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Spatial-Temporal Re-Analysis of Seasonal Air Quality Data in Karachi City for Future Prospects

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Abstract: Air quality in Karachi, Pakistan appears to be deteriorating in the world due to rapid increase in population, economic growth and subsequent increase in urbanization and energy demand. This study Re-is about the cumulative effects of anthropogenic activities on air chemistry of the study area atmosphere with ground base concentration measurements of gaseous air pollutants (SO_2, NO_2, CO, CO_2 and O_3), particulates (PM_{10} and TSP), Methane, Lead and Noise with temperature and seasonal influences on Karachi city. The primary goal of this study was to define spatial and temporal distribution of air pollutants with ArcGIS, seasonal behavior of airborne contaminants, convert the five major pollutants termed as criteria pollutants into Air Quality Index (AQI) and their temperature association for future prospects. The maximum average values of four seasons concentrations of air pollutants were found SO_2=64.5 ug/m^3 (GR), NO_2=55.5 ug/m^3 (FB), CO= 8.00 mg/m^3 (CC), CO_2=645 ug/m^3 (NZ), O_3=56.7 ug/m^3 (ST), PM_{10}=225 µg/m^3 (CC), TSP=402 ug/m^3 (CC), Methane=1.65 m/gm^3 (CC), Lead=5.1 ug/m^3 (ST), and Noise=85 dB (GR). The minimum four seasons average concentration values with monitoring location as {SO_2=48.2 ug/m^3 (FB), NO_2=44.6 ug/m^3 (NZ), CO=4.1 mg/m^3 (BC), CO_2=601 ug/m^3 (JH), O_3=42.4 ug/m^3 (GR), PM_{10}=150 ug/m^3 (BC), TSP=226 ug/m^3 (JH), Methane=0.68 mg/m^3 (BC), Lead=32 ug/m^3 (GZ), and Noise=81 dB (BC). The spatial-temporal analysis of air quality revealed that the pollutants in the summer are higher in industrial and high-density traffic junctions. In this study, temperature and air quality are significantly associated, while rainfall and relatively high humidity days are negatively correlated. High temperature months have highest air pollution values, whereas the washout impact of precipitation and relative humidity have the lowest levels. The analysis of air quality index parameters demonstrated a high coherence among NO_2, CO and O_3 with variation in temperature. The higher levels of air pollution in hot days are related to the local climate and anthropogenic activities.

Keywords: Spatial-temporal, ArcGIS, gaseous pollutants, Air quality index (AQI).

Introduction

Air pollution in metropolitan areas is a delicate subject with a well-documented impact on humans, plants, and animals, environmental habitat and ecosystem overall. The standard air of a region can be contaminated and not be retreated (Manisalidis et al., 2020). South, East Asian countries including Pakistan, India, Bangladesh and China with a burgeoning population (45% of the world population) are predominantly affected by hazardous air pollution mainly caused by an abundance of population, rapid economic growth, industrialization and urbanization (Pakistan, 2006) with an associated increase of energy demand (Khwaja et al., 2012; Vadrevu et al., 2017). The IQAir report from thirty most pollutant cities, twenty-seven belong to South Asia, whereas Lahore and Karachi are top ten in this list (Lin et al., 2022; IQAir, 2020). Air pollution is hard to escape, no matter how rich an area you live in. It is all around us (Li et al., 2019). Air pollutants come from multiple sources such as the industrial sector, heavy transport, city traffic, power generation plants etc. Therefore, action should be taken together across sectors, national and international boundaries to improve air quality for breathing communities (Zhang et al., 2022).

The current state of air quality in Pakistan appears to be worst as the rapid increase in population, economic growth subsequent increase in urbanization, energy demand and vehicular terrific loads have contaminated the breathing air filled with harmful pollutants at the highest rate (WHO, 2021). Such huge transportation of microscopic air hazards can slip past our body's defense system, penetrating deep into our respiratory and blood circulatory system, damaging our lungs, heart, mind and brain (Mackenzie and Turrentine, 2021). Pakistan was among the top countries having the highest environmental and health factor of five percent in the Global Burden of Disease (Tichenor and Sridhar, 2019 Anjum et al., 2021). Karachi appeared as one of the most polluted cities in the world and held the fourth position on the MPI-based ranking (Colbeck et al., 2010). The Air Quality Index (AQI) is used nowadays for reporting daily air quality around the globe for each city because there are multiple pollutants with several units and different sorts of standards (Business Standards, 2022). In this study Air Quality Index (AQI) level is determined by anthropogenic criteria pollutants SO_2, NO_2, CO, O_3 and PM_{10}, (Hoque et al., 2020) whereas TSP, methane, lead and noise are analyzed by the metric system.

