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COMPARISON OF URBAN CLIMATE IN MULTAN AND OTHER BIG CITIES OF PAKISTAN

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ABSTRACT

Background: Now a day's smog is the major concerns in the world as well as in Pakistan. Smog is one of the biggest sign of climate change. There is more pressure on local habitats and air pollution as a result of a growing percentage of the world's population living in urbanized areas. Air pollution is the term used to describe any chemical, physical, or biological influences brought about by human activity that interferes with the environment's natural processes. This study was conducted to assess air quality status in Multan, and to compare it with Lahore, Faisalabad and Karachi through Air Quality Index (AQI) and Multi Pollutant Index (MPI) and their correlation.

Methodology: For this investigation, major air pollutants including carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter were used and compared with Punjab Environmental Quality Standards. The AQI was determined using Eq. 1. AQI= (CO/5) + (NO_2 /40) + (SO_2/80) + ($PM_{2.5}$ /15) + ((PM_{10}/120)) 5×100 and multi pollutant index were determined by MPI= (1/n) [{(ACi-GCi/GCi}]. Air quality indices, Multi Pollutant Index (MPI) and the Air Quality Index (AQI) were used in the study. Overall condition of the air pollutants in the particular location was described using the Air Quality Index.

Results: The average ambient air pollutant concentration of Multan was 200µg/m3. The average AQI of Multan was 100µg/m3 followed by Faisalabad (80µg/m3), Karachi (150µg/m3) and Lahore (200µg/m3). Carbon monoxide concentration in all four cities was higher (400µg/m3) as compared to other pollutants. The occurrence of smog in Lahore was higher than Faisalabad, and Karachi. The significant concentration of air pollutants were noticed in Multan district. Results

showed that Multan is moderately unhealthy to hazardous AQI values and poor air quality according to MPI values.

Conclusion: Air quality is deteriorating in industrial and traffic-congested city where pollution levels significantly exceeded the threshold values. Using the linear regression, the results confirmed the strong association between the AQI and MPI. There is a need for immediate action to be taken to lower pollutants' concentrations and improve air quality in urban areas of Multan, Pakistan.

Keywords: Air Quality Index, Multi Pollutant Index, Pollutants Concentration, Multan Pakistan

INTRODUCTION

One of the essential components needed to keep life alive is air. Global public opinion, the government, and the scientific community start to express concern about it (Fan, 2020). According to Irshad et al. (2020), air pollution is the release of dangerous pollutants into the atmosphere that may have a negative impact on both human health and the condition of the planet as a whole. Because of increased traffic, industrialization, urbanization, and poor road conditions, the quality of the ambient air has steadily declined (Uddin, 2022). Automobiles and industrial pollutants are the two main sources of air pollution. Anything from particles from sneezes to chemicals emitted by industry that cause cancer could be the pollutant (Karimi, 2021).

The most hazardous air pollutants are particulate matter (PM10 and PM2.5), ozone (O3), sulphur dioxide (SO2), nitrogen dioxides (NO2), and carbon monoxide (CO). Studies on the effects of air pollution on human health have been conducted. Pollution exposure for an extended period of time can cause a number of health problems, such as respiratory conditions, cardiac problems, eye irritation, and early mortality (Jyothi, 2019). According to Zhao et al. (2019), China's air pollutants have a very bad impact. Breathing in contaminated air increases the risk of respiratory and cardiovascular diseases, according to numerous research (Fan, 2020).

The World Health Organization (WHO) states that breathing in SO2 and particles smaller than a micron can cause heart attacks, bronchitis, asthma attacks, lung function impairment, and even death. Additionally, there has been a 6% increase in mortality in several European towns at a concentration of 10 g/m3 for particles smaller than 10 um. Together with shifts in the quantity and distribution of secondary pollutants like ozone, one of the major health issues facing cities in recent times has been the size of particulates in the air. Statistics show that for the past 20 years, epidemiological research has shown a connection between outdoor air pollution and a rise in

