Spatial Variation in Urban Air Pollution: A GIS Based Approach in Faisalabad, Pakistan

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ABSTRACT

Air pollution is becoming more acute problem across the world as well in the major cities of Pakistan. Faisalabad is the main industrial hub and the 3rd largest city of Pakistan. Where situation is aggravating day by day, by rapid urbanization, industrial expansion, population growth and increasing volume of traffic are major factor responsible for environmental pollution is generally an air particle. The study was conducted to assess the present situation with respect to total suspended particulate concentration and lead concentration in ambient air of Faisalabad, and to suggest remedial measures 30 sites were selected from different areas of Faisalabad city. Samples were collected and analyse for the month of October and November 2012. The field work comprises of sample collection, whereas TSP and lead concentration, level of NOx, COx and SO_x were determined respectively in the laboratory of Environmental protection department of Faisalabad. The mean TSP level in the ambient air was 381.63. The concentration of TSP was found ranging from 203-515 $\mu g/m^3$ with average worth 381 $\mu g/m^3$ throughout the whole study duration. The TSP concentration in the study area was 40 percent within the limit of NEQS. Lead contents were recorded 0.07 to $18\mu g/m^3$ (4.97 $\mu g/m^3$ average) throughout whole study duration. The mean lead level in the ambient air was 4.97 micrograms per cubic meter. The lead concentration in the selected areas was 70 percent exceed the NEQS. Level of NOx in the range of 26 μ g/m³to 64 μ g/m³. Athematic mean of level of NOx was 41.4 $\mu g/m^3$. Level of SOx is in the range of 110 $\mu g/m^3$ to 150 $\mu g/m^3$. Arithmetic mean of level of SOx was 126.2 $\mu g/m^3$. Level of COx in the range of 6.5 μ g/m³ to 20 μ g/m³. Arithmetic mean of level of COx was 13.34 mg/m^3 . The obvious reason noted for high concentration of TSP, Lead Concentration, Level of NO_x , CO_y and SO_y were rapid urbanization, industrial expansion, population growth and increasing volume of traffic.

Keywords: Air pollution, Heavy metals, TSP, Lead, NOx, SOx, Cox, GIS, mapping

INTRODUCTION

Environmental pollution is a worldwide problem. Although industrialization is very important for the development of a country but this is a bitter fact that it speeds up the process of environmental degradation. A significant increase in the harmful gases and chemicals was observed after industrial revolution. Increased traffic emission, industrial waste and urbanization have added many harmful gases and chemicals in air that contaminated the urban environment in the form of atmospheric pollution (Stevens et al., 2004). The increase of pollution in the Third World countries is much more as compared to

its rate of increase in the developed countries. Pakistan is no exception and the big cities are all under attack.Almost, all the major cities of Pakistan are facing the issue of air pollution. With the development of urban land and increasing of traffic, concentration of pollution has increased. Lahore, Karachi, Faisalabad, Kolkata, Mumbai, Chinghai, Beijing and many other cities are under great threat of pollution (Chakraborty et al., 2010).

In the previous decade, a considerable amount of pollutants has increased in Faisalabad urban area because of unplanned urbanization and transportation. Automobiles, industries and incineration sites are major contributors of toxic gases and particulate matter in the air of Faisalabad that contaminate urban atmosphere (Ali and Athar, 2010). According to various surveys of Punjab EPA, pollution levels in Faisalabad have either crossed safe limits or have reached the threshold values (Punjab EPA, 2009). Potential health and non-health issues are related with pollution and asthma, cancer and irritation are observed in Faisalabad (MoE, 2009). Pollution source identification, monitoring, its spatial analysis and visualization of pollutants in Faisalabad, are still under developing stage. People living closer to major roads, industrial units and in dense settlements are more vulnerable to health issues (Anwar et al., 2013).

Faisalabad is one of the badly polluted cities of Pakistan. Monitoring is done on government, private and research based but spatial based analysis and relation of pollutants with geographical location of source are ignored. Spatial based study is not only helpful in visualization but also in source identification, land cover relation with pollution and to build a relation of concentration with population density (Ali & Athar, 2010). Air contamination in the urban areas has turned into a significant issue as there are no controls on outflows. The National Conservation Strategy (NCS) Report assesses that the normal Pakistani vehicle emanates twenty-five times as much carbon monoxide, twenty times as numerous hydrocarbons and more than three and one-half times to the extent that oxide in grams for every kilometer as the normal vehicle in the US (Madrigano et al., 2015). The bikes and rickshaws because of their two-stroke motors are the most wasteful in blazing fuel and help most to discharges. The vehicle-based natural contamination has as of recently arrived at disturbing levels and further postpone inbringing it under control could have shocking impacts. (Pm)is a mixture of fine solids and pressurized canned products that are suspended buzzing around. Particles originate from diverse sources. PM might be solids, such as dust, fiery remains, or sediment. PM can additionally be fluid mist concentrates, or solids suspended in fluid mixtures. Ignition sources going from diesel trucks and transports to coalterminated force plants are the significant source of Pm2.5 contamination (Calderon-Garciduenas et al., 2014).