The essential objective of this study was to compare the airborne contaminations with standard levels and behavior of pollutants with the help of ArcGIS. This study has multi-components, a) four seasonal air data analyses with an average of four seasonal data, b) Spatial-temporal analysis, c) modeling of the air pollutants parameters on ArcGIS, d) relationship between air pollution and ambient temperature, e) convert the five major pollutants termed as "criteria air pollutants" into Air Quality Index (AQI).

ArcGIS is an innovative geostatistical and spatial data tool that shows the relationship between poor air quality and occurrences of deficient human and environmental health. In this way, a GIS aids in monitoring pollutant emissions and nature wellbeing (Zhou et al., 2021).

The heat and high temperature trigger chemical reactions as a catalyst between primary air pollutants causing a chemical reaction that transforms primary pollutants into secondary (Ulpiani et al., 2021). High temperatures make all pollutants more toxic and produce synergistic to the overall health of living habitats and climate change (Idress et al., 2021).

This study also compares the monthly average temperatures of the Karachi region with the seasonal concentration of the air pollutants and with average four-season air data (Underground Weather, 2021). The main purpose of this study is to update old air quality data with recent techniques and integrated it with new air data for further study and comparison.

Materials and Methods

The Study Area is the metropolitan city of Pakistan and the financial hub of the region. Karachi lies between 24°47'N to 25°12'N Latitude and 66°50'E to 67°37'E Longitude with an area of 3,640 km² and is situated along with the coast of the Arabian Sea (Wikipedia, 2022). Karachi has a moderately version arid climate with generally high relative humidity in summer with low precipitation rate. In winter, the average temperature of the city is about 21°C ± 3°C with high relative humidity of 58% ±5% in December as the driest month while in summer temperature reaches up to 35°C ±3°C with 85% ±5% relative humidity in August wettest month due to Monsoon trends.

The air contamination data default units used for SO_2, NO_2, CO_2, O_3, PM_{10}, TSP, Lead, whereas were ug/m^3, mg/m^3 for CO & Methane and dB for Noise, accordance with PakEPA prescribed standards acquired by SUPARCO yearlong (Sept2003-June2004) four seasoned air quality data of the Karachi region (Hashmi et al., 2005; Ghauri et al., 2007). Table 1 and Fig. 1, show the labeling of sampling locations, feature description of sampling stations with geographical coordinates. The average monthly temporal temperature data at Jinnah Airport (Underground Weather., 2021) is correlated the with air quality index of Karachi.

The following truck loaded analyzers monitored the ambient air of Karachi at ten locations. SO_2 analyzed with Environmental SA, France, Model AF 22M and for ambient NO and NO_2 used "Monitor Thermo Environmental Instrument Inc. USA, Model 42C". The CO & CO2 analyzed with Thermo Environmental Instruments Inc. USA, (Model 48C and 48 H). The Ozone Analyzer of Monitor Lab. Inc., USA (Model 8810) was employed for surface ozone measurements and Sierra Andersen PM10 size-selective stage (Model 321-A) was used to measure PM_{10}.

Table 1, Data points (ID of locations, name of station lat, long, field observation (road, industry, clear weather).

Location ID	Name of Station	Latitude	Longitude	Field Observation (road, industry, clear weather)
CC	Civic Center	24.900N	67.0731E	Commercial, Terrific thickly populated Residential.
GR	Garden	24.868N	67.0230E	Residential and commercial are, moderate traffic
TW	Tower	24.848N	66.9975E	A junction of Seaport, top business and traffic hub.
KG	Singer Korangi	24.846N	67.1605E	Heavy industrial, densely populated, traffic.
ST	SITE	24.890N	66.9846E	Major industrial, densely populated, heavy traffic.
GZ	Gizri	24.816N	67.0513E	Residential and Commercial, moderate traffic flow.
NZ	Nazimabad	24.925N	67.0315E	Commercial and residential, high commuter traffic.
FB	FB Area	24.936N	67.0761E	Commercial and residential, high commuter traffic.
BC	Baloch Colony	24.867N	67.0834E	Business, commercial active, high urban traffic.
JH	Gulistan-e-Johar	24.912N	67.1259E	Thickly Populated and commercial, high traffic

