Global Scientific JOURNALS

GSJ: Volume 8, Issue 5, May 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

NATIONAL METEOROLOGICAL AGENCY OF ETHIOPIA

STUDY ON SEASONAL MAGNITUDE AND VARIATION OF FINE PARTICLET MATTER POLLUTION ($PM_{2.5}$) OVER ADDIS ABABA, ETHIOPIA IN METEOROLOGY PERSPECTIVE

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ADDIS ABABA, ETHIOPIA
05/2020

ABSTRACT

In this study, aimed at studying the impact of meteorology might have on the seasonal magnitude and vibration of fine particulate matter in Addis Ababa, Ethiopia, meteorological parameters such as air temperature, relative humidity, rainfall and wind speed. Two outcome measures were concerned, the first outcome was to study the effect of meteorological variable on Fine particulate matter and the second outcome was effects of seasonal change on fine particle. The monthly mass concentrations of fine particulate matter ($PM_{2.5}$) were measured along with the monthly unit of meteorological parameter from 2017 January to December 2019. after analyzing, found that The magnitude and variation of $PM_{2.5}$ concentrations were highest in summer season than in dry and winter season. However, during winter season $PM_{2.5}$ concentrations were higher than dry season.

Keywords; pollution, fine particulate matter, meteorological parameter and season

1. INTRODACTION

1.1. Background

Climate change is expected to adversely affect air quality by changing meteorology patterns and vice versa. If regional meteorology changes lead to increasing in air quality this would be a climate disadvantage; if on the other hand it reduces concentrations this would be a climate advantage (Fiore et al., 2015). Removed PM from the atmosphere by precipitation and increased frequency and intensity of rainfall will reduce PM concentrations. Conversely, reduced rainfall would increase concentrations.

The pollutants also have effects on change in climate due have role in the formation of PM, O_3 on the surface and the lifetime of GHGs (Fiore et al., 2015). The weather influence also the PM through the local wind the increase dispersion, the thermal inversion, the long-range transportation.

On the basis of land use and lad cover urban and rural area are uses may the proposes of technology system, transportation system, agriculture system (EPA, 2001). But urban and rural areas are heterogeneous by using the land, link to this the topography, wind and pressure gradients. Hence, these all the special distributions of air pollutants made different.

Increasing demand on transportation service, agricultural and challenges of the prevailing poverty are basic Problems in developing cities of Ethiopia, such as Addis Ababa. Such emerging processes with economy and technology lead to improve pollutant in atmosphere.

Addis Ababa city has different distributions of rainfall and temperature in each season, high rainfall during summer season from Jun-September, moderate rainy period during Belg season from February- May and dry period during October- January months, these up and down rainfall lead to improve or dis-improve air pollutant in air. And also, in Addis Ababa by average high temperatures and cold night is measured from October- January, this led to the formation secondary pollutant specially pollutants of O_3 and Particle pollutants. Those Particle pollutions are the major problems in urban area, haves the acute effects on human health, on environment and on climate and weather. Consequently, it is highly required to reduce pollutions concentrations in Addis Ababa city to protect human health, reduce environmental damage and change in the weather of air quality.

1.2. Description of the problem to be solved

Influence of meteorology might have on the PM seasonal variation is unknown. The first cause is Influence of meteorology on seasonal magnitude and variation of $PM_{2.5}$ this is due to Uncertainty of technologies used in the next future duo to the causes of unknown people activity under seasonal variation $PM_{2.5}$ and Poor information about relationship between meteorology and air pollution this also as results of Lake of literature review, Lake of data about PM variations and lake of data about climate change. These all problems have effects on unanticipated health effect of the human, ecology and climate Change. The other effect is lack of air quality management strategies as result no scheduled adaptation plan, weak protective efforts, weak attentions has been paid on meeting air quality goals and shortage of air pollution data can exist.

1.3. Objective

The mean objective of this paper is to study the impact of meteorology might have on the seasonal magnitude and vibration of fine particulate matter. To study the mean objective, the following activity were performed; a detail background information about the impacts meteorological parameter on air pollution, analyses the data including meteorological and particle pollution with diameter less than 2.5 micrometer and carefully analyzing the quantified results of magnitude and vibration of $PM_{2.5}$ in the perspective of meteorology.

1.4. The relevance of the study

This study is important to provide information about the impacts of meteorology on the $PM_{2.5}$ seasonal variation and magnitude. this study is also finding the advisory solution to growing city and land use change relation with air pollution, meteorology relation with air pollution, air pollution relation with meteorology. coupled to these, advice possible air pollution strategies and management activities for the local government, for the people, for planer and researcher in response to air pollution impact on health, environment and ecology.

1.5. Scope of the study

The general scope of this study is mainly focus on in five tame; The first tame was focus on a detail background information about the impacts of meteorology on air pollution, the second tame was focused on analyses the data including meteorological and particle pollution with diameter less than 2.5 micrometer, the third tame was focused on carefully analyzing the quantified results of meteorology impacts on the magnitude and variation of $PM_{2.5}$. the fourth tame was focused carefully analyzing the quantified results of magnitude and vibration of $PM_{2.5}$ impacts by meteorological parameter and also the fifth tame set information to possible air pollution strategies and management activities of people, planer and researcher in response to air pollution impact on health, environment and ecology.

1.6. Limitation of the study

There are some limitations to this study that should be considered such as limited data represents to the study area, documents that is reference to the topic of the study, expertise on team of air quality study and the type of air quality/climate change integrated assessment model. These all limitations were reducing the quality and timely finalize the study.

2. LITRATUER REVIWE

2.1. Implication of meteorology on air pollution

Change in climate has negative effect on air quality by changing weather patterns, through alternations to mixing, dilution, formation and removal processes, and affects both anthropogenic and natural emissions. If regional meteorology changes lead to a deterioration in air quality this would be a climate penalty; if on the other hand it reduces concentrations this would be a climate benefit (Fiore et al., 2015).

