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Comparison of Ambient Air Quality among Industrial and Residential Areas of a Typical South Asian City

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Abstract: The rapid increase in population growth due to industrialization and urbanization has resulted in air quality deterioration in Pakistan. Consequently, a considerable increase has been seen in the types of sources of air pollutants. However, the air quality of the country has deteriorated in the absence of management capabilities against air quality. Evidence from numerous governmental organizations and international bodies has specified that the environment, health, and quality of life are at high risk due to air pollution. Although the government of Pakistan established the Pakistan Clean Air Program, along with continuous monitoring stations to manage the quality of ambient air, air quality values have not yet been achieved. The present investigations were made in the city of Faisalabad in selected locations. Sampling of a 24 h average was done for selected sites. The air quality parameters such as NO_2, SO_2, CO_x, O_2, noise level, and suspended particulate matter (SPM) were measured at two locations, *i.e.*, Khurrianwala and Liaqatabad in the Faisalabad District. The measured values of air quality parameters were compared with national environmental quality standards (NEQS). Air pollutants such as SPM, SO_2, and noise levels were found to be significantly higher than the 24-h standards of NEQS, which poses harmful effects on the quality of air and health, whereas the O_2 concentration was found to be lower than the normal values, and NO_2 and CO_x values were normal. The SO_2, CO_2, noise level, SPM, and O_2 values ranged from 418–652 and 423–661 μg/m^3, 3.03–3.44 and 3.08–3.51 mg/m^3, 68–73 and 69–75 dB, 555–667 and 581–682 μg/m^3, and 19.5–20 and 19.5–20.3 % for summer and winter season, respectively, as compared to standard values (150 μg/m^3, 10 mg/m^3, 65 dB, 550 μg/m^3 and 21%). After the complete analysis of the selected locations, it was concluded that the ambient air quality of this area is severely degraded due to industrial as well as other commercial activities. These significant variations in air quality parameters suggest that there is a need to check the air quality regularly to take appropriate measures for reducing ambient air pollutants, especially in industrial areas as well as commercial areas.

Keywords: ambient air quality; NEQS; pollution; industrial area; residential area

1. Introduction

Asian countries have seen substantial growth in development, urbanization, motorization, and energy use during the last century. A significant rise has been seen in the number of sources of air pollutants [1]. Increased industrialization and the use of motor vehicles are those factors that have severe impacts on the environment as well as population health in

Asia [2]. The WHO [3] reported, with considerable evidence, that population health in the region is at the mercy of air pollution. Air pollution has become a very problematic issue related to the environment and human health due to industrialization and urbanization [4]. It is predicted that about two million premature deaths occur each year in urban areas of the world due to air pollution [5]. The substantial increase in population growth and industrialization is coupled with motorization, which is one of the principal air emission sources of air pollutants [1].

Air pollution has become a major problem for the quality of life, health, and environment in South Asia because of non-compliance with emission control technologies and strategies [3,6,7]. The most common type of air pollution is ambient air pollution, which has adverse health effects including burning of the eyes, coughs caused due to a sore throat and colds, and even heart attacks and deaths in extreme cases. Airborne particulate matter signifies a composite mixture of inorganic and organic constituents. Composition and mass are inclined to divide into two key groups: coarse particles frequently >2.5 µm in aerodynamic diameter, and fine particles typically <2.5 µm in aerodynamic diameter. Fine particles comprise the secondarily molded aerosols; recondensed organic and metal vapors and combustion particles. The bigger particles generally comprise earth crust constituents and fleeting dust from industries and roads. The sources of pollutants were industries that emit SO_2 due to the burning of coal, whereas some pollutants such as CO and CO_2 are produced due to vehicles. Dust particles are the main source due to the construction in commercial areas. Construction and transportation made this site more polluted with dust. Heart and lung diseases in children and patients are predominantly liable to air pollution showing chronic effects on human health [8]. Six pollutants that are major contributors to air pollution and account for the majority of air pollution are sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), lead (Pb), and suspended particulate matter (SPM) [9]. TSP concentration in Pakistan's major cities seems to have reached alarming levels and city dwellers are being continuously exposed to its harmful effects that could potentially lead to cardiovascular disorders, asthma, chronic obstructive pulmonary diseases such as bronchitis/emphysema, and other respiratory diseases (Pak-EPA/JICA 2006). A survey of Lahore, Rawalpindi, and Islamabad concluded that ambient air pollutants in Pakistan were more than the NEQS limits. The survey shows that the quantity of CO was 114–10,745 mg/m^3 and 114–7658 mg/m^3 in Lahore and Islamabad, respectively. Similarly, the quantity of SO_2 varies from 0.8–553 mg/m^3 and 0.8–157.8 mg/m^3 in Lahore and Islamabad, respectively, whereas particulate matter was found to be exceeded in these areas, at 80–535 µg/m^3 for a 1-h average time. Moreover, its concentration ranged in different cities in Pakistan between 85 and 835 µg/m^3 for 24 h.