Geospatial Application

GIS can be used to forecast the emissions influenced by exhaust coming from pollutant sources and fluctuated with meteorological variables (Saraswat, 2017), management policies (and for air quality data imputation (Deligiorgi and Philippopoulos, 2011). Nearest neighbor or natural neighbor is chosen an imputation technique because for the computational simplicity, and it has previously been used in spatial interpolation comparison studies (Kolehmainen et al., 2002). Air pollution in industrial megacities is too complex because of the wide variability within the nature, intensity, density and spatial distribution of emission sources (Wei et al., 2022).

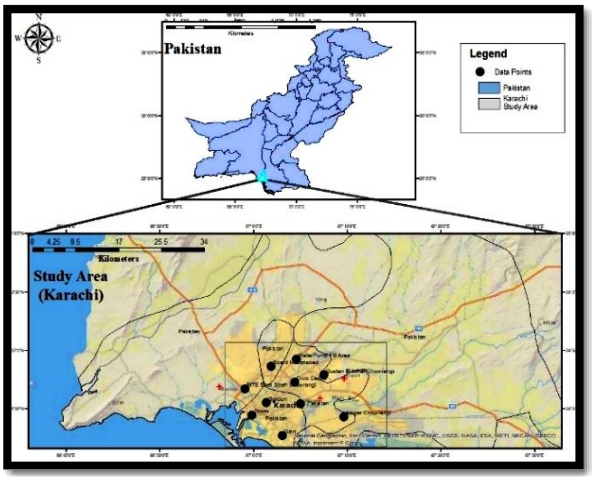


Fig. 1 Base map of the Air Quality Data locations in the study area.

Air Quality Index (AQI)

The AQI is a standard method for describing air quality and is linked with the color scheme (Fig. 2) that displays air quality category designations and meaning of assigned category is easily understood by the public (Stieb et al., 2005; Gurjar et al., 2008). The AQI focuses on health affects you may experience within a few hours or days after breathing polluted air. Air Quality Index of criteria pollutant concentrations (SO_2, NO_2, CO, O_3 and PM_{10}) Karachi region were calculated on the AirNow AQI calculator based on the given empirical formula.

Results and Discussion

The results of atmospheric pollutants (SO_2, NO_2, CO, CO_2, O_3, PM, TSP, Methane, Lead and Noise) maximum and minimum with averaged vales of four seasons of all concentration levels are presented in Table 3. In this section the all ten air pollution results discuss in this section. The SO_2 is a byproduct of the burning of fossil fuels (coal, oil, diesel, and other materials that contain sulfur). The sources of SO_2 are

Air Quality Index

Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	100 to 151	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects, members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health warnings of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects.

Fig. 2 AQI categories (First Environment.org, 2016).

Table 2, below defines the Air Quality Index scale as approved as the US-EPA2016 standard, EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act (2021).

Following statically formula is used to calculate the AQI values by using the pollutant concentration data.

$$Ip = \frac{I_{Hi} . I_{Lo}}{BP_{Hi} . BP_{Lo}} \times (Cp - P_{Lo})$$

Ip = Index for pollutant p; Cp = Rounded concentration of pollutant p; BP_{Hi} = Breakpoint that is greater than or equal to Cp; BP_{Lo} = Breakpoint that is less than or equal to Cp; I_{Hi} = AQI value corresponding to BP_{Hi}; I_{Lo} = AQI value corresponding to BP_{Lo}.

power plants Diesel vehicles, metals processing and smelting facilities, (Molina and Gurjar, 2020). The average of four seasons (Fig. 3 e) of SO_2 finds 64.5 ug/m^3 at GR and 50.4 ug/m^3 in NZ area (Table 3).

Table 2: Pak-EPA (NEQS, 2012) standards for Air Pollutants.

Pollutant	Average Time	Standard Levels
Sulfur Oxides	Annual	120 µg/m^3
	24 Hours	80 µg/m^3
Nitrogen Oxides	Annual	40 µg/m^3
	24 Hours	80 µg/m^3
Corban Oxide	8 Hours	5 mg/m^3
	1 Hours	10 mg/m^3
Ozone	24 Hours	130 µg/m^3
Particulate Matter (PM_{10})	Annual	75 µg/m^3
	24 Hours	150 µg/m^3
Lead	24 Hours	1.5 ug/m^3
Sound	4 Hour	85 dB

Table 3 Air quality parameter's status with Max and Min category, location and Seasonal Cycle. of Air data.