2.1.1. Implication relative humidity on air pollution

The redaction of stagnation of air with reducing relative humidity in air, reduce rainfall, increasing temperature, increase wind speed and reduce pressure gradient, would increase mixing and dilution of emissions, these all phenomenon improving air pollution; conversely, increasing stagnation of air would reduce mixing and dilution of emissions over the surface of the earth lead to decrease air pollution on the surface (Fiore et al., 2015).

2.1.2. Implication of temperature on air pollution

Temperature and heat wave are improving the formation of secondary pollutants associated with particle pollution and surface ozone some increase pollution episodes. Increasing temperature is could improve water vapors, which will lead to reduction in rural areas and more polluted regions where higher pollutant concentration sources, there could also be an increase in the flux of O_3 from the stratosphere to the troposphere, further increasing concentrations at the surface (Fiore et al,.2015).

Increases in temperature will also lead to increases in emissions of biogenic compounds such as isoprene, and hence the formation of O_3, secondary aerosols and other photochemical pollutants. Since emissions of VOCs vary between tree species, tree-planting schemes aimed at energy production or carbon sequestration should take account of the potential for emissions and their impact on the formation of O_3 and secondary organic aerosols (QUARG, 2007)

2.1.3. Implication of rainfall on air pollution

Precipitation has played a great role by removing pollutants on the surface, increasing the intensity of rainfall will reduce the concentrations of pollutant. The same conditions would reduce the mineral dust component, as rain is effective at suppressing dust emissions. Conversely, reduced rainfall would increase concentrations (Fiore et al., 2015).

2.1.4. Implications of wind speed and wind direction

The dispersion and diffusion of air pollutants different in spatiotemporal setting; hence they have local, regional and continental scale effects. These have been attributed to meteorological dynamics, particularly winds. Generally, winds help to equalize imbalance in pressure that result from differential heating of the earth's surface, always following the pressure gradient and being influenced due to the presence of or absence of fraction on the surface (APTI, 2005). Because of the differential friction, which is influenced by the boundary layer characteristics, pollutants in winds aloft are dispersed faster than those at or close to the surface. Thus, turbulent diffusion is extinguished at the surface and within the atmospheric boundary layer where pollutants are transported by force of molecular diffusion (Rosenberg, 1974). Studies have proven that wind speed and direction influence air pollution dispersion and concentration. Generally, upwind location have less pollutant concentration than downwind (Garcia et al, 2007) confirming that a comparatively high concentration of pollutants are found on sites, which lie either low in attitude, in the downwind location or close to the source of pollution (Hung et al, 2005; and Tsai et al, 2004).

It is also observed that during light wind speeds and stable atmospheric conditions, pollutants tend to accumulate in the stagnant air around emission sources and can accelerate background concentrations (Garcia et al, 2007).

In cases of wind speed below 2ms-1, the concentration of pollutants increases and becomes uniformly distributed around areas within the source zones, while stagnant weather conditions with low wind speed contributes to accumulation of pollutants at ground level Hung et al, 2005) and (Tasai et al, 2004)

2.2. Land uses and air pollution

Indicators of spatial variation in air pollution have been provided on the basis of land uses, technology, urban-rural dichotomy and regional transportation system, Regional development patterns are usually heterogeneous, hence spatial distribution of ambient air quality (EPA, 2001). Apart from this, air pollutants can be transported from one land use to another, depending on the topography, wind and pressure gradients. The effects of pollution are universal and continuously experienced, not only in congested urban areas, but also in remote rural areas. Even within the urban areas, there could be

no statistically significant different in the mean concentration of pollutant in different land uses (Saksena etal, 2001).

2.3. Impacts of air pollution on meteorology

The precursors of secondary aerosols are sulfur oxide (SO_2), nitrogen oxide (NO_2) and volcanic organic compounds (VOCs). aerosols are reflecting and scatter solar radiation back to space and exert a negative (cooling) radiative forcing effect on climate. They also influence the radiative properties of clouds (Fiore et al, 2015). Thus, reductions in the precursors of secondary aerosols, and therefore in secondary aerosols themselves, are likely to lead to increases in temperature. There is evidence that the cooling effects of sulphate aerosol may have partly masked the warming effects of greenhouse gases.

The air is polluted by different pollutants, the meteorology and the quality of surroundings air were polluted, acid rain could be raining, thus sea water, soil, plants were polluted and we breeze polluted oxygen.

GSJ: Volume 8, Issue 5, May 2020
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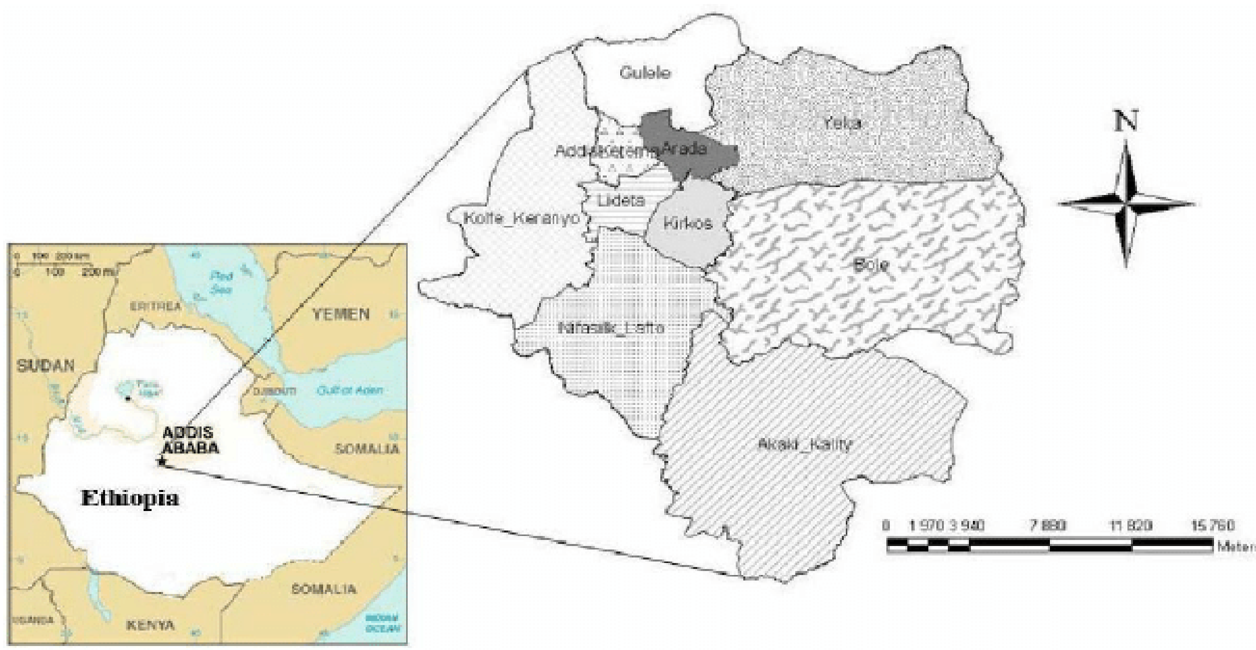
3. DATA AND METHODOLOGY