cardiovascular disease, chronic bronchitis, respiratory failure, and even mortality, which is connected to global mortality. Compared to around one million in 2000, almost 1.3 million individuals died from air pollution in 2010, with more than half of these deaths occurring in Asia (Taghizadeh, 2019). One of the oldest cities in the area, Multan is situated in South Punjab, Pakistan, and is well-known for its significant agricultural importance, rich history, and vibrant culture. But like many other Pakistani cities, Multan has recently had to deal with a serious environmental problem: smog. Smog, a mixture of smoke and fog, has grown to be a recurring issue, especially in the winter, greatly impacting the city's overall environmental quality and urban climate (Ali et al., 2020). The main human-caused causes of Multan's smog are transportation-related emissions, industrial pollution, burning of solid waste, and agricultural practices like crop burning. These activities contribute to the production of smog by releasing a variety of pollutants into the atmosphere, such as carbon monoxide (CO), sulphur dioxide (SO2), nitrogen oxides (NOx), particulate matter (PM), and volatile organic compounds (VOCs) (Ahmed et al., 2017). The impacts of smog on the urban climate in Multan are multifaceted and far-reaching. First of all, smog raises air pollution levels, which has a negative impact on people's health by causing respiratory ailments, cardiovascular disorders, and even early death among the city's population. Second, it reduces visibility, which increases the risk to the safety of vehicles and impedes business operations. Thirdly, smog disrupts the microclimate of the city and exacerbates weather extremes by changing meteorological patterns that affect temperature, precipitation, and wind patterns (Hafeez et al., 2019). There is still a dearth of thorough study analyzing the precise effects of smog on Multan's urban climate, despite increased knowledge and concern about the harmful effects of the pollution. As a result, the purpose of this study paper is to close this gap by thoroughly examining how pollution affects Multan, South Punjab, Pakistan's urban climate. This study attempts to offer important insights into the intricate relationships between smog and urban climate dynamics in Multan using an interdisciplinary analysis that includes meteorological data, air quality measurements, and health statistics (Khan et al., 2010).Comprehending the complex relationship between Multan's urban climate and smog is imperative in order to devise efficacious ways for mitigating air pollution and implementing policy measures that protect public health and environmental integrity.

This research aims to add to the wider discussion on sustainable urban development and environmental stewardship in Pakistan and beyond by illuminating the complex links between

pollution and urban climate. The recent study were conducted to evaluate the impact of smog on human health and urban climate in Multan, Pakistan through experimenting the air quality index and multi pollutant index of Multan Pakistan under Pakistan meteorological department.

MATERIAL AND METHODS

Study site

Four Pakistani cities—Multan, Lahore, Faisalabad, and Karachi—were chosen as the study sites for this investigation. With a population of 6.31 million, Lahore is the capital of Punjab Province and the second-largest city in Pakistan. Faisalabad, with 2.51 million residents, is Pakistan's third-biggest city. With a population of 11.62 million, Karachi is the largest metropolis in the nation and the capital of Sindh province (World Population Review, 2022).

Measurement of ambient air pollutant concentrations

The five ambient air pollutants (CO, NO2, SO2, PM2.5, and PM10) were employed in this inquiry, and Table 1 displays the comparison between the pollutants and the National Environmental Quality Standards (NEQS). As of right now, Pakistan has six air quality monitoring stations that measure important pollutants on an hourly basis, including carbon monoxide, nitrogen dioxide, sulphur dioxide, and particulate matter (PM2.5 and PM10). These stations were built with the intention of continuously gathering, measuring, and monitoring all the specified ambient air quality information. Each station is equipped with a set of instruments that are used to measure the principal pollutants. Two air quality indices were used to analyse the data: the Multi Pollutant Index and the Air Quality Index. The Air Quality Index was used to describe the overall condition of the gaseous air pollutants in the particular location. The Environmental Protection Agency (Pak-EPA) is the source of the AQI colour coding. The AQI was determined using Eq. 1.

$AQI= (CO/5) + (NO_2/40) + (SO_2/80) + (PM_{2.5}/15) + ((PM_{10}/120))\ 5\times100$ (Tabinda, 2020)

Using this formula, the average concentration of each pollutant over different time periods was first determined. Then, the concentration of each pollutant was divided by the relevant standard value to create its index, which was then cumulatively averaged and represented as a percentage (Tabinda, 2020). Table 2 shows the health impacts of selected contaminants along with the Air Quality Index (AQI). Second, the Multi Pollutant Index (MPI) was chosen in order to reduce the potential impact of subjective estimates on the amount of emissions in certain cities

based on pollution levels with one or more contaminants in a particular megacity. The MPI is represented by the following equation: MPI= (1/n) [{(ACi-GCi/GCi}]. Where n is the number of pollutants considered, ACi is the atmospheric concentration of the pollutant in the background air of a megacity, GCi is the recommended concentration of the pollutant, and i is the pollutant under consideration (e.g., CO, SO2, NO2, PM2.5, or PM10). The most appropriate techniques were determined to be one-way ANOVA testing and linear regression (R2) for correlation in order to assess the significant link between AQI and MPI (Gurjar, 2008).

