Analysis of Temperature, Relative Humidity and Precipitation Change in Different Months and their Relation with Air Pollutant (PM2.5)

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Abstract:

This project aims to analyze the changes in temperature, relative humidity and precipitation in different months and investigate their relationship with the air pollutant PM2.5. The data on temperature, relative humidity, precipitation and PM2.5 concentration were collected from various weather stations in the study area. The collected data was then analyzed using simple chart to determine the relationship between the variables. The results obtained from the study will help in understanding the impact of changing climate on air quality and the implications for public health.

Key words: PM2.5, Relative Humidity, Precipitation, Wind Speed, Temperature, Pollutant.

1. Introduction:

PM2.5, or fine particulate matter, refers to tiny particles that are 2.5 micrometers or smaller in diameter. These particles are a major component of air pollution, and are emitted by a wide range of sources including transportation, industrial processes, and burning of fossil fuels.

The health effects of exposure to PM2.5 are well-documented. When inhaled, these particles can penetrate deep into the lungs and even enter the bloodstream, leading to a range of negative health outcomes such as respiratory and cardiovascular disease, stroke, and premature death. In fact, it is estimated that PM2.5 is responsible for millions of premature deaths worldwide each year.

Reducing exposure to PM2.5 is a major public health priority, and efforts to address this issue involve a range of strategies such as improving air quality regulations, promoting cleaner transportation, and transitioning to cleaner sources of energy. Individuals can also take steps to reduce their exposure, such as using air purifiers and avoiding outdoor exercise during times of high pollution. Despite the known health risks associated with PM2.5, there is still much to be learned about its sources, behavior, and impacts on human health. Ongoing research in this area is critical for developing effective interventions and policies to protect public health and mitigate the effects of air pollution on vulnerable populations.

Over 200 million people reside in Dhaka, the capital and most populous city in Bangladesh, where there are plenty of amenities to help them support themselves. (UN, 2018 Population Trends). Alarming population growth is occurring in the city at a pace of 3 (World Bank, 2016). Due to excessive human activity, there are numerous sources of air pollution, including a large number of two- and four-stroke engines, the burning of fossil fuels, building sites, brick and stone crushers, and other anthropogenic activities (Poschl, 2005). These substances release harmful gases such as carbon monoxide (CO), sulfide (SO2), nitrogen oxides (NOx), ozone (O3), and particulates

(PM2.5 and PM10) that can lead to a variety of acute and persistent illnesses in people (Kampa and Castanas 2008).

Bangladesh is unable to make lead-free gasoline at a single refinery site, which results in high levels of lead in the air. Additionally, black fume, which is the product of partially burned fuel released by unfit vehicles, also adds to the pollution load in Dhaka (Karim et al., 1997). Rapid urbanization, the construction of roads and highways, and the building of high-rise apartments all require a variety of bricks, which leads to unplanned, unsecured brick fields around Dhaka and the use of outdated production techniques rather than modern technology (Daraina et al., 2013). Brick production requires a lot of energy. For about six months during the dry season, fossil fuels like coal and wood are burned in the brick kiln, which produces a significant quantity of greenhouse gases (Croitoru and Sarraf, 2010; Narasimha and Nagesha, 2013). Deficiency of environmental facilities, uncontrolled rules and regulations results air pollutants in our Dhaka city air (Haque et al., 2017).

Developing countries like southern part of Asia for example Bangladesh, India, Pakistan, high amount of particulate matter (PM10 and PM2.5) is the foremost apprehension due to morbidity and early mortality (Kojima et al., 2000). Air pollutant has chronic effect and long term exposers suffer different respiratory disorders, various cardiovascular illness as well as cancer which cause death of huge number of people globally. (Rumana et al., 2014; Yamamoto et al., 2014; Zhang et al., 2014; Brucker 2014; Biggeri et al., 2004; Vermaelen et al., 2013; Kan et al., 2010).