The information about the quality of ambient air in Pakistan is not available on a large scale but intimates the brutality of the problem. Due to the absence of comprehensive legislation, the quality of ambient air is deteriorating quickly s and is thus categorized as a life-threatening problem [10]. The present study aimed to assess the ambient air quality in the Faisalabad district, in areas such as Khurrianwala and Liaqatabad. These areas were selected to analyze ambient air quality because Khurrianwala is an industrial area and Liaqtabad is a commercial one. Therefore, the two different areas were used for comparison of ambient air pollutants because ambient air pollutants vary at different sites. Positive results were expected due to industrial areas of Khurrianwala and this method is considered to be a better way to assess the changes in ambient air quality. For this purpose, NO_x, CO, and SO_2, SPM, Pb, and O_2 air quality parameters were selected as representative of the air quality of these two selected places and then compared with the standards of NEQS.

2. Materials and Methods

The selected sites shown in Figure 1 were densely populated and have a high load of traffic. The present study aimed to assess the ambient air quality in the district of Faisalabad in areas such as Khurrianwala and Liaqatabad. Sampling of a 24 h average was done for selected sites. The interpretations were taken daily during the winter and summer seasons.

The average temperature in Faisalabad city was 38 °C during summer months and 15 °C during winter months. The maximum rain is received during July–September.