Table 01 Standard Guideline Values of National Environmental Quality Standards (NEQS) (Lokys, 2015)

Sr. No	Pollutants	Standards
1	Carbon monoxide	5 mg/m3
2	Sulphur Dioxide (SO2)	80µg/m3
3	Nitrogen Dioxide (NO2)	40µg/m3
4	Respirable particulate matter. PM2.5	15µg/m3
5	Respirable particulate matter. PM10	120µg/m3

Table 02 Air Quality Index and its Health Impacts

Sr. No.	Range	AQI Category	Health Impacts
1	0-50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk.
2	51-101	Moderate	Air Quality is acceptable, however for some pollutants there may be more moderate health concerns for a small number of people.
3	101-150	Unhealthy for sensitive peoples	Members of sensitive groups may experience health effects. The General Public is not likely to be affected.
4	151-200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
5	201-299	Very unhealthy	Health Alert: Everyone may experience more serious health effects.
6	300-500	Hazardous	Health warnings of emergency conditions. The entire population is more likely to be affected.

Table 03. Average Ambient Air Pollutant Concentrations in Selected Cities of Pakistan

Sr. No.	City	CO (mg/m3)	NO2 (µg/m3)	SO2 (ug/m3)	PM2.5 (µg/m3)	PM10 (µg/m3)
1	Karachi	0.00105	63.43	89.19	95	384.4
2	Lahore	1.68	175	20.84	19.21	310
3	Faisalabad	0.00195	25.7	19.81	36.5	172
4	Multan	0.0064	15.64	29.58	35.88	434.62

Data Collection

During the study period, daily meteorological parameters from the Pakistan Meteorological Department (PMD) in Multan were gathered. These included temperature, relative humidity, wind speed, and precipitation. Particulate matter (PM10 and PM2.5), nitrogen dioxide (NO2), sulphur dioxide (SO2), ozone (O3), and carbon monoxide (CO) were among the air quality metrics that were continuously monitored using stationary monitoring stations dispersed across Multan in order to get data on the state of the air.

Air quality Assessment

The average concentrations of distinct air contaminants were ascertained, and their geographical dispersion in diverse Multan regions was scrutinized. In order to calculate the disease burden in Multan that can be attributed to exposure to air pollution, health risk assessments were carried out.

Statistical Analysis:

The study period's variability and trends in meteorological parameters were examined using descriptive statistics. The correlations between climatic factors and air quality parameters were evaluated using Pearson correlation coefficients.

RESULTS AND DISCUSSION

Table 3 lists the sources of pertinent research studies along with the ambient pollutant concentrations of the target pollutants (CO, NO2, SO2, PM2.5, and PM10). All of the areas that were chosen had average CO concentrations that were below NEQS (5 mg/m3), whereas Karachi had the highest average concentration (63.435 µg/m3). Everywhere but Karachi, NO2 levels were below the recommended threshold of 40 µg/m3. In Karachi, the average SO2 content was

the greatest at 89.19µg/m3, while in Lahore, it was the lowest at 19.21µg/m3. Except for Karachi, SO2 emissions were below the recommended values (80 µg/m3), as illustrated in Fig. 1.