Parameter	Range	1st Cycle	Location ID	2nd Cycle	Location ID	3rd Cycle	Location ID	4th Cycle	Location ID	Mean of 4 Cycles	Location ID
SO_2 µg/m^3	Min	33.0	JH	33.3	JH	59.2	JH	47.9	FB	50.4	NZ
	Max	51.9	NZ	66.6	GR	76	GR	80.4	BC	64.5	GR
NO_2 µg/m^3	Min	37.6	TW	34.8	NZ	45.1	NZ	51.3	JH	44.8	NZ
	Max	62.2	CC	48.7	FB	58.1	FB	69.9	BC	55.5	FB
CO mg/m^3	Min	2.98	GZ	3.2	JH	4.6	GZ	6.4	JH	4.5	GZ
	Max	5.72	CC	7.0	CC	7.8	CC	9.16	CC	7.96	CC
CO_2 mg/m^3	Min	570	GR	586	FB	600.7	FB	603.2	ST	601	JH
	Max	612	KG	700	KG	637.7	NZ	642.8	NZ	620.5	KG
O_3 µg/m^3	Min	48.2	JH	32	GR	24	GR	42.2	NZ	46	GZ
	Max	61.6	CC	55.2	ST	62	ST	60.6	TW	56.7	ST
PM_{10} µg/m^3	Min	128	JH	146	CC	139	BC	156	BC	173	JH
	Max	239	KG	208	KG	231	CC	302	CC	225	CC
TSP µg/m^3	Min	228	JH	210	JH	208	NZ	247	JH	226	JH
	Max	367	KG	341	FB	339	CC	410	CC	402	FB
HCMethane µg/m^3	Min	0.26	GZ	0.46	GZ	0.4	BC	0.4	BC	0.68	BC
	Max	1.31	GR	0.92	ST	1.3	CC	1.38	CC	1.65	CC
Lead µg/m^3	Min	3.25	NZ	3.03	GZ	3.1	GZ	3.2	KG	3.2	KG
	Max	5.78	ST	4.8	CC	4.8	CC	5.8	CC	5.1	CC
Noise dB	Min	73.3	CC	75.9	NZ	80.6	BC	80.6	FB	80.9	BC
	Max	84.9	GZ	81.1	GR	91.7	TW	87.5	GR	84.7	GR

NO_2 pollution in Karachi air comes from both natural and human sources, the most significant anthropogenic source is the fossil fuel burning in automobiles and industry (Mukta et al., 2020). Table 3, shows value of NO_2 is 55.5 ug/m^3 (four season's average) is at the location of FB and the lowest 44.8 ug/m^3 at NZ. The spatial concentration of NO_2 in the connected maps (Fig. 3, f,g,h,i.j) shows the distribution patterns of high traffic density to a residential area. The high and low are much below the PakEPA (AAQS) standard (80 ug/m^3).

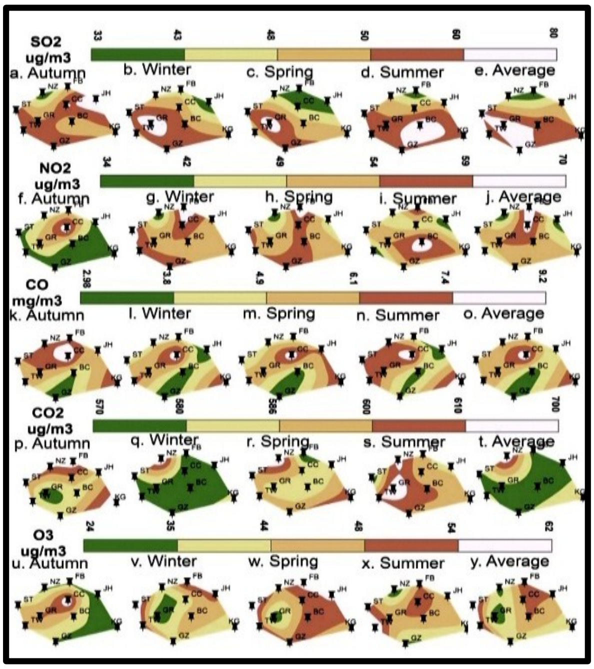


Fig. 3 Seasonal variation of five air pollutants (SO_2, NO_2, CO, CO_2 and O_3) concentrations with four seasons average.