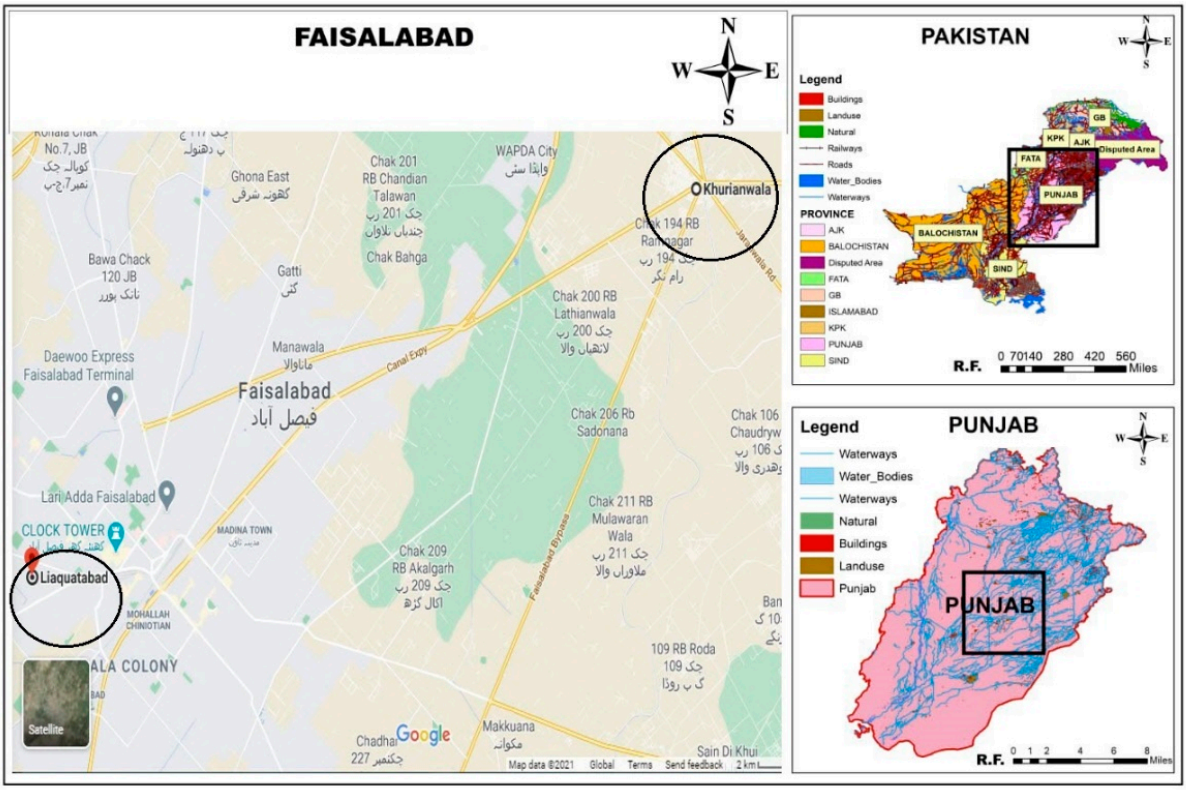

Figure 1. The map showing the selected sites of study area in Faisalabad.

2.1. LaMotte Test for SO_2 and NO_2 Measurement

The LaMotte test was used for the monitoring of gases such as SO_2 and NO_2 in the air using an adjustable flow meter, which measures the rate of airflow through the absorbing solution (calibrated to measure the rate in liters per minute (Lpm). The SO_2 from ambient air was sucked through an absorbing solution with a vacuum pump. It absorbs 20 L of air through the absorbing solution at 2.0 Lpm for 10 min. It was positioned at a height of approximately 120 cm above the floor, and more than 1.5 m away from the walls or any obstacle. An absorbing solution that extracts the chemicals from the atmosphere was included in the testing units as the system of reagents. To produce color, a single indicator is added to the absorbing solution in some systems, whereas in others, pretreatment is done before adding the indicator. In the present study, three samples were taken from each site, averaged, and an air calibration chart is used to convert index reading to concentration. The analytic balance (Model: GR-202) was used to measure the weights.

2.2. Mini Vol Portable Air Sampler for SPM Analysis in Air

A Mini Vol portable air sampler (Model SN: 4478) was used to measure the SPM in the air. The filter paper was loaded in filter assembly carefully and transferred to the field site. The dust from the ambient air of both sites was allowed to stick to the filter paper and the filter paperweight was measured to calculate the SPM by the difference method. Operating at a fixed flow rate of 5 Lpm, the MiniVol can be equipped with $PM_{2.5}$ or PM_{10} internal fractionators and collects particles on 47 mm diameter filters for subsequent gravimetric and/or chemical analysis.

2.3. Single Gas Detector for O_2 and CO

Gas alert extreme (VS-70) was used to measure O_2 and CO. For O_2, the operating humidity was 0–99%. For sampling, the cube button and circle button were pressed simultaneously and held for 5 s. The detector beeped, vibrations were produced, and after CAL was displayed on the LCD detector, more beeps were produced. The LCD flashed auto-zero while the detector sensor reading became zero. Finally, the beep was produced twice at the end of auto-zero and the LCD displayed the current calibration gas concentration, which was recorded by pressing "accept concentration".

2.4. Noise Level Measurement Meter

Ambient air quality monitoring has a strong correlation between traffic density and concentration of pollutants; therefore, the SESELLA CEL-6XO series model sound level meter was used for measuring noise in the selected area of Khurrianwala and Liaqatabad. The before-use meter was calibrated by setting the calibration frequency at 1 kHz. The noise levels were recorded at different distances and finally recorded readings were averaged.

2.5. Analysis of Carbonaceous Aerosols

Components of carbonaceous aerosol, elemental carbon (EC), and organic carbon (OC) account for a large element of atmospheric particulate matter (PM) and, on average, subsidize to 20–35% of coarse particulate and 20–45% of fine particulate [11,12]. Carbonaceous aerosols have a chief role in the interactions of light particles within the atmosphere and are one of the significant components of fine and coarse particulate matter; they are therefore associated with the negative climatic and environmental impacts and worsening public health and air quality [2,13–16]. The Thermal-optical transmittance [TOT] method was used to address quantitative amounts of EC and OC in the samples collected for $PM_{2.5}$ and PM_{10} evaluation through the use of the NIOSH 870 protocol for evaluating EC and OC with the laboratory analyzer. In the first phase of the investigation, samples collected for evaluation were thermally desorbed through the use of fluctuating temperatures in a pure helium (He) atmosphere and a perceived distributing series of carbon peaks (OC1–OC4). The selected temperatures were: 310 °C (OC1), 475 °C (OC2), 615 °C (OC3), and 870 °C (OC4). In the second phase, 2% O_2 and 98% He atmosphere at temperatures of 550 °C (EC1), 625 °C (EC2), 700 °C (EC3), 775 °C (EC4), 850 °C (EC5), and 870 °C (EC6) occurred. The split point between those phases is mechanically set when the restrained optical signal returns to the reference line to abate the ambiguity due to the development of pyrolytic carbon (PC) from the organic carbon (OC) into the thermally constant form, bearing a resemblance to elemental carbon [11].