According to Ahmed et al. (2021), earlier research also revealed that the concentrations of NO2 and SO2 were higher than WHO acceptable levels. Similarly, research revealed that Lahore was one of the most polluted cities, with air pollution levels above WHO recommended baselines and detrimental effects on public health (Naveed, 2022; Aslam, 2022). According to the study, children who lived and attended school in high-PM2.5 exposure areas of Lahore had significantly higher blood pressure than children in lower-PM2.5 exposure areas. A study found that traffic-related urban pollution can raise children's blood pressure and raise their risk of hypertension and cardiovascular issues in the future (Bhatti, 2021). Riaz (2018) asserts that elevated PM2.5 in conjunction with elevated pollution has detrimental effects on health. Using the matching colour codes, the concentration of pollutants as well as their standard values was used to estimate the Air Quality Indexes for six cities that were chosen. With an average AQI of 307 (hazardous), Lahore was the most polluted city out of the six; Islamabad and Faisalabad had comparatively lower average AQIs of 78 and 95, respectively (moderate). Karachi, with an average AQI of 245 compared to comparable cities, is regarded as a very unhealthy city.

The results showed that uncontrolled development, urbanization, and an increase in automobiles will make the situation in Lahore and Karachi worse. Numerous factors, including burning fossil fuels, cars, and industrial pollutants, have a negative impact on the quality of the air, which has resulted in serious health problems (Sarmadi, 2021; Ahmed et al., 2021). As was already indicated, different colour coding was utilized to indicate the severity of the air quality at different locations. The colour code is provided by the Pak-EPA. The onset of the industrial revolution and other human endeavors has substantially deteriorated the quality of the air. In a similar vein, rapid economic growth and urbanization have harmed the environment in numerous ways and reduced the quality of the air in cities (Wang,2018).Furthermore, according to certain research, the prevalence of lung conditions may rise as air pollution levels rise. Due to their immature respiratory systems, children are more susceptible to respiratory infections, and airborne particles ranging in size from 10 to 2.5µm can raise the mortality rate of newborns.

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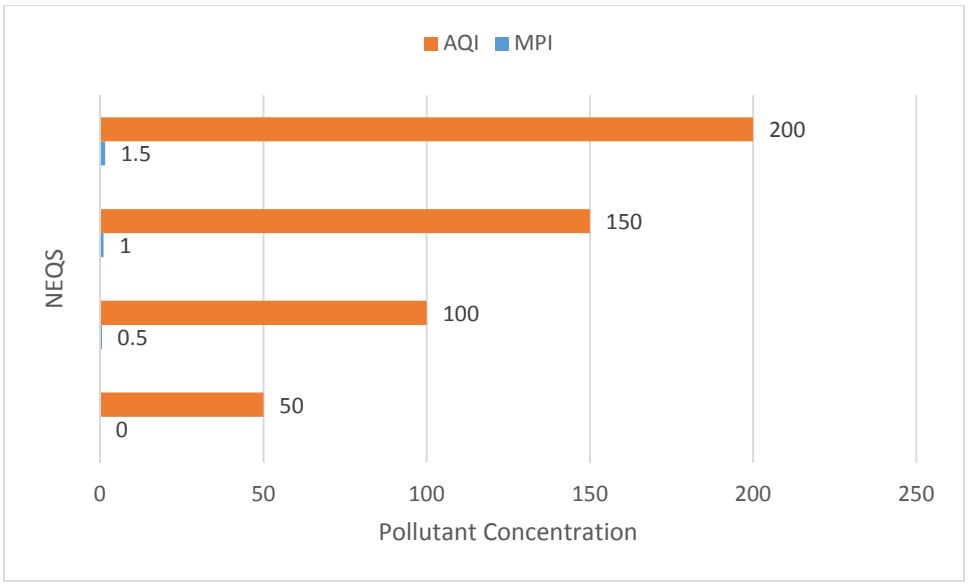