3.1. Study area

At the foot of Intoto mountain, the area of Addis Ababa city is 54 000 hectares, with diameter 30-40 Kms, the elevation varies between 2,200 and 2,800 meters above sea level with an average of 2,400 meter above sea level with average minimum and maximum temperature were 11.10c and 23.80c respectively. (FDRECAS,2009). The climatology of Addis Ababa city rainy or summer season from Jun – September, little rainy season from February – May and dry and solder night season from October – January, with average annual rainfall is 1175.8.



Map representations of study aria of Addis Ababa city, Ethiopia

3.1.1. Data

Data management and screening were hourly concentration of fine particulate matter and meteorological data were imported into MS Excel®. For this analyses form 2017- 2019 meteorological data such as Air Temperature (T_{air}), Relative Humidity (RH), Rainfall (RF) and Wind Speed from black line observatory station monitored by National Meteorological Agency of Ethiopia, together to this, Particle pollution diameters lesser 2.5 data from 2017-2018 community school station represents for old airport area and 2017-2019 central station represent for Intoto area downloaded from air now website monitored by USA embassy of Ethiopia.

3.1.2. Methods

To conduct statistical analysis, synoptic meteorological data mainly T_{air} in ^{0}c, RH in %, RF in mm, WS in m/s and fine particulate matter ($PM_{2.5}$) in µg/m^3 data were season-lazed by monthly moving average from the original data to focus on day-to-day observations. The parameters were calculated by the following two equations.

$$(Tair, RH, WS, RFandPM2.5)^{n=31,30,28} = \sum_{n=1}^{n=31,30,28}$$ ……………………………...…Equation1

Equation1 used to calculate monthly summations of the parameters

Where (T_{air}) represents to monthly summations of air temperatures, (RH) represent to monthly summations of relative humidity, (WS) represents to monthly summations of wind speed and ($PM_{2.5}$) represents to monthly summations of concentrations fine particulate matter.

Where n=1 represents the first or day 1, n=31 the number of days is 31, n=30 the number of days is 30 and n=28 is the number of days is 28.

$$\overline{(Tair.RH.WS.RFand\ PM2.5\ )^{n=31,30,28}} = \frac{1}{31,30,28}\sum_{n=1}^{n=31,30,28}$$ ………......................................Equation 2

Equation 2 used to calculate monthly mean of the parameters

Where ($\overline{Tair}$) represents to monthly mean air temperatures, ($\overline{RH}$) represents to monthly mean relative humidity ($\overline{WS}$) represents to monthly mean wind speed and ($\overline{PM2.5}$) represents to monthly mean concentrations of fine particulate matter.

4. RESULT AND DESCUSSION

4.1. Monthly Average of Meteorological and Fine Particulate Matter

The overview of the parameters analyses results from the Figures.1,2 and 3 were $PM_{2.5}$ concentrations over central and community school monitoring stations the *estimated* average concentration was highest magnitude by the months of July and Jun 2017 for respective monitoring stations , March and Jun 2018 for respective monitoring stations and Juley 2019 for central monitoring stations and lowest concentration was estimated by the months of September and march 2017 for respective monitoring stations, December and September 2018 for respective monitoring stations and September 2019 for central monitoring stations.

By the same figures. 1,2 and 3 the meteorological parameters T_{air}, RH, RRR, WS, the analyses have been showed that highest values during Juley 2017, August 2017, August 2017 and December 2017, for respective meteorological parameter, March 2018, August 2018, August 2018, Jun 2018 for respective meteorological parameters and March 2019, April, 2019, Juley 2019 and September 2019 for respective meteorological parameters. Low values were measured during April 2017, December 2017, January 2017, September 2017 for respective meteorological parameter, Juley 2018, February 2018, December 2018, March 2018 for respective meteorological parameter and November 2019, December 2019 January 2019 and August 2019 for respective meteorological parameter.