2.6. Air Quality Guidelines

The assessment of exposure risk and global exposure calculations reveals air pollutant's exposure has been augmented, more so than earlier projected [17]. In future megacities such as Faisalabad, emissions from road vehicles, industrial, and other man-made activities are significant factors for increased acquaintance to air pollution. Faisalabad is an urban city with a high concentration of particulate pollution, which mostly exceeds the safe limits set by the World Health Organization (WHO) and the National Ambient Air Quality Standards (NAAQS) of Pakistan [18]. Suspended particulate matters cause numerous types of health issues [19,20]. Environmental deprivation, including soil and water, is around 6% of the GDP of Pakistan. Outdoor and indoor air pollution accounts for approximately half of premature mortality and illness in Pakistan [21]. We observed a lack of implementation of air pollution regulations and the mass transit conveyance system adds additionally to the matter of local air pollution [19]. It is obvious that particulate matter also performs a substantial role in disturbing the global climate [22,23].

3. Results and Discussion

3.1. Sulphur Dioxide (SO_2)

The concentrations of SO_2 in both locations i.e., Liaqatabad and Khurrianwala, were found to be 418 and 423 μg/m^3 and 652 and 661 μg/m^3, for the summer and winter seasons respectively (Table 1). The measured values indicate that the level of SO_2 at both sites was higher than the NEQS limits. This high value of SO_2 indicates that the ambient air quality becomes polluted which might be due to the emission from industrial activities. These findings were found to be significantly higher than previously reported data, such as [6] in Faisalabad (126 μg m^{-3}), Ali and Athar [24] and Ghauri, et al. [25], who reported SO_2 level in Faisalabad (57.6 μg m^{-3}), Karachi (57.6 μg m^{-3}), Quetta (68.1 μg m^{-3}), Peshawar (57.6 μg m^{-3}), Islamabad (52.4 μg m^{-3}), and Rawalpindi, Pakistan (41.9 μg m^{-3}). Power generation plants, industrial processes, and diesel-fueled vehicles are the main sources of SO_2 [26]. It was noticed that the number of diesel vehicles during 2005 increased to three times higher than in 1980 [27]. The current levels in various cities are two to three times higher than the WHO air quality guideline value (20 μg m^{-3}) for 24 h [27]. These significant differences in the SO_2 levels at selected sites pertain to the burning of different types of biomass or feedstock for industrial purposes [28].

Table 1. Seasonal variation of SO_2 at selected sites in comparison to NEQS and WHO and corresponding health effects.

Locations	Summer	Winter	NEQS	WHO (2021)	Health Effects	Diseases
Liaqatabad	418 μg/m^3	423 μg/m^3	120 μg/m^3	40 μg/m^3	Respiratory illness, alterations in pulmonary defenses, lung cancer	Cardiovascular problems, bronchitis emphysema, asthma, pneumonia
Khurrianwala	652 μg/m^3	661 μg/m^3				

3.2. Nitrogen Dioxide (NO_2)

The value of NO_2 was found considerably lower than the NEQS in the ambient air of Liaqatabad and Khurrianwala during the study period. According to Iqbal and Bokhari [6], NO_x level may be expected high in the dry season and this low value of NO_2 may be due to the variation in season, and in dry and hot climates it is expected to be high. According to Nasir, Colbeck, Ali and Ahmed [26], NOx is a group of gases that are convertible with each other known as oxides of nitrogen. Most combustion processes increase the oxidation of atmospheric NO to NO_2. The low concentration of NO_2 in the ambient air of both sites indicates that there was no conversion of NO to NO_2 (Table 2). Pakistan-EPA has recently declared NO_2 as the second most important air pollutant and to quantify a study was carried out in 2006 to assess its concentration in five major cities (including Karachi, Lahore, Quetta, Peshawar, and Islamabad).