Fig.1. Comparison of average ambient air pollutant concentration with NEQS

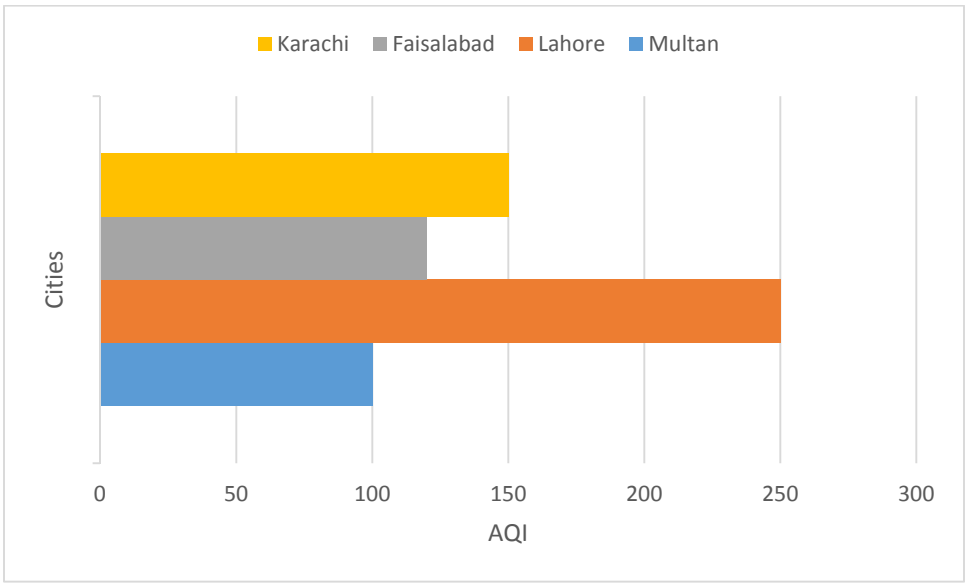

Fig. 2 Air Quality index of selected cities of Pakistan

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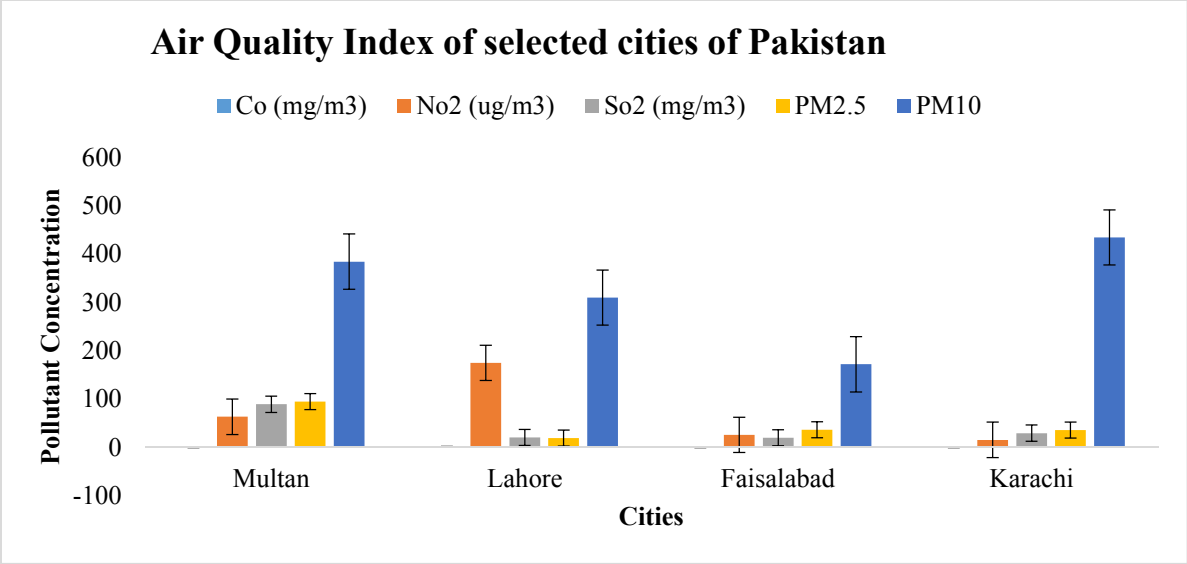

Fig. 3 Multi Pollutant Index of Ambient Air Pollutant Concentrations in Selected Cities of Pakistan

Table 4. Multi Pollutant Index of Ambient Air Pollutant Concentrations in Selected Cities of Pakistan

Sr. No	City	CO (mg/m3)	NO2 (µg/m3)	SO2 (ug/m3)	PM2.5 (µg/m^3)	PM_{10} (µg/m^3)
1.	Karachi	-0.16	0.12	0.02	1.07	0.44
2.	Lahore	-0.13	-0.10	-0.15	2.13	0.32
3.	Faisalabad	-0.20	-0.07	-0.15	0.29	0.09
4.	Multan	-0.20	-0.02	-0.03	0.27	0.10