This study is conducted, seasonal variation of the particulate matter (PM) especially PM2.5 from 2019 to 2021 in Dhaka city using secondary data collected from the US embassy, Dhaka.

2. Work done:

2.1. Location Selection:

According to air quality, Dhaka is one of the worst cities in the globe. Dhaka has been chosen to monitor the seasonal shift in air quality. The US Embassy in Dhaka has been collecting statistics on PM2.5 concentrations based on the Air Quality Index (AQI) since January 2019 to December 2021. Figure 1 shows a map created using a Geographic Information System (GIS) of the sampling site in Bangladesh's Dhaka metropolis.

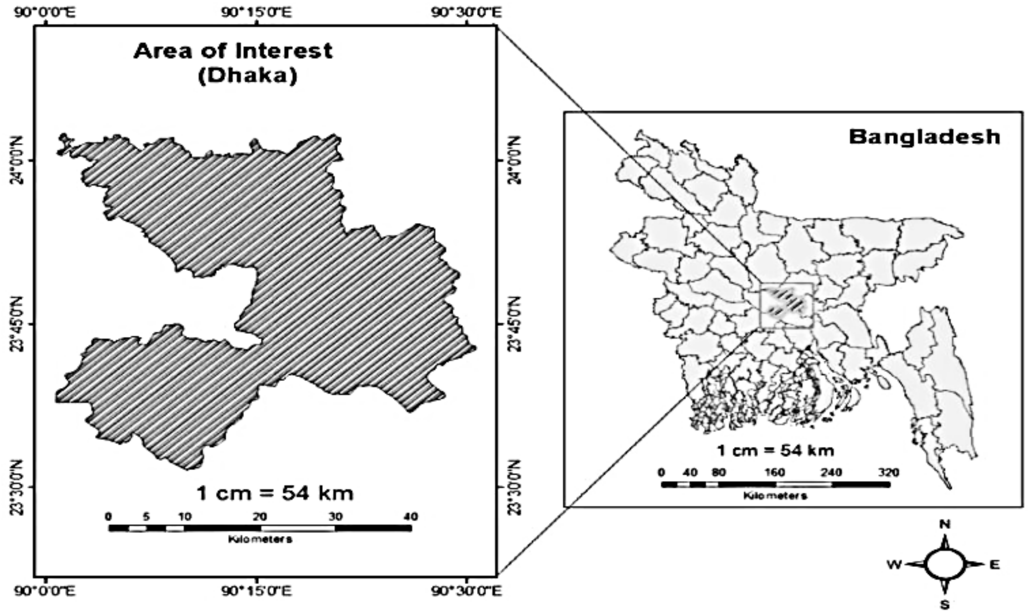

Fig 01: Area of Study.

2.2. Data Collection:

2.2.1. AQI Data collection:

The US embassy in Dhaka, Bangladesh has been collecting PM2.5 data since 2013 using a specialized air quality monitoring system installed on the embassy compound. The data is publicly available on the embassy's website and is updated hourly, providing real-time information on PM2.5 concentrations in Dhaka City. The embassy's air quality monitoring system uses a high-precision instrument to measure PM2.5 concentrations in the air. The system also collects data on other air pollutants such as ozone and nitrogen dioxide.

While the embassy's PM2.5 data provides valuable information, it is important to note that the data is collected from a single location and may not fully represent air quality conditions across the entire city. Additionally, the embassy's data collection methods may differ from those used by other organizations, which can affect the comparability of data across different sources.

To do this project AQI data has been collected from US embassy official website.

2.2.2. Climate Data Collection:

Climate data available for Dhaka City through the POWER data access viewer includes temperature, precipitation, wind speed, and solar radiation. Users can access daily, monthly, or yearly averages for these variables, as well as maximum and minimum values. The POWER data access viewer uses data from various sources, including satellite and ground-based observations, to provide accurate and reliable climate data. The data is updated regularly and can be downloaded in a variety of formats, including CSV, JSON, and NetCDF.

Climate data has been collected from this site.