The elevated CO content is most likely due to incomplete fossil fuel combustion in malfunctioning automobiles or a variety of mechanical and industrial combustion pollutants. The greatest yearly average CO value, on the other hand, (four seasons average) is 7.96 mg/m^3 at industrial area of KG and the lowest annual average is 4.5 mg/m^3 at an elite residential area of GZ. Fig. 3, (k,l,m,n,o), shows the spatial distribution of CO concentration samples, the Karachi city is divided into high and low emissions groups according to their CO emissions values.

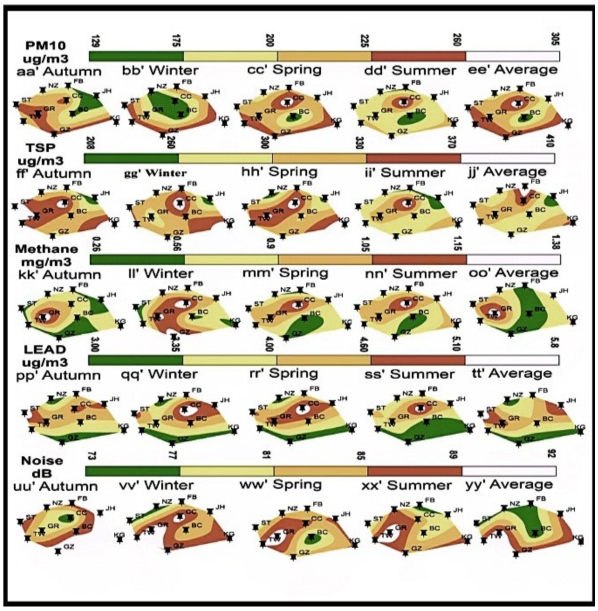


Fig. 4: The Spatial-Temporal distribution of five air pollutants (PM_{10}, TSP, Methane, Lead and Noise) with average.

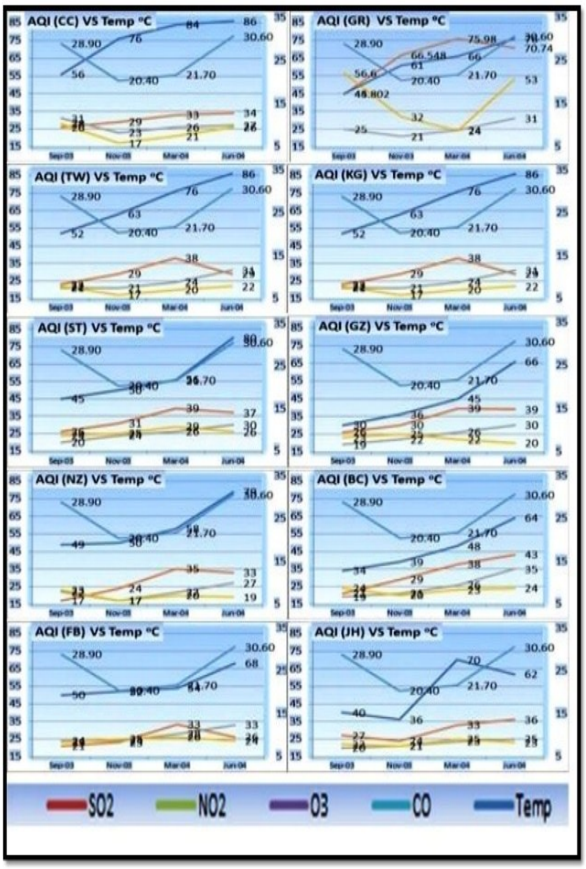
CO_2 is a major Earth's greenhouse gas that traps heat in the atmosphere and is responsible to warm the planet. CO_2 spatial distribution (Fig. 3, p,q,r,s,t) is integrated with ArcGIS to estimate the intensity (Table 3).The ground level O_3 is a secondary pollutant, generated by the reaction of VOCs and NO_2. O_3 has significant potential impacts on human health, agriculture, and the environment. Fig. 3, (u,v,w,x,y) showed average of all four seasonal readings of Ozone ranged from 56.7 ug/m^3 to 41.4 ug/m^3 from ST to GR locations at Karachi. Both the high and low are well below the PakEPA standard (130 ug/m^3).