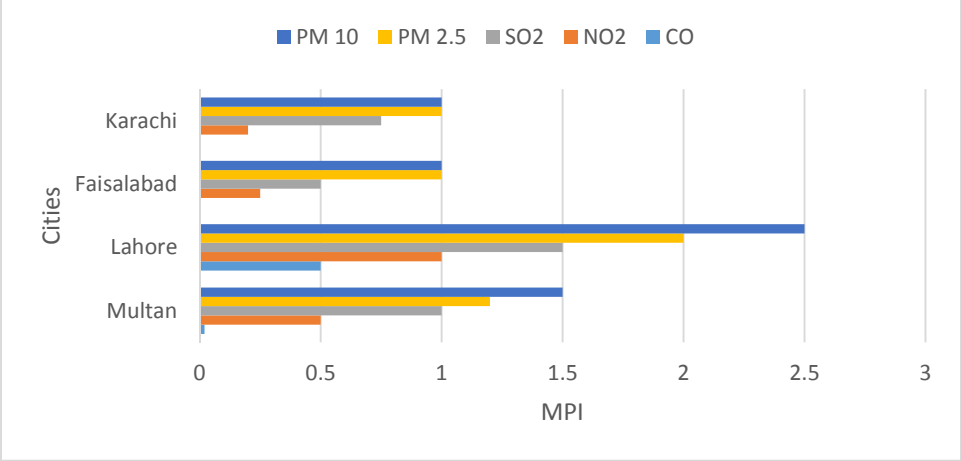

Fig. 4 Multi Pollutant Index of selected cities of Pakistan

Cardiovascular and respiratory diseases, both acute and chronic, are among the issues (Mehmood et al., 2020; Anwar et al., 2021; Mehmood et al., 2021). The primary pollution sources in these selected cities include heavy traffic, the dust produced during the construction of multiple infrastructure projects, and smoke emissions from numerous other sources. The AQI's black colour coding for the majority of the chosen cities indicates that the quality of the air is generally bad, since metropolitan areas are becoming more and more affected by ambient air pollution. The current state of the air quality has gotten worse since a few years ago due to an increase in traffic and the number of automobiles on the road.

It is predicted that additional pollutants like CO, SO2, and NOx might surpass NEQS if suitable policies are not implemented. Thus, it is imperative that we pay careful attention to this problem and devise practical solutions (Tabinda, 2020). As an example, Table 4 shows ambient atmospheric concentrations of CO, SO2, NO2, PM2.5, This study has taken the MPI as a quantitative measure of pollution in a selected cities expressing the combined pollution levels of five criteria pollutants (i.e., CO, SO2, NO2, PM2.5, and PM10) relative to the guidelines for air quality (Pak-EPA, 2010).

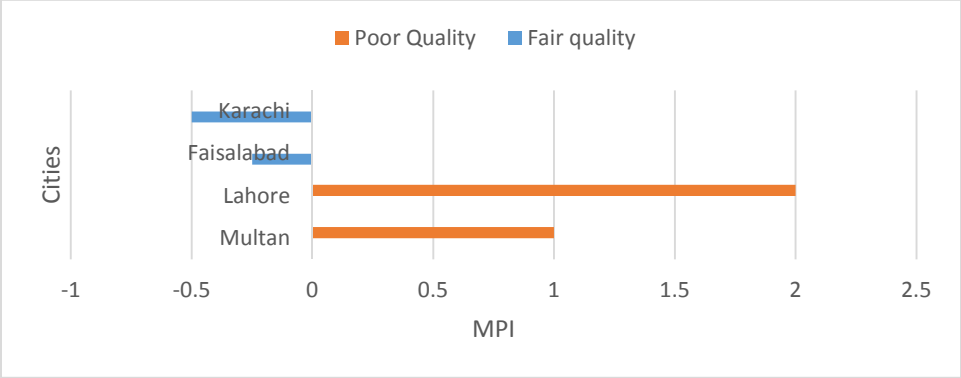

Fig.4.MultiPollutantIndexbasedrankingofselectedcitiesofPakistan

Lahore topped the MPI ranking of Pakistan's major cities as the most polluted megacity in 2021 (Fig 4). Pakistan's second-most polluted megacity is Karachi. This is brought on by urbanization, population growth, and the absence of appropriate policy execution (Saleemi, 2022; Ali, 2022, Naveed, 2022). Fig. 5 displays linear regressions of the AQI and MPI relationship. The results indicated a higher degree of correlation (R2 = 0.9998) between AQI and MPI. The phrase "responsible pollutant" in the index refers to the pollutant that has the greatest influence on the final index value because all pollutants have an effect on the MPI

and AQI. The relevant pollutants, as determined by the MPI and AQI calculation method, were PM2.5 and PM10, which consistently have the largest percentage of the recommended value due to the dense population of these two cities (Karachi and Lahore). Arguably the primary cause of the elevated levels of PM2.5 and PM10, industrialization and arid weather patterns are other significant contributors to elevated PM concentrations.