2.2.3. Data Analysis:

Both AQI and climate data have been inserted in excel to generate some graphical representation of those data for different months and different parameter to make a visual relation between PM2.5 and different climate parameter.

3. Result and Discussion:

3.1. PM2.5 data:

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PM2.5	2019	239.7	230.7	191.51	142.93	130.72	86.8	87.7	77	96.16	132.2	160.36	205.34
PM2.5	2020	235.9	218.31	174	121.2	111.04	91.63	87.09	79.129	92.03	126.8	165.76	233
PM2.5	2021	262.58	236.25	211.42	157.77	114	106.3	75.25	99.06	98.3	152.551	195.1	206.48

Table 01: PM2.5 data from 2019 to 2021

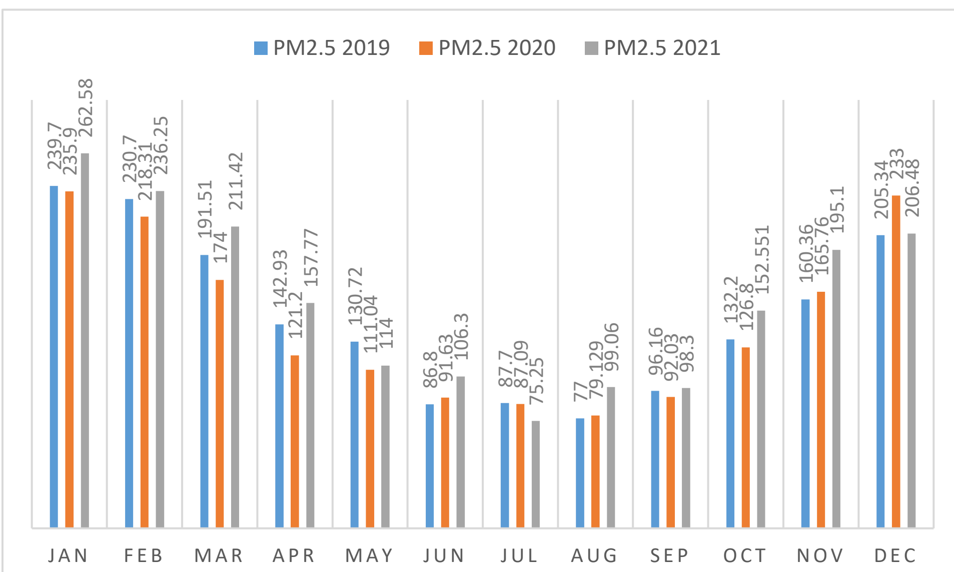

Fig 02: PM2.5 of different months for 3 years.

3.2. Precipitation data:

Name: Precipitation Corrected

Abbreviation: PRECTOTCORR

The bias-corrected average of the entire amount of precipitation on earth's surface expressed as a mass of water (includes water content in snow).

Monthly & Annual: Daily and yearly averages of total precipitation at earth's surface expressed in water mass (includes water content in snow).

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PRECTOTCORR	2019	0	3.11	2.03	3.56	14.24	16.52	24.03	11.92	10.56	9.56	2.3	0.38
PRECTOTCORR	2020	1.57	0.09	1.82	8.65	16.81	14.85	14.57	9.28	12.06	12.72	1.18	0.06
PRECTOTCORR	2021	0	0	1.02	2.8	11.8	16.24	12.7	12.94	7.66	6.88	0.59	3.47

Table 02: precipitation data.

