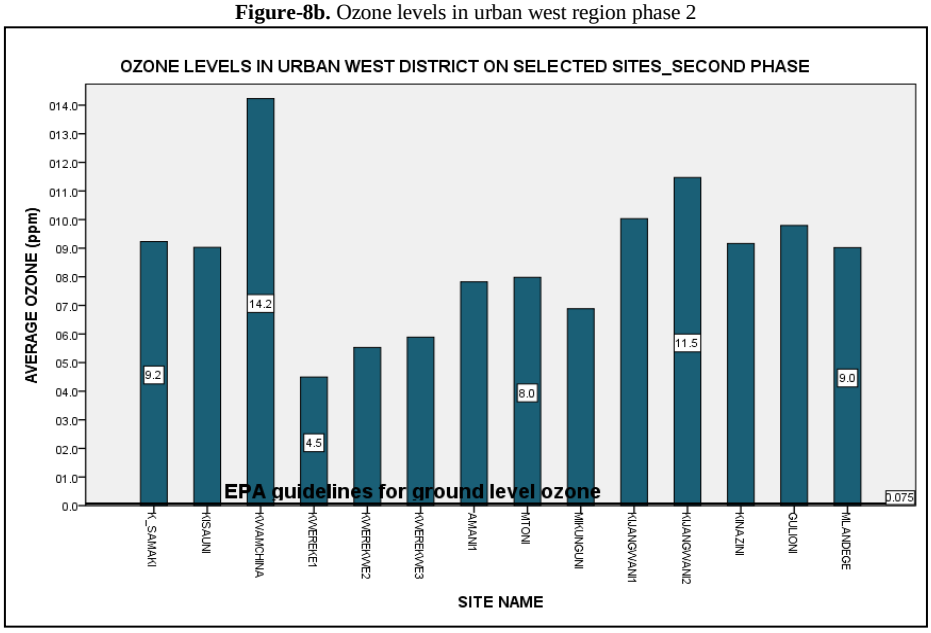


Figure-8b. Ozone levels in urban west region phase 2



4. Conclusion

The study revealed that the emission of VOCs, especially at gas stations, has a significant influence on the formation of ground-level ozone. Hence, controlling the VOC emission from the stations can probably resolve this critical greenhouse gas formation at a ground level.

Acknowledgement

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