Table 2. Seasonal variation of NO_2 at selected sites in comparison of NEQS and WHO and corresponding health effects.

Locations	Summer	Winter	NEQS	WHO (2021)	Health Effects	Diseases
Liaqatabad	0 μg/m^3	0.2 μg/m^3	80 μg/m^3	25 μg/m^3	Respiratory infections, acute respiratory illness in children	Influenza, respiratory diseases, bronchitis, asthma, COPD
Khurrianwala	0 μg/m^3	0.3 μg/m^3				

3.3. Carbon Monoxide (CO)

The CO level was found to be 3.03 and 3.08 mg/m^3 at Liaqatabad, whereas it was 3.44 and 3.51 mg/m^3 at the Khurrianwala location in the summer and winter seasons, respectively (Table 3). Although the concentration of CO at both locations was within the limits, the monitored value is an alarming matter for the future, because the measured concentration was considerably high in comparison to previous studies [6,10]. Our findings are also supported by the earlier findings Ghauri and Mirza [25] who reported 1.8 mg m^{-3} CO in Islamabad, 2.1 in Rawalpindi, and 10.4–11.5 mg m^{-3} in Karachi, Pakistan. Similarly, [29] reported 0.56 mg m^{-3} of CO in an industrial area, 0.14 mg m^{-3} in a residential area, 0.71 mg m^{-3} at Port Qasim, and 0.32 mg m^{-3} in downtown Karachi. The CO concentrations measured at both stations in Faisalabad were also found to be lower than Peshawar (3.5 mg m^{-3}), Rawalpindi/Islamabad (4.6 mg m^{-3}), Karachi (5.8 mg m^{-3}), and Quetta (16.1 mg m^{-3}) as reported by [24]. The CO levels varied widely across the country, but generally higher amounts were found near congested metropolitan streets, and the USEPA 1-h air quality threshold (40 µg/m^3) was frequently surpassed. The WHO recommends averaging times: 15 min–100 µg/m^3, 30 min–60 µg/m^3, and 1 h–30 µg/m^3 [3]. Based on the available research, it has been determined that urban areas have greater CO levels during the day than these standards. CO levels are rising due to an increase in the number of automobiles on the road and a weak mass transit infrastructure designed that 23–26% of the excess CO is produced due to inappropriate running of the mass-transit system [30]. A major contributor to CO is solid waste that is produced about 48,000 tonnes each day [27,28].

Table 3. Seasonal variation of CO at selected sites in comparison of NEQS and WHO and corresponding health effects.

Locations	Summer	Winter	NEQS	WHO (2021)	Health Effects	Diseases
Liaqatabad	3.03 mg/m^3	3.08 mg/m^3	10 mg/m^3	4 mg/m^3	Bloodstream Oxygen delivery, Toxicity of nervous system and heart	Asthma, headaches, dizziness, nausea, loss of vision
Khurrianwala	3.44 mg/m^3	3.51 mg/m^3				

3.4. Suspended Particulate Matter (SPM)

The values for suspended particulate matter were measured as 667 µg/m^3 and 682 µg/m^3 in Liaqatabad, whereas at Khurrianwala Station, the concentration level of SPM was recorded as 555 µg/m^3 and 581 µg/m^3 for summer and winter seasons, respectively (Table 4). The SPM at both places was significantly higher as compared to NEQS permissible limits. The average concentrations of SPM were also found higher than European Commission Ambient Air Quality Standards (30 µg/m^3), USEPA national ambient air quality standards (50 µg/m^3), Hong Kong (55 µg/m^3), and Chinese Secondary Standards (100 µg/m^3) [31]. These higher SPM values require serious attention as they may add to problems related to respiration, aggravated asthma, coughing, decreased lung functions, painful breathing, chronic bronchitis, and premature death as reported in a study [31]. Significant variations exist between different seasons among the selected sites (Table 4). These are in agreement with the earlier findings of Aslam et al. [10] who reported variations in fine and coarse particulate matter in this semi-arid region of Pakistan.

Table 4. Seasonal variation of SPM at selected sites in comparison to NEQS and WHO and corresponding health effects.