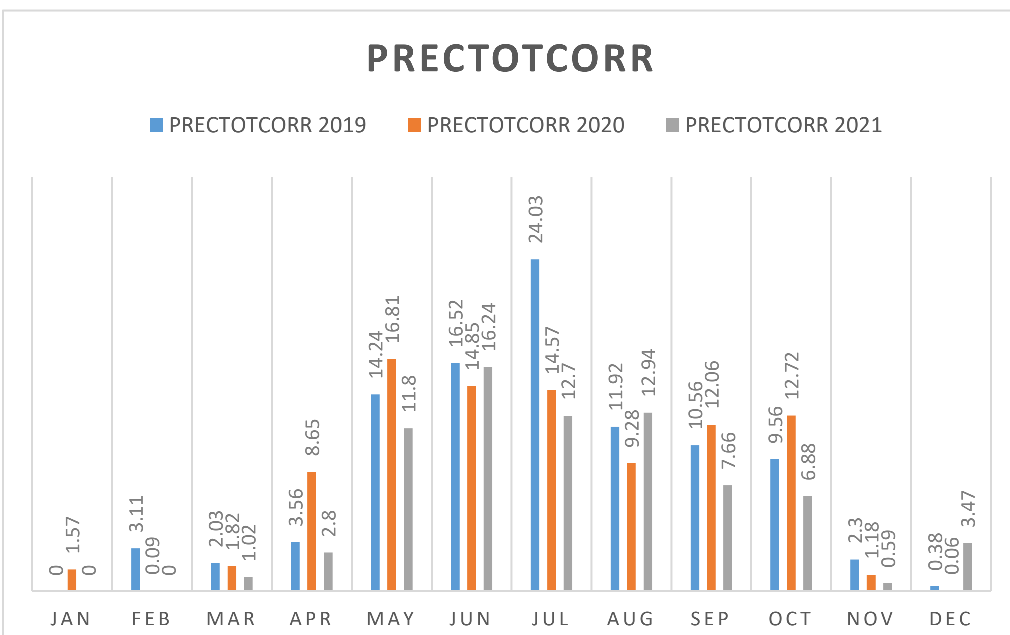

Fig 03: graphical representation of precipitation data.

3.3. Wind speed data:

Name: Wind Speed at 10 Meters

Abbreviation: WS10M

The typical wind speed at 10 meters above the earth's surface is referred to as climatology.

Monthly & Annual: Average wind speed at 10 meters above the earth's surface, monthly and annually.

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
WS10M	2019	2.12	2.36	2.71	3.02	4.12	3.36	4.35	3.27	2.64	2.05	1.69	2.06
WS10M	2020	2.17	2.2	2.2	2.7	3.16	3.77	3.88	3.79	2.88	1.86	1.77	1.7
WS10M	2021	2.08	2.33	2.46	2.73	2.92	4.2	3.86	3.62	2.4	2.02	1.7	2.12

Table 3: wind speed data.

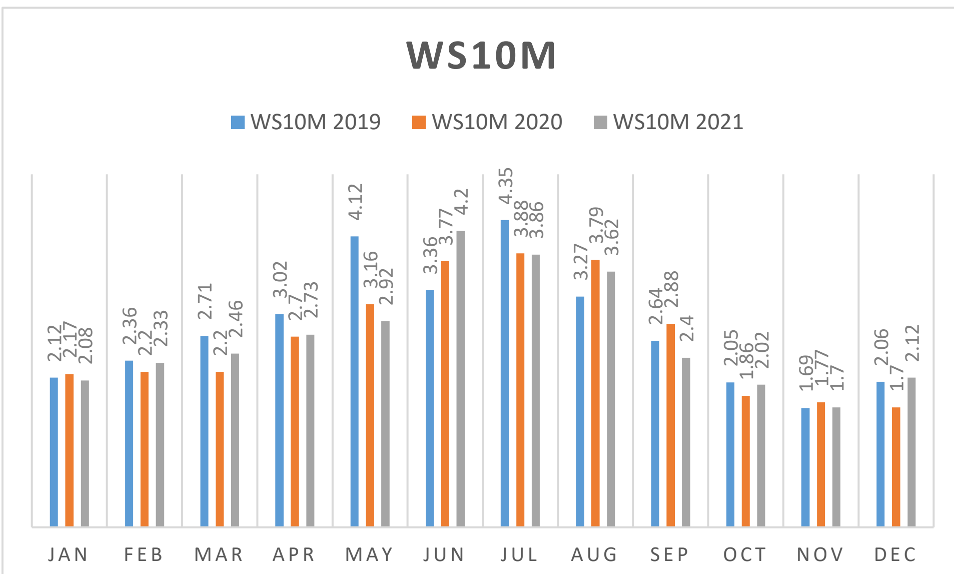

Fig 04: graphical representation of wind speed data.