The PM_{10} is largely released in Karachi from automotive vehicular and industrial activity, which causes fine dust from roads fraction, windblown dust, sea salt spray, construction sites, and mines. Which has serious health consequences, cardiovascular diseases including respiratory disease. The average of four seasons of PM_{10} calculated highest 225 ug/m^3 at CC and lowest 173 ug/m^3 in JH area. TSP refers to particulate matter with a diameter less than or equal to 100 microns (20 to 100 microns), considered to be a primary contributor to air pollution, smog formation and environmental contamination. The general trend PM_{10} concertation maximum and minimum values in Karachi air are above the PakEPA standard (150 ug/m^3). The average of four seasons of TSP is calculated for individual location, finds high 402 ug/m^3 at FB (Fig. 4, jj) and low 226 ug/m^3 in the JH area. Methane is an odorless, transparent gas that may be found kilometers under the Earth's surface. The average of four seasons of Methane is calculated finds 1.65 mg/m^3 at CC and 0.68 mg/m^3 in BC area (Table 3).

(Table 3). The level for Methane ranges exceeding the prescribed PakEPA (AAQS) 1.5 mg/m^3 limits at most of the study sites (Ghauri et al., 2007).

The high concentration of airborne Lead is probably due to the quality of lead additive fossil fuels used for all-purpose combustions and chemical processes industry in the study area (Hussain et al., 2018). The average of four seasons (Fig. 4, tt) Lead in the air for individual location finds a maximum of 5.1 ug/m^3 at CC and a minimum of 3.25 ug/m^3 in the GZ area (Table 3). Both the high and low are much above the new PakEPA (AAQS) standard (0.15 ug/m^3).

Noise pollution is a significant environmental problem in all megacities of developing countries, our study confirms that noise pollution in Karachi is rampant and exceedingly higher than all the international standards. Mostly Noise levels in atmosphere readings in Karachi were below or near to permissible noise level from PakEPA (AAQS) (85 dB). The average of four seasons of Noise level is calculated with a statistical formula for individual location, finds highest 84.7 dB at Garden location and lowest 80.9 BC area (Fig. 4,yy).



Relationship in Air Quality Index and Ambient Temperature

The AQI is a daily air quality index that measures and reports on the quality of the air and evaluate how clean or unhealthy the air is, as well along with potential health hazards to breathing community. The AQI focuses on potential health effects that could happen after breathing in polluted air for a few hours or days. The AQI values for trace gases ((NO_2, SO_2, CO, O_3 and PM_{10}) calculated and obtained vary between the limits of PakEPA regulatory authorities with some exceptions. Table 4, shows maximum to minimum AQI values of SO_2 43 (BC) to17 (NZ), NO_2 AQI values 33 (FB) to 17 (NZ), for CO varying from a maximum to a minimum 86 (CC) of 30 (GZ), for O_3 varies between a maximum 29 (ST) and a minimum of 11 (GR) and PM_{10} varies 174 (GR) to 87 (JH) respectively. The ambient air temperature has long been recognized as a catalyst for

Table 4 average monthly temperature with air quality index (AQI) status and air quality category in Karachi air quality to become more pollutants transportable; it is a well-known phenomenon that an increase in temperature influences air pollution on hot days. Fig. 3, and Fig. 4, depicts spatial air quality fluctuations throughout four data cycles of SO_2, NO, CO, O_3, and **Fig. 5,** Shown Ambient Temperature correlates with four Air Quality Index PM_{10}, with an average of four seasons' data. The association between air quality pollutants (SO_2, NO_2, O_3 and CO) and air temperatures in Karachi's metropolitan districts was discovered positive to be that on hot days, observed that all pollutant levels climbed at each location, with the highest temperature corresponding with the peak levels of NO_2, O_3 and CO. These findings in Fig. 5, proved that the effect of temperature on air pollution did not differ depending on whether the location in a residential, commercial or industrial region, even though air pollutants increased with increasing temperatures particularly during middays. The five colors (Fig. 4), SO_2 concentration of the study area shows increasing trends from September to May-June. The increase of temperature has a linear effect on SO_2 and NO_2 concentrations varied with the season from September to June.