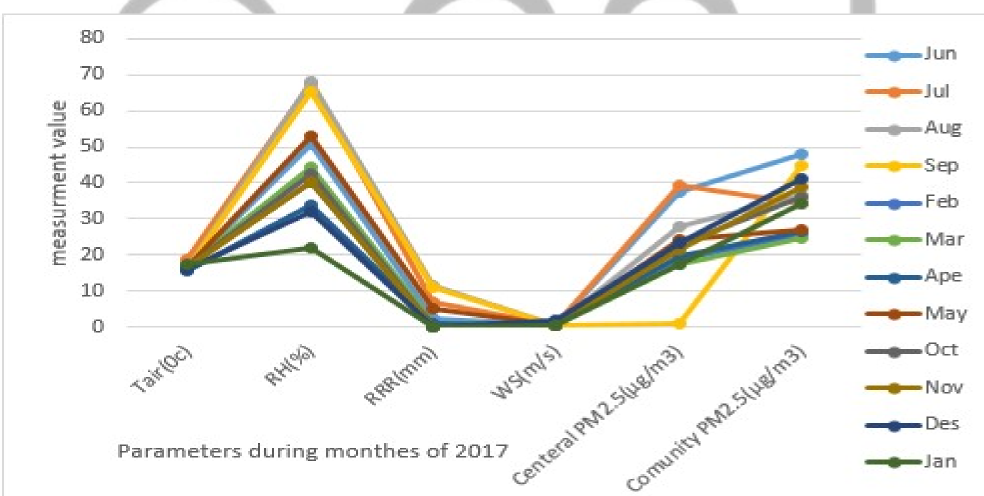


Figure1. Monthly mean Meteorological and fine particulate matter during 2017

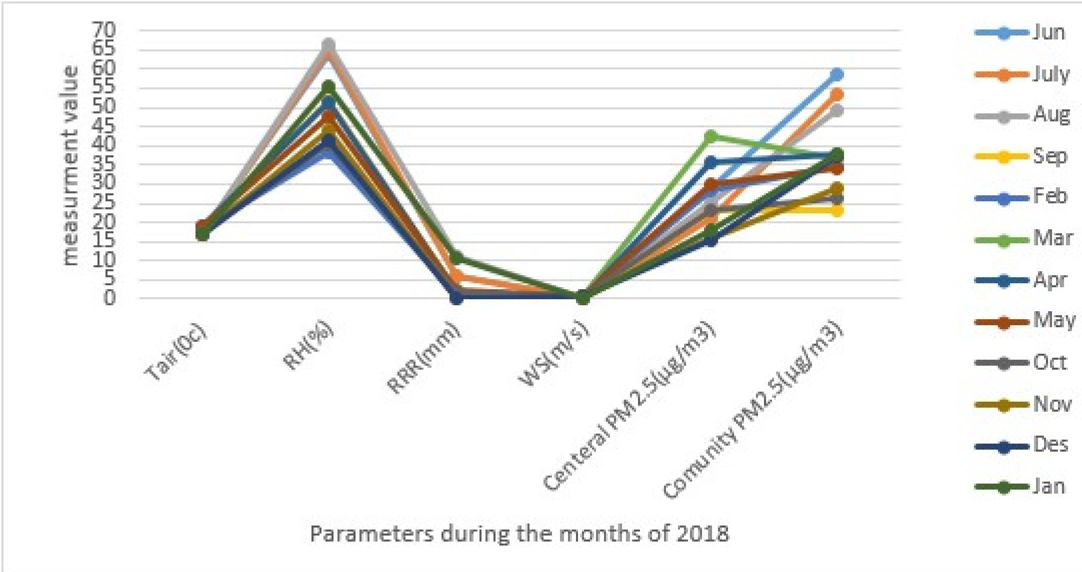


Figure2. Monthly mean Meteorological and fine particulate matter during 2018

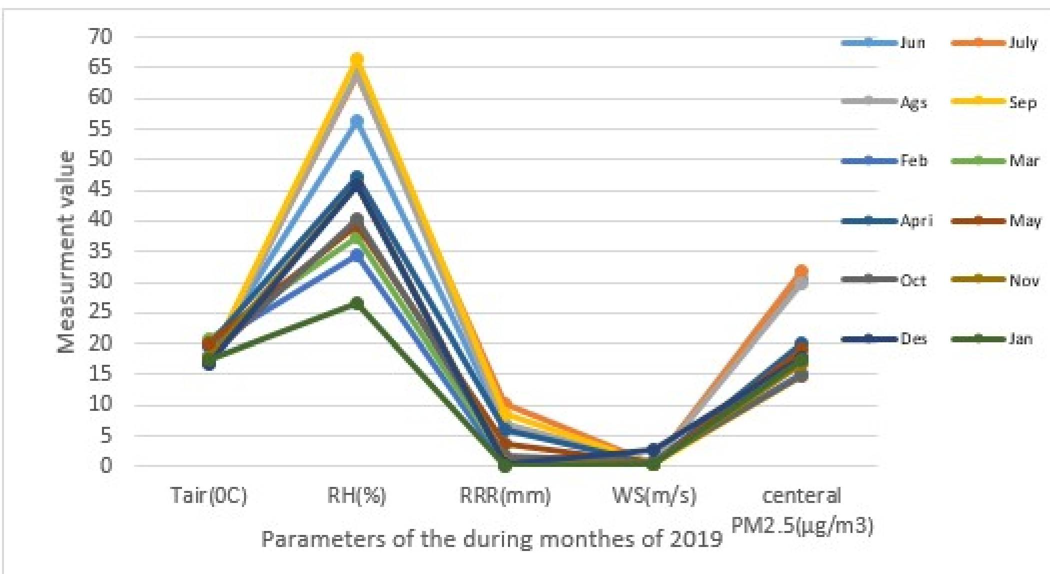


Figure3. Monthly mean Meteorological and fine particulate matter during 2019

4.1.1. Seasonal analyses of Meteorological and Fine Particulate Matter

Presenting in figures. 4, 5, 6, 7, 8, 9, 10, 11 and 12 in average highest concentration of fine particulate matter ($PM_{2.5}$) was estimated during summer seasons (Jun – September) by the reverse during Bega seasons from (October – January) or over both monitoring stations (central and community school).

Coupling with fine particulate matter by the same figures. 4, 5, 6, 7, 8, 9, 10, 11 and 12 in average highest air temperature (T_{air}) was estimated during Belg seasons from (February –May), highest rainfall and relative humidity estimated during summer seasons from Jun – September and highest wind speed was stated during Bega season from October – Jan. However, by average low air temperature was measured during Kiremt or Summer season, low rainfall and relative humidity during Bega or dry season and low wind speed during summer season.