Pollution is released from different sources but it varies with geographical location and time. There are some natural sources of pollution as volcanoes and wind dust but Weng and Yang, (2006) believe that rapid urbanization, burning of fossil fuel, indoor and outdoor incineration and automobile exhaust are the major contributors of pollution in metropolitans. Urban houses produce solid waste that requires proper recycling and management. Developing countries are still on the way to manage solid waste where it is burned in open air. Burning of solid waste produces a heavy amount of SO2, NOx, Soot, Smoke, CO, PM and many other harmful pollutants (Vu et al., 2013).

In the present times, Geographical Information Systems (GIS) with remote sensing data and ground surveys is used for monitoring, mapping and spatial analysis of air pollution (Cyrys et al., 2005). Remote sensing and ground surveys provide accurate, timely and spatial information for the processing and analysis of data in GIS environment. In the situation of

poor monitoring and management of air pollution, improvements through latest technologies such as, GIS and remote sensing are required. Capabilities of these fast growing technologies should be tested in environmental and urban management studies (Kheirbek et al., 2014).

Study Area

Faisalabad city was established as a mandi (market) Town throughout 1885 – 1905. The city was arranged as a field design and was once known as Lyallpur. The city-area of Faisalabad is bound on the north by the areas of Gujranwala and Sheikhupura; on the east by Sahiwal region, on the south by Toba Tek Singh locale and on the west by Jhang district. The city has a worldwide runway, track station and a dry-port. The high rate of populace development has brought about packed, disintegrated environment with poor level of administration gave by different modes of transportation, including the mechanical and the creature driven vehicles. The present information demonstrates that there were 307,471 engine vehicles in 2005 as contrasted with 141,634 vehicles in 1998. The vehicles have expanded altogether.

Small and heavy industries are located within and around the city while. There is a huge transport network with heavy and light traffic in the city of about 07 million people. Moreover, the urban area produces a huge amount of solid waste that is allowed for incineration. In the presence of all these pollution sources, environmental management and anti-pollution laws are not applied for citizens and stockholders. Therefore, Faisalabad is considered as the third polluted city of Pakistan after Karachi and Lahore (City District Govt Faisalabad, 2015).



Figure 1. Study Area Map

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METHODOLOGY

The ambient air samples were collected from the Faisalabad city area in the month of October and November 2013. The parameters to check the concentration of pollutants were Total Suspended Particle, Lead, Nitrogen Oxides, Carbon Monoxides and Sulfur Oxides. Random sampling technique was used to collect ambient air data samples. The ambient air samples were collected from 30 different geographical locations of the city Faisalabad. The ambient air samples were tested in the analytical laboratory of Environmental Protection Department of Faisalabad. The parameters of ambient air quality were analyzed in different instruments and in different methods. The parameters of ambient air were TSP, Lead, Cox, Sox and Nox. The results and the point sampling locations were arranged in MS Excel and then this file was used in Arc Map 10 software to apply different kind of analysis. Interpolation and Geostatistical analysis were performed to show the spatial variation of different air pollutants.

RESULTS AND DISCUSSION

The concentration of Total suspended particles, Lead, Nitrogen Oxides, Sulpher Oxides and Carbon Oxides in urban air of Faisalabad city.

ID	Sites	TSP	Lead	NOX	SOX	COX	X- Coordinates	Y- Coordinates
1	Abdullah Pur Chowk	378	1.07	49	118	9	73.105345	31.41916
2	Canal Lodge Chowk	250	0.3	25	122	7	73.082149	31.43119
3	Chenab Club	340	10.18	42	128	17	73.089037	31.423243
4	Clock Tower Chowk	365	4.6	32	130	14.5	73.079081	31.418739
5	D Ground	394	0.07	41	116	14	73.109722	31.409051
6	General Bus Stand	515	15	50	150	19	73.093586	31.428315
7	GTS	411	2.42	38	144	15.2	73.091183	31.416761
8	Gulfishan Colony	342	1.54	39	128	16	73.043064	31.4044
9	Hilal e Eahmar Chowk	412	1.05	35	130	11	73.086119	31.420625
10	Imam Bargah	360	2	38	130	16	73.071549	31.416431
11	Jamia Chishtia Chowk	300	1.25	28	115	15	73.092191	31.435053
12	Jhaal Satyana Road	332	9.88	36	119	20	73.094101	31.410205
13	Jhang Bazar	425	15	50	135	13	73.080325	31.41493
14	Jinnah Colony Gate	472	2.7	59	122	10	73.068912	31.42255
ID	Sites	TSP	Lead	NOX	SOX	COX	X- Coordinates	Y- Coordinates

Table 1. Concentration of different air pollutants in different areas of Faisalabad city