3.4. Relative Humidity:

Name: Relative Humidity at 2 Meters

Abbreviation: RH2M

Climatology: The percentage difference between the real partial pressure of water vapor and the partial pressure at saturation.

Monthly & Annual: The percentage difference between the real partial pressure of water vapor and the partial pressure at saturation.

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RH2M	2019	57.06	53.81	56.44	65.44	78.38	88.69	90.62	89.25	87.94	86.5	81.38	81.62
RH2M	2020	78.81	63.75	55	68.5	82	90.69	90.38	89.88	89.19	86.69	81.88	81.31
RH2M	2021	74.44	56	50.56	53.12	74.75	89.31	89.12	89.94	88.44	84.69	80	81.06

Table 04: RH data.

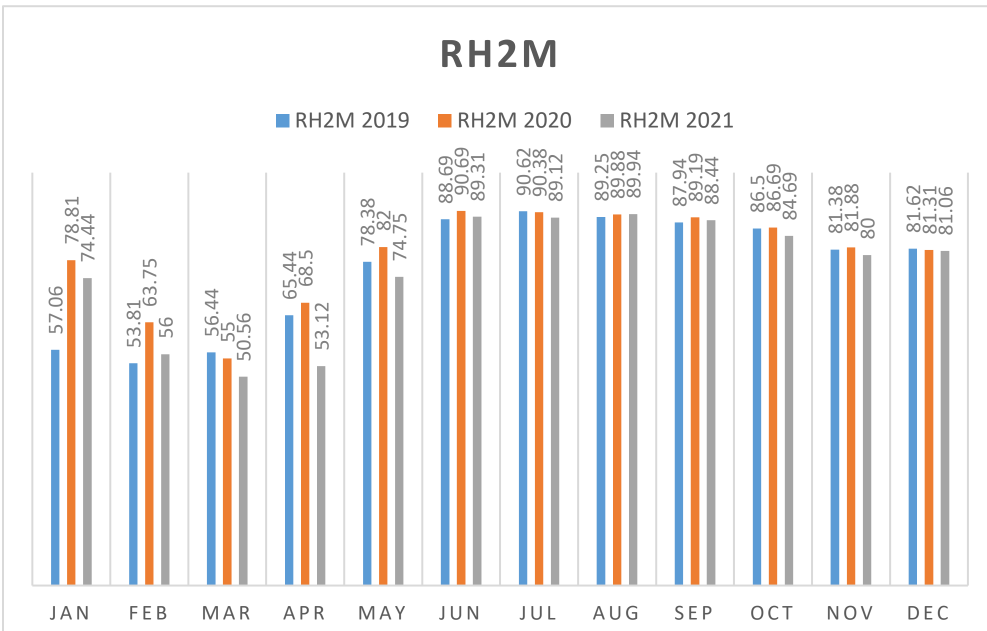

Fig 05: Graphical representation of RH data.

3.5. Temperature data:

Name: Temperature at 10 Meters

Abbreviation: T10M

Climatology: The temperature of the air (dry bulb) 10 meters above the earth's surface.

PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

T2M	2019	18.98	21.9	25.68	29.47	29.92	28.95	28.51	28.58	28.01	25.91	23.43	17.83
T2M	2020	16.79	19.47	25.59	28.19	28.44	28.39	28.61	28.44	28.44	27.73	22.69	18.13
T2M	2021	17.55	21.02	27.95	30.69	29.47	28.26	28.55	28.34	27.82	26.76	21.47	18.62

Table 05: temperature data.