Locations	Summer	Winter	NEQS	WHO(2021)	Health Effects	Diseases
Liaqatabad	667 µg/m^3	682 µg/m^3	500 µg/m^3	500 µg/m^3	Respiratory systems, lungs, eye effect, Skin	Asthma attacks, dust allergy, influenza, scabies, dermatitis
Khurrianwala	555 µg/m^3	581 µg/m^3				

3.5. Oxygen (O_2)

The data (Table 5) shows the O_2 values recorded at Khurrianwala and Liaqatabad sites. The measured values of O_2 at both places were found to be significantly lower than the normal level. The O_2 value at Liaqatabad and Khurrianwla were 20.2 and 20.3 % and 19 and 19.5 % in the summer and winter seasons, whereas the required level is 21%. This might be due to the higher consumption of oxygen in combustion processes. Therefore, this deficiency of O_2 causes various health effects including muscle fatigue and accelerated heartbeat [32,33]. The non-significant differences between two seasons exist at selected sites regarding O_2 concentration

Table 5. Seasonal variation of O_2 at selected sites in comparison to NEQS and corresponding health effects.

Locations	Summer	Winter	NEQS	Health Effects	Diseases
Liaqatabad	20.2%	20.3 %	21%	Increased breathing volume, nausea, muscle fatigue at a low level, accelerated heartbeat	
Khurrianwala	19.0%	19.5 %			

3.6. Noise Level

Ambient air monitoring results show the direct relationship between traffic and air pollutant concentrations. Traffic volume in any area has a direct relation with noise pollution and the kind of vehicles passing by, such as cars, buses, trucks, etc. Noise levels were found directly related to the time of day [34]. Traffic volume was high in afternoons and evenings because of office timings, other recreational activities, or due to the culture which organizes events in the late evening in Faisalabad. Nowadays, noise pollution is also an environmental issue in the industrial areas. Khurrianwala Station is an industrial as well as a residential area, where a high noise level is expected. The average noise level measured at Khurrianwala was 73 dB(A) and 68 dB(A) at the Liaqatabad location in the summer season, whereas in winter, the level was recorded as dB(A) and 75 dB(A) for both the locations, respectively. At both locations, the noise level was found to be violating the NEQS. This high level is due to traffic load and industrial activities in the area (Table 6).

Table 6. Seasonal variation of noise levels at selected sites in comparison to NEQS and corresponding health effects.

Locations	Summer	Winter	NEQS	Health Effects	Diseases
Liaqatabad	68 dB(A)	69 dB(A)	65 dB(A) Elementa	Deafness, headache, nausea, depression	
Khurrianwala	73 dB(A)	75 dB(A)			

3.7. Analysis of Carbonaceous Aerosols in Air Pollutant Samples

Elemental carbon (EC) and organic carbon (OC) are the main components of atmospheric aerosol [35]. Elemental carbon is discharged from a variety of ignition procedures, categorized as a short-lived climate forcer that is put up to atmospheric warming [36], and also allied with human mortality and morbidity [37]. Organic carbon (OC) comprises both direct releases primary organic carbon (POC) and secondary organic carbon (SOC) molded in the atmosphere through oxidation [38]. Common sources of atmospheric primary and secondary organic carbon antecedents are biomass burning, vehicular exhaust, biogenic emission, and industrial emissions [39–42]. SOC often accounts for 72.21% of the total mass of organic aerosols except near strong emission sources [20]. We conducted a current study to analyze the concentration level in the ambient air in Faisalabad city and the findings of analysis for the concentration level of carbonaceous aerosols in air pollutants during the summer and winter seasons are presented in Tables 7 and 8, respectively. The results are not satisfactory such as with fine and coarse particulate contamination. It was clear that the concentration of EC (elemental carbon) and OC (organic carbon) was higher in winter as compared to the summer season. According to the results, EC was found in low concentration on average in the samples of O_2 particles collected from Liaqatabad (18.79 ± 1.70 μg/m^3) in the summer season. The highest OC values were recorded in the ambient air in Liaqatbad (178.4 ± 3.51 μg/m^3), nominated as the busiest commercial zone in Faisalabad with a variety of businesses [32,43].

Table 7. Carbonaceous species in air pollutant samples during the summer season.