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15	Kachehri Bazar	506	2.62	40	124	17	73.081634	31.421174
16	Koh e Noor	350	0.5	35	115	10	73.116481	31.410645
17	Maddan Pura Bus Stop	421	5.36	56	126	17.5	73.050199	31.430933
18	Millat Chowk	378	1.36	30	122	13	73.096805	31.447355
19	Narwala Bus Stop	350	2.55	36	136	12.8	73.074017	31.41872
20	National Hospital	484	18	64	140	18.2	73.061727	31.41997
21	Old Bakarmandi Chowk	400	4	45	125	12	73.049555	31.417384
22	Panj Pullian	411	0.39	32	116	6.5	73.075604	31.455629
23	PMC	203	1.52	34	118	10	73.085325	31.451804
24	P.S Gulberg Chowk	450	7.5	50	120	15	73.066238	31.424241
25	Pull Nishatabad	273	0.41	36	128	8.5	73.123069	31.454787
26	Railway Station	419	14.29	30	134	9	73.095517	31.418427
27	Sabina Cinema Chowk	432	17.5	54	139	18	73.068008	31.413556
28	Saleemi Chowk	428	0.39	45	110	9	73.09953	31.407
29	Tatha Pull	323	5.23	50	120	11	73.116503	31.427235
30	UAF	325	0.49	43	126	16	73.075562	31.428736



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Concentration of Lead

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Sampling Sites in the Study Area

Figure 2. Concentration of different kind of pollutions in different areas in Faisalabad city

The highest concentration of Total suspended particles records in General Bus stand, Ketcheri Bazar, National Hospital, Jinnah Colony gate, Sabina cinema Chowk, Saleemi Chowk, Jhang Bazar, Maddan Pura Bus stop, Railway station, Hilal e Ehmar, GTS, Panj Pullian and Old Bakar Mandi Chowk. Vehicles are one of the major sources of TSP in ambient air of Faisalabad, which are emitting particulate in the atmosphere. And industries neither observing any type emission standard to check up the TSP concentration nor any sort of control measures are adopted. These uncontrolled and untreated emissions are responsible to increase the TSP concentration in the ambient air of Faisalabad.

Particles less than 10 micrometers in diameter (PM_{10}) pose a health concern because they can be inhaled into and accumulate in the respirator system. Particles less than 2.5 micrometers in diameter ($PM_{2.5}$) are referred to as fine particles and are believed to pose the largest health risks because of their small size (Less than one seventh the average width of a human hair), fine particles can lodge deeply into the lungs.





The maximum value of lead concentration is found at National Hospital is $18 \ \mu g/m^3$ and the minimum value lead concentration is found at D-ground. High concentration of lead in ambient air of Faisalabad is mainly due to leaded patrol, battery manufacturing and different leaded parts used in electrical equipment manufacturing. The leaded patrol is the major source of the lead particulates in ambient air. How leaded gasoline has already been introduced by the govt. of Pakistan, but further lowering of lead contents is still required.

The maximum value of NOx found at National Hospital was 64 μ g/m³ and the minimum value of NOx found at Canal lodge chowk was 25 μ g/m³.Level of SOx is in the range of 110 μ g/m³ to 150 μ g/m³. Arithmetic mean of level of SOx was 126.2 μ g/m³. The maximum level of SOx found at General Bus stand was 150 μ g/m³ and the minimum value level of SOx at Saleemi Chowk was 110 μ g/m³.Level of COx in the range of 6.5 mg/m³ to 20 mg/m³. Arithmetic mean of level of COx was 13.34 mg/m³.

CONCLUSION

Total suspended particles were recorded within the range 203 to $515\mu g/m^3$. Almost 18 percent of the values were within the permissible limits according to NEQ Standards and only 20 percent of the concentration of the TSP was within the limits set by NEQs. Arithmetic mean values of TSP come out to be $381\mu g/m^3$. TSP concentration is generally on higher side as compared with the concentration measured in different of Pakistan. High values of suspended particulates are mainly due to fugitive dust and unpaved roads. Lead concentration values were recorded within the range of 0.07 to $18\mu g/m^3$. Almost 35 percent of reading of lead concentration within NEQS and most of the lead concentration values were beyond the permissible limits according to NEQS. Arithmetic mean values of lead concentration are $4.97\mu g/m^3$. Level of NOx was recorded within the range of 25 to $64\mu g/m^3$. Almost 50 percent of level of NOx within the permissible limits according to NEQS. Arithmetic mean value of level of NOx comes out to be $41.4\mu g/m^3$. Level foSOx within the range of 110 to $150\mu g/m^3$. Almost 60 percent of reading level of SOx within the permissible limits according to NEQS arithemitc mean value of SOx comes out to be 126.2µg/m³. Level of COx was recorded within the range of 6.5 to 20mg/m³. Almost 30 percent reading of level of COx within the permissible limit according to NEQS. Arithmetic mean value of level of COx comes out to be 13.4mg/m^3 .

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