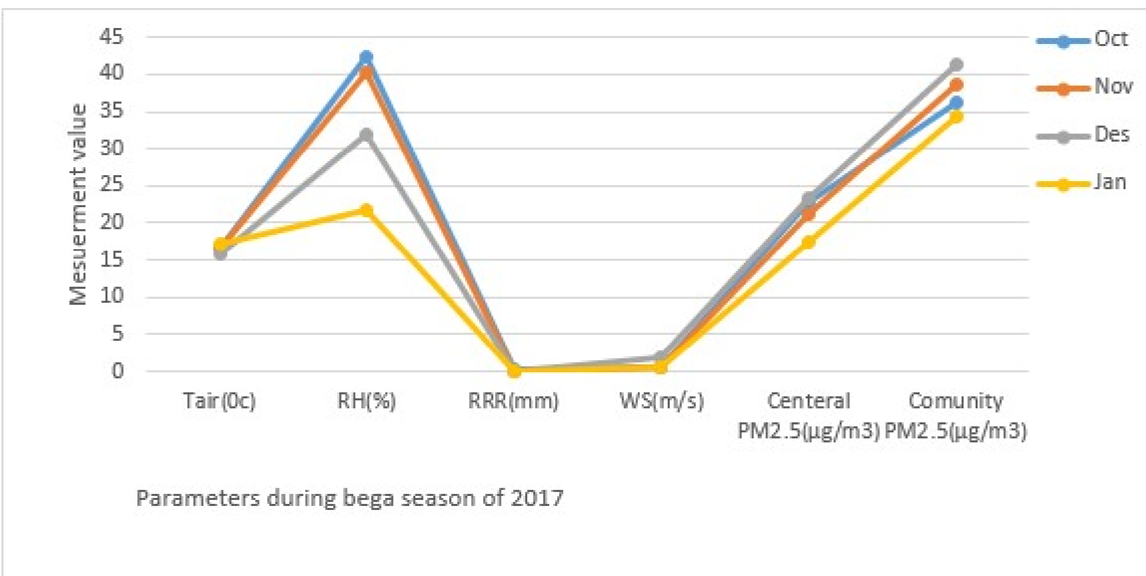


Figure4. Selected meteorological parameters and fine particulate matter during Bega 2017

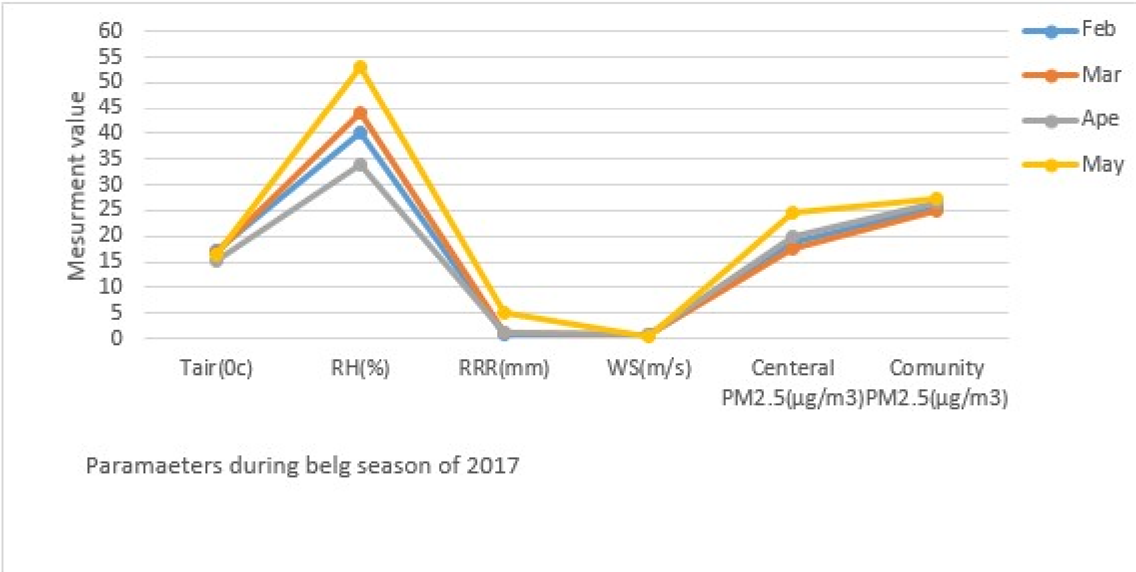


Figure5. Selected meteorological parameters and fine particulate matter during Belg 2017

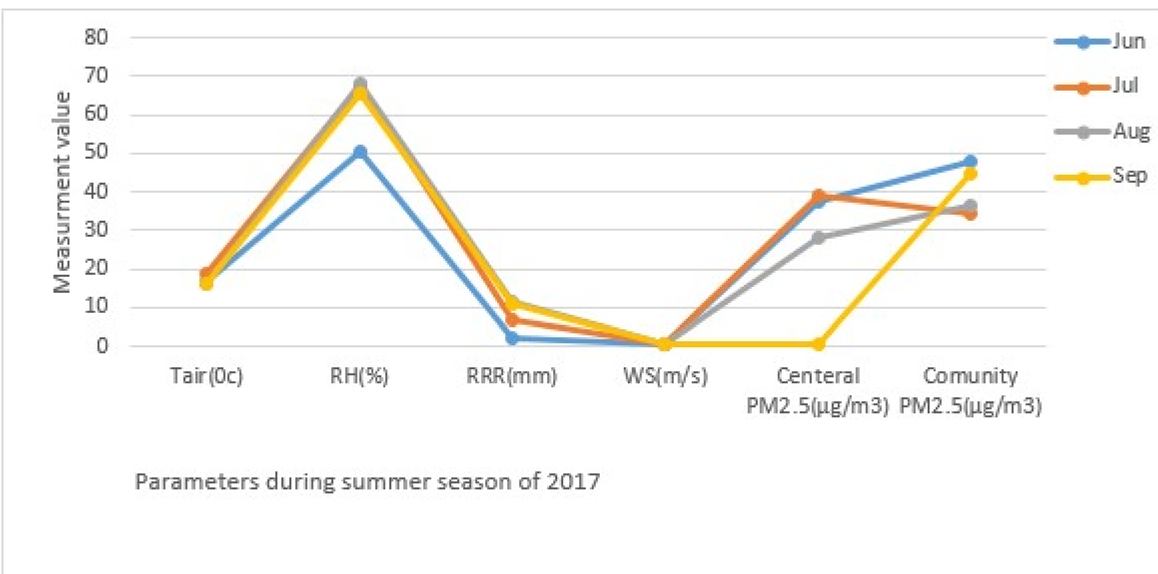


Figure6.Selected meteorological parameters and fine particulate matter during Kiremt 2017