Cycle	Parameter	AQI Max	Category	Location	AQI Min	Category	Location	Month	Temperate C°
Autumn (September)	PM_{10}	143	Unhealthy	KG	87	Moderate	JH	Sept 03	28.9
	SO_2	26	Good	CC	17	Good	NZ		
	NO_2	31	Good	CC	19	Good	GZ/BC	Oct 03	28.3
	CO	56	Moderate	CC	30	Good	GZ		
	O_3	28	Good	CC	22	Good	GZ	Nov 03	24.4
Winter (November)	PM_{10}	127	Unhealthy	KG	96	Moderate	BC		
	SO_2	36	Good	GR	23	Good	FB	Dec 03	20.5
	NO_2	24	Good	FB	17	Good	NZ		
	CO	76	Moderate	CC	36	Good	GZ	Jan 04	19.4
	O_3	25	Good	KG	17	Good	CC		
Spring (March)	PM_{10}	139	Unhealthy	CC	93	Moderate	BC	Feb 04	19.6
	SO_2	41	Good	GR	33	Good	JH		
	NO_2	28	Good	FB	22	Good	NZ	Mar 04	21.7
	CO	84	Moderate	GR	45	Good	GZ		
	O_3	29	Good	ST	11	Good	GR	Apr 04	25.6
Summer (May-June)	PM_{10}	174	V.Unhealthy	GR	101	Unhealthy	BC		
	SO_2	43	Good	BC	26	Good	FB	May 04	28.3
	NO_2	35	Good	BC	25	Good	TW		
	CO	86	Moderate	KG	62	Moderate	BC	Jun 04	30.6
	O_3	28	Good	TW	19	Good	NZ		

The more positive effect of temperature is observed in Fig. 5, on O_3 concentration, discovered maximum values, particularly during middays. The O_3 concentration trend varies with the average temperature in every component of Fig.5, Furthermore, a rise in ambient temperature has a significantly positive effect on the NO_2 and CO concentration. It is a well-recognized factor that favourable weather conditions contribute to the dispersion of air pollutant concentrations and overall improve air quality in Karachi

Conclusion

Karachi is one of the unique coastal megacities in which there are no distinct bounded regions for residential, commercial and industrial activities in the city. Mostly huge slump areas are established with permanently settled localities in all seven industrial regions. The Air Quality data shows an inherent sequence that the general trend of all the air pollutants (SO_2, NO NO_2, CO, CO_2, O_3, PM_{10}, TSP, Methane, Lead and Noise) concentration gradient varies with seasonal temperature rate ranging from September 2003 to June 2004. Modern analysis tools are associated AQI with spatial and temporal include in this study with ArcGIS application. The general metrological variables trend of Karachi shows that air flows change with seasons. Generally, the May month is hottest due to a reduction in wind speed and changing the direction from North (up Country) to South-West (Seaward). The minimum values of all air pollutants are in November and maximum in September/May. It's critical to mitigate or reduce precursors like SO_2 and NO_2 to better understand the sources, behavior, and mechanism of particle formation in the atmosphere because both contribute to the formation of secondary CO and O_3, which make up a significant portion of total PM in the atmosphere. A strong coherent relationship was found between CO, NO_2 and O_3 during the air quality survey. Generally, peak levels of O_3 were recorded at high temperatures and its high numbers were observed throughout the city on sunny days. The high concentrations of trace gases such as NO_2, O_3 and CO have present at traffic-congested intersections of Karachi. The spatial-temporal distribution of O_3 in the hot, arid climate of Karachi to identify the sources and temperature association. The particulates levels (PM_{10} and TSP) contain a significant amount of vehicular soot besides crustal dust and sea salt. Methane levels in Karachi were revealed above the regulatory limits (1.0 mg/m^3) at most half of sites which are correlated with traffic density and industrial exhaust. Maximum street noise level (92 dB) has been observed at traffic crossings. However, the highest levels of acoustic were found at the heaviest traffic-congested intersections of the study area during March (spring season).

Air Quality Index (AQI) with the temperature, indicates that the main source of pollutants in the summer are industrial output and high-density traffic. In this study, the temperature has a positive association with air quality and a negative relationship with rainfall and high moisture days, respectively. The highest concentrations of air pollutants were associated with dry air during the summer months, whereas the lowest concentration levels were associated with the washout effect of precipitation. The analysis of air quality index parameters demonstrated a high coherence among NO_2, Co and O_3 variation concerning temperature. The higher levels of air pollution on hot days are related to the local climate and anthropogenic activities.

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