Location	Aerosol species	EC (μg/m^3)	OC (μg/m^3)	TC (μg/m^3)
Liaqatabad	(a) SO_2	33.73 ± 6.92	101.89 ± 1.18	135.62 ± 8.1
Khurrianwala		65.34 ± 1.60	119.5 ± 2.67	184.84 ± 4.27
Liaqatabad	(b) NO_2	89.67 ± 1.52	178.4 ± 3.51	268.08 ± 5.03
Khurrianwala		69.37 ± 3.56	133.4 ± 4.86	202.77 ± 8.42
Liaqatabad	(c) CO	79.46 ± 0.65	144.87 ± 2.97	224.34 ± 3.62
Khurrianwala		41.58 ± 1.23	73.12 ± 1.53	114.71 ± 2.76
Liaqatabad	(e) SPM	83.41 ± 2.30	164.82 ± 3.49	248.23 ± 5.79
Khurrianwala		72.79 ± 1.94	150.42 ± 1.87	223.21 ± 3.82
Liaqatabad	(f) O_2	18.79 ± 1.70	32.37 ± 1.44	51.16 ± 3.14
Khurrianwala		67.94 ± 2.92	167.74 ± 2.10	235.68 ± 5.02

EC = elemental carbon; OC = organic carbon; TC = total carbon.

Table 8. Carbonaceous species in air pollutant samples during the winter season.

Location	Aerosol species	EC (μg/m^3)	OC (μg/m^3)	TC (μg/m^3)
Liaqatabad	(a) SO_2	36.07 ± 6.09	106.51 ± 1.60	142.58 ± 7.69
Khurrianwala		69.78 ± 1.12	124.48 ± 3.18	194.27 ± 4.30
Liaqatabad	(b) NO_2	94.1 ± 1.41	183.4 ± 3.49	277.5 ± 4.9
Khurrianwala		85.16 ± 1.03	151.97 ± 1.86	237.13 ± 2.89
Liaqatabad	(c) CO	49.71 ± 1.24	80.34 ± 1.36	130.04 ± 2.6
Khurrianwala		75.92 ± 4.22	140.06 ± 4.61	215.97 ± 8.82
Liaqatabad	(e) SPM	41.39 ± 1.01	39.08 ± 2.40	80.47 ± 3.41
Khurrianwala		90.49 ± 1.41	171.52 ± 2.27	262.01 ± 3.68
Liaqatabad	(f) O_2	78.46 ± 1.59	155.94 ± 2.50	234.4 ± 4.08
Khurrianwala		25.47 ± 1.44	37.87 ± 1.34	63.34 ± 2.77

EC = elemental carbon; OC = organic carbon; TC = total carbon.

3.8. Correlation Matrix between Different Parameters of Air

The correlation matrix of different air quality parameters with each other is defined in Figure 2, according to which a strong positive correlation was indicated between $PM_{2.5}$ and PM_{10} and with TSP, NO_2, and noise level. Whereas a strong positive correlation was developed between PM_{10} and SO_2, on the other hand, a mildly positive correlation was identified between $PM_{2.5}$ and SO_2, and CO. The recognized pollutants belong to optical glasses wares, proper paints, refrigerators and air conditioners with full burning batteries, pottery, lubricants, tire and bearings, plastic, and ceramics, all showing the contribution of industry and transport to the air quality in Faisalabad. The current study shall provide a baseline information in the understanding of the interaction between different parameters of air quality e.g., fine and suspended particulate matter and the meteorological conditions in some regions of Faisalabad. The dust transported from adjacent regions reaching the study area by wind and atmospheric circulation contributes significantly to suspended

PM. Generally, each season has its own unique meteorological conditions that affect the concentration of the particulate matter [20,41].