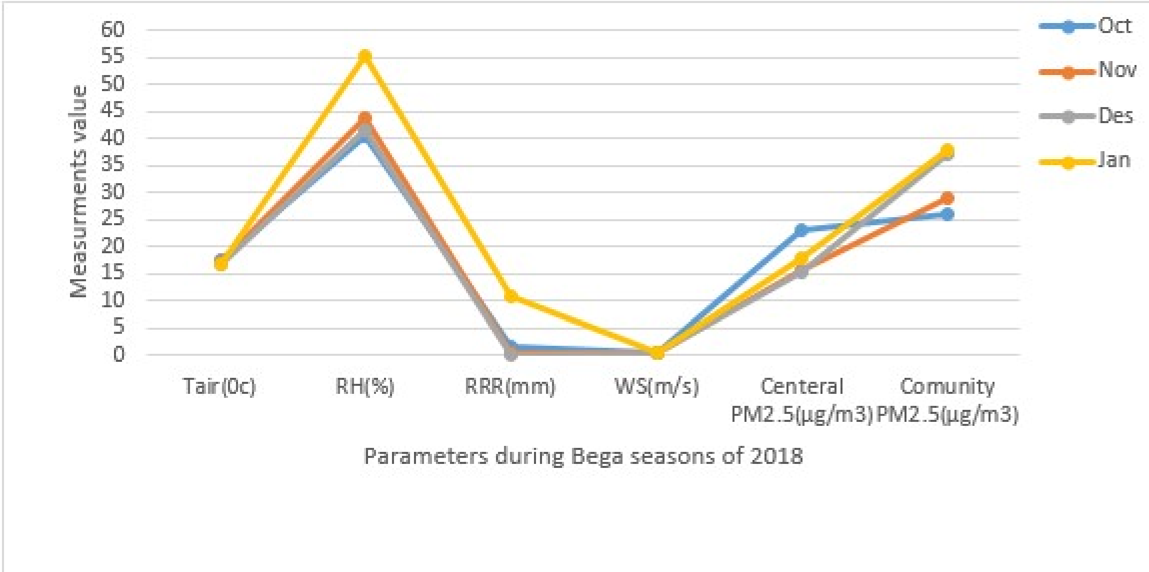


Figure7. Selected meteorological parameters and fine particulate matter during Bega 2018

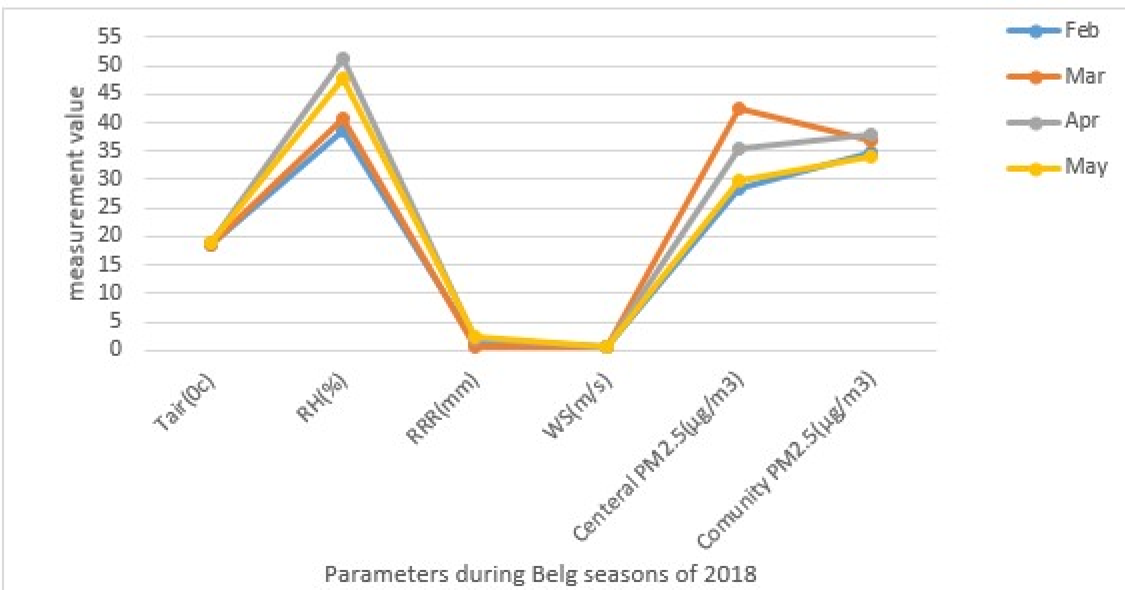


Figure8. Selected meteorological parameters and fine particulate matter during Belg 2018