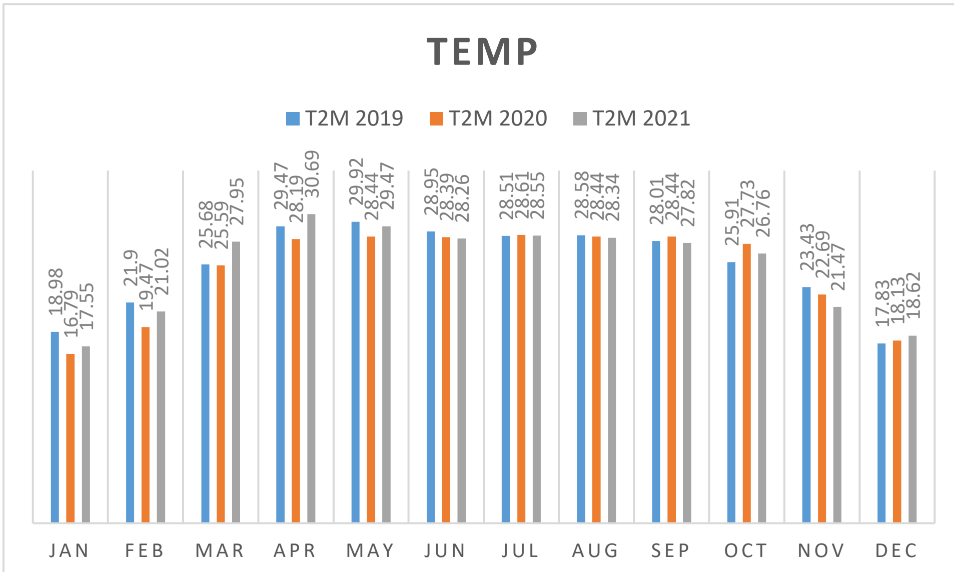

Fig 06: graphical representation of temperature data.

Discussion:

The relationship between PM2.5 and meteorological factors such as precipitation, wind speed, temperature, and relative humidity (RH) has been the subject of numerous studies in recent years. Understanding these relationships is critical for developing effective strategies to reduce PM2.5 concentrations and improve air quality.

Several studies have found that precipitation can have a significant impact on PM2.5 concentrations. For example, heavy rain or snowfall can effectively remove PM2.5 from the atmosphere by causing it to settle to the ground (zhen liu, 2020).

However, from this data we can say lighter precipitation or mist can actually increase PM2.5 concentrations by making it easier for particles to remain suspended in the air. The relationship between PM2.5 and precipitation can vary depending on factors such as the duration and intensity of the precipitation, the season, and the location.

Wind speed is another important factor that can affect PM2.5 concentrations. From this data we can say that Higher wind speeds can help to disperse pollutants and reduce their concentration, while lower wind speeds can allow pollutants to accumulate and build up. However, the relationship between wind speed and PM2.5 is complex, and can depend on factors such as the source of the pollutants and the local topography.

Temperature and RH can also have a significant impact on PM2.5 concentrations. From this study we can say that higher temperatures can lead to increased PM2.5 concentrations, possibly due to increased emissions from sources such as vehicles and industrial processes.

RH can also affect PM2.5 concentrations by influencing the ability of particles to remain suspended in the air. From this study we can also say that high RH can decrease PM2.5. Higher RH value lead to more water content in air which may makes the particle heavier and which ultimately lead to removal of particulate matter (zhen liu, 2020).

Conclusion:

The study indicates that temperature, relative humidity, and precipitation have a significant influence on PM2.5 concentrations. The correlation between PM2.5 and meteorological variables varies across different months and regions. Therefore, the findings of this study can help policymakers to develop effective strategies to reduce air pollution. For example, during the winter season, the temperature in Beijing is low, which leads to high PM2.5 concentrations. Therefore, policymakers should consider implementing measures to increase the temperature, such as using renewable energy sources. Additionally, the study suggests that policymakers should consider the season and region when developing policies to reduce air pollution.

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