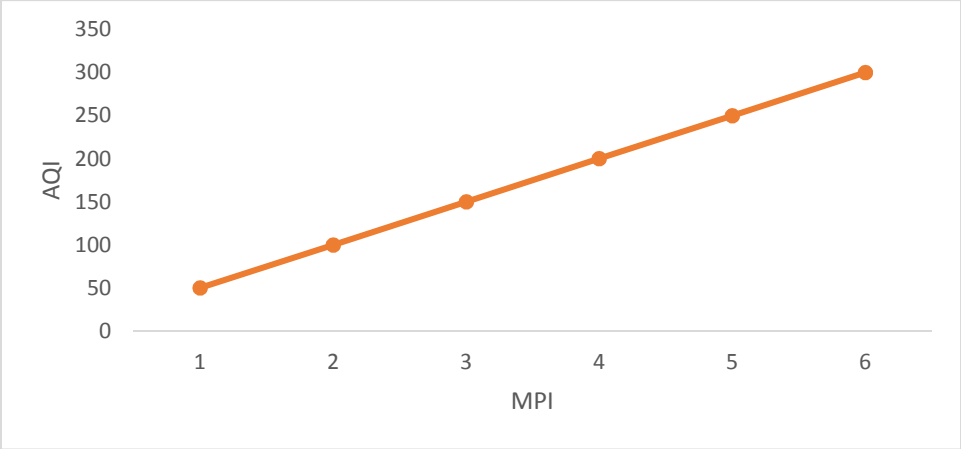

Fig.5. Linear regression of Air Quality Index and Multi Pollutant Index of selected pollutant so f selected cities

Table 5. One-way ANOVA Test Analysis

Source of Variation	Df	SS	MS	F	P-value
Between Groups	2	102492.6	51246.3	18.04681	0.000102
Within Groups	15	42594.48	2839.632	--	--
Total	17	145087.1	--	--	--

The concentration of primary industrial sources, the deficiency of public transit, and the lack of efficient pollution controls. One-way ANOVA was used to confirm statistically that AQI and MPI were extremely significant ($p < 0.01$). The findings demonstrated the substantial positive trends in the air quality indicators, with the AQI and MPI values of p being less than 0.01 at 0.0001, as shown in Table 5. This implies that research on air quality indices may offer a thorough understanding of the state of the air and any possible health effects.

CONCLUSION

The majority of Pakistan's urban areas struggle with air pollution, and a monitoring plan is required to assess the problem. Pollutant concentrations are rising daily and above national

limits. The average amounts of CO, NO2, and SO2 were all marginally below the allowable level, with the exception of Karachi. However, it was discovered that PM2.5 and PM10 concentrations were higher than allowed in all of the chosen locations because of the dense traffic and commercial districts. It is predicted that in the event that planned countermeasures are not implemented, then additional pollutants such as CO, SO2, and NO2 would also surpass allowable levels. Lahore and Karachi were found to have extremely unhealthy to hazardous air quality, as well as MPI categories and poor air quality, based on the AQI category among the selected cities. Due in major part to PM2.5 and PM10, the poor ambient air quality in Lahore and Karachi has resulted in significantly higher levels of AQI and MPI. The results indicate a high degree of agreement between the MPI and AQI. The findings show a strong correlation between the MPI and AQI levels. Making recommendations to legislators in the future to maintain a healthy level of air quality in urban areas requires serious thought. To control air pollution for sustainable urban management, more ecologically friendly and alternative energy sources must be developed, as well as careful traffic planning, vehicle technological developments, more plantations, and the backing of relevant authorities.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors. Proper citations and acknowledgements are made for use of published information.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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