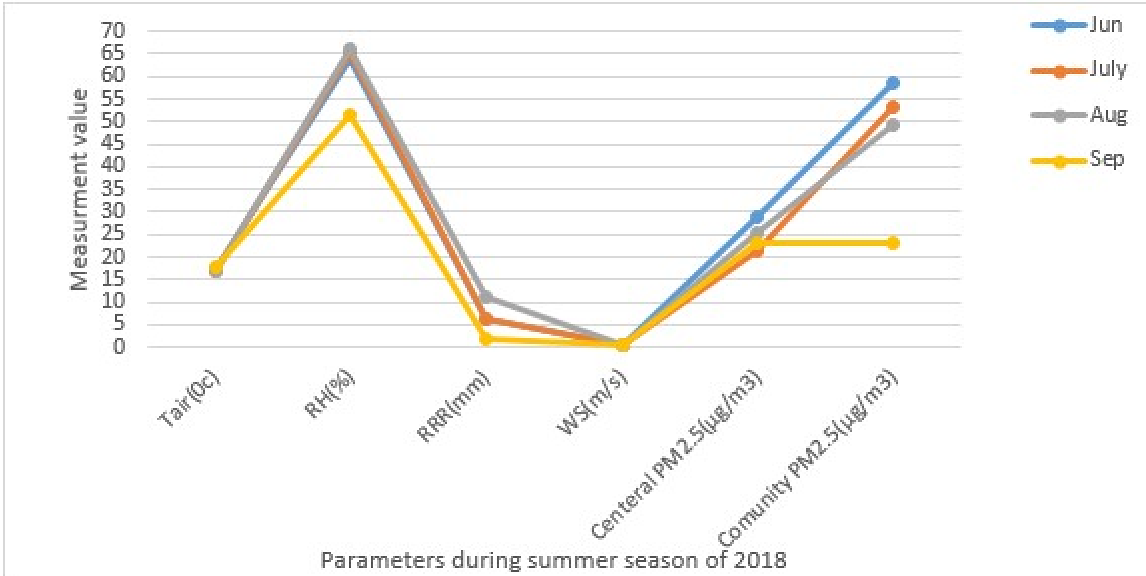


Figure9. Selected meteorological parameters and fine particulate matter during Kiremt 2018

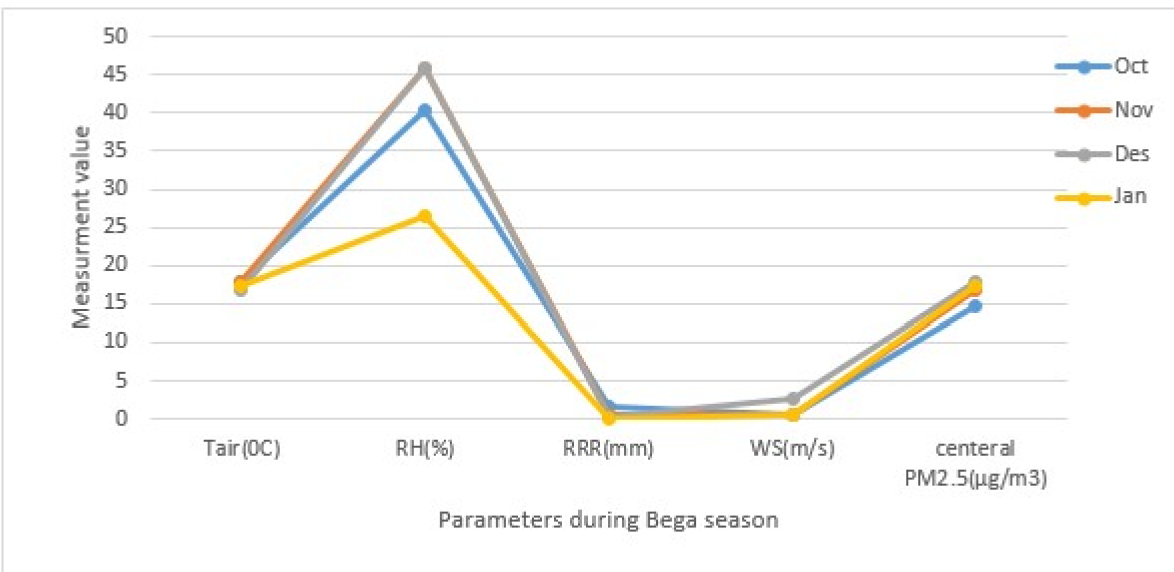


Figure10. Selected meteorological parameters and fine particulate matter during Bega 2019

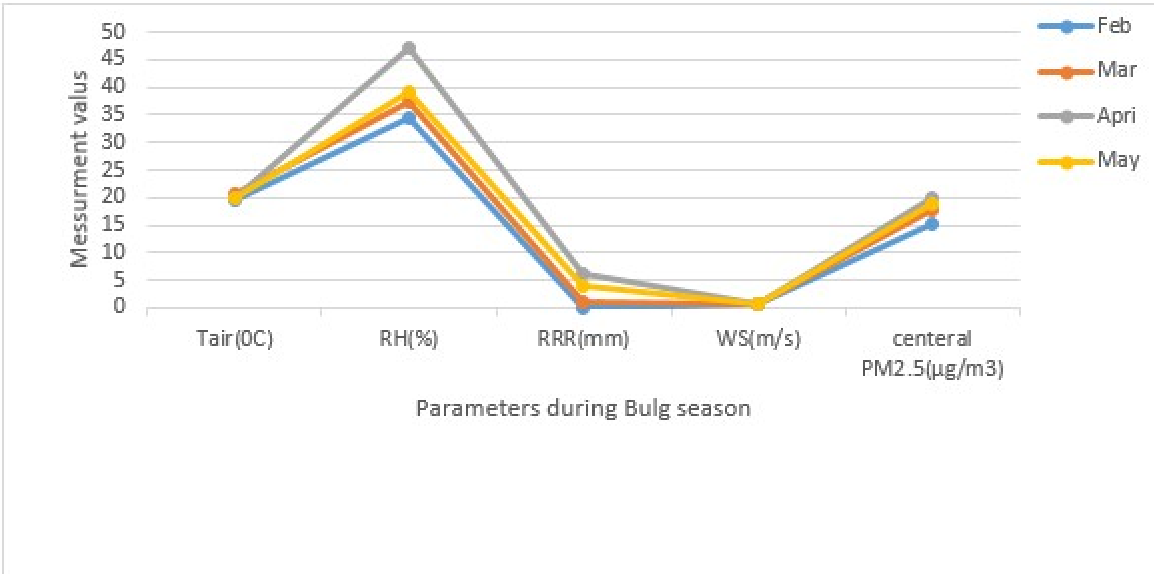


Figure11. Selected meteorological parameters and fine particulate matter during Belg 2019