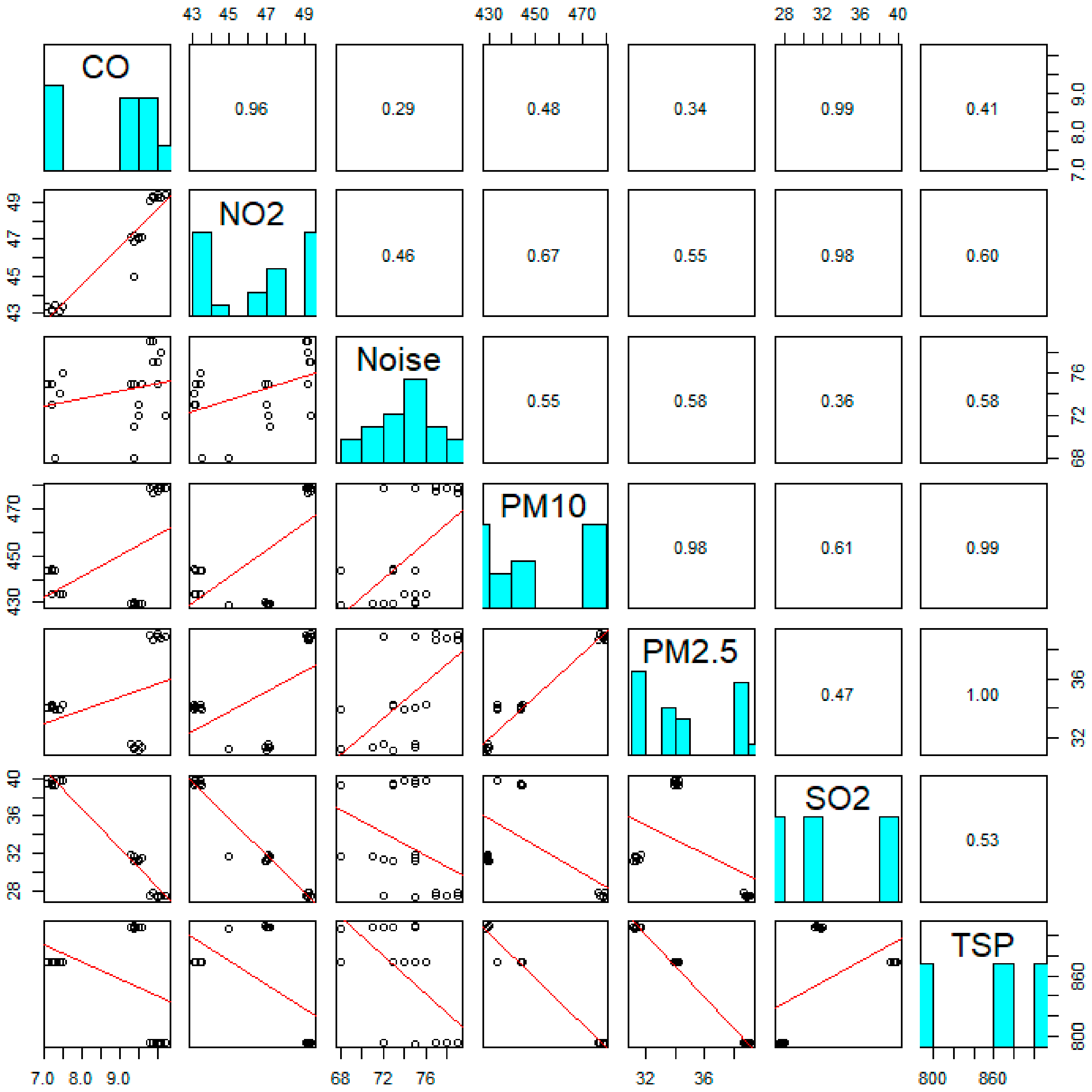

Figure 2. Correlation between different parameters with particulate matter in Faisalabad.

4. Conclusions

The concentration level of SO_2, CO_2, SPM, noise level, and O_2 were beyond the permissible limits in the study sites. However, the NO_2 value was found to be normal. The contents of SO_2, CO_2, SPM, and noise levels were found quite high as compared to NEQS and USEPA and this situation may be more alarming in the coming days due to dry weather conditions, increasing industrialization, and urbanization. The results recommended that in industries, there must be less use of sulfur and strategies should be adopted to control the quantity of SO_2. One of such strategies is the attachment of a filter to entrap poisonous gas such as SO_2. The quantity of CO can be controlled by reducing anthropogenic activities such as forest fire and combustion. More SPM is produced from the construction activities that may be made more environmentally friendly to reduce SPM. The environmental agencies should start environmentally friendly programs to control, protect, and clean the ambient air quality. Urgent attention is required to control the current situation of air quality worsening by adopting air quality standards. Basic control strategies are required to establish and strengthen the air quality monitoring and implementation system. To decrease air pollution, an integrated effort is needed by all stakeholders. Additionally, scientific studies on the existing level of air pollution and associated health effects in numerous zones of the country should be conducted.

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