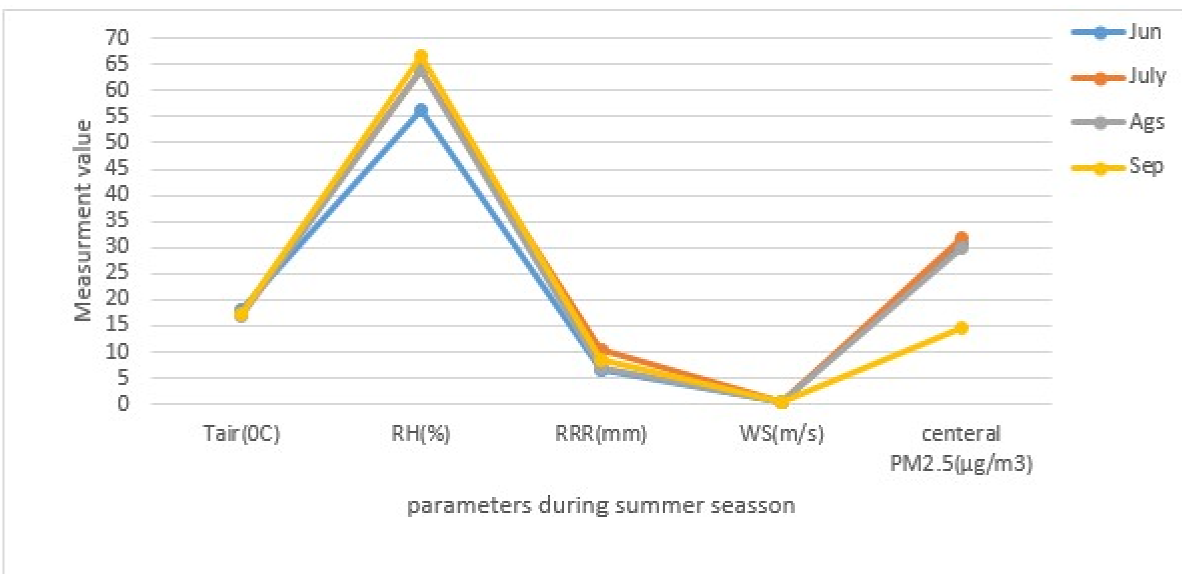
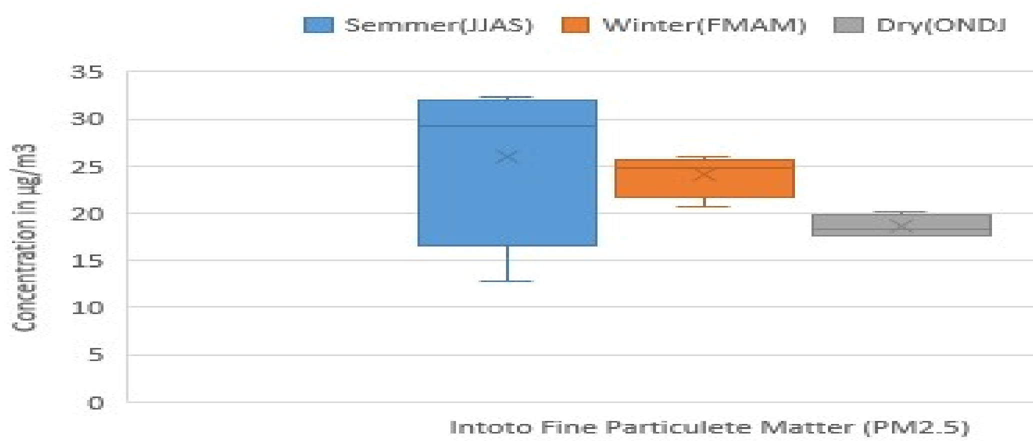
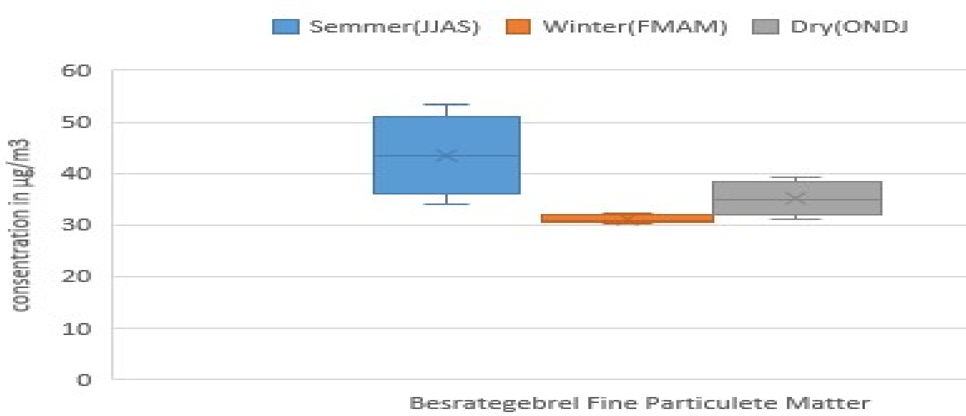


Figure12. Selected meteorological parameters and fine particulate matter during summer 2019

5. Conclusion and Recommendation

In this study present the synoptic meteorology observatory station located at Addis Ababa Black lion meteorological service campuses, the measurements were measured high rainfall and relative humidity, but low wind speed and air temperature during summer seasons, however, by the same season from both stations at Intoto represented by central station and at Besrategebrale represented by community school stations was estimated high fine particle matter.in the other hand, low fine particle matter was estimate during dry or cold night season, but in this season high wind speed was observed. In general, found that, During Bega or Winter season the relatively relative humidity low, wind speed was high and the atmosphere was clear, as a result the fine particle reduces the existence of on surface.





Relatively fine particulate matter levels become high during summer season, the local government should be introducing stricter measures to limit activities, such as driving in city areas, industry and construction activity in the city areas. It is therefore, important to check the advice from local authorities to guide planned activities. Limiting exposure and stopping activities that may add to the problem become important to reduce air pollution.

For advanced air quality work is recommended that includes additional monitoring station with advanced expertise, modeling, air quality source apportionment, and characterizing the spatial and temporal variations of air pollutants.

Acknowledgment

Thank you to National Meteorological Agency of Ethiopia and American US embassy for provided me and putted online the data for this research.

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