Influence of automotive emission on air pollution using GIS in Faisalabad, Pakistan

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Abstract: This study was conducted to explore the major sources of pollutants including total suspended particles and levels of NOx, COx, and SOx in Faisalabad Pakistan, which make key contributions to the smog in Faisalabad. Faisalabad is the third largest city of Pakistan where the situation is aggravating due to industrial expansion, population growth and an increasing volume of traffic. Study was conducted for the period of three months at different stations in Faisalabad. The concentrations of total suspended particles, levels of NOx, SOx and COx are 160 μg/m^3 to 506 μg/m^3, 26 μg/m^3 to 64 μg/m^3, 110 μg/m^3 to 139 μg/m^3 and 5.5 mg/m^3 to 18.2 mg/m^3, respectively. As a result, air pollution control should not simply focus on controlling particulate emission, but also involve adopting an integrated multi-pollutant control strategy. Measured concentrations were at an intermediate level with respect to parameters by using Geographical Information System (GIS) and GPS. The results were compared with the permissible limits of United States Environmental Protection Agency (USEPA) and National Environmental Quality Standards (NEQS).

Keywords: automotive emissions, air pollution, total suspended particulates (TSP), geographical information system, GPS, USEPA, NEQS

DOI: 10.3965/j.ijabe.20150801.015

Citation: Niaz Y, Zhou J T, Yu Z. Influence of automotive emission on air pollution using GIS in Faisalabad, Pakistan. Int J Agric & Biol Eng, 2015; 8(1): 111－116.

1 Introduction

The air is never found clean in nature, due to natural and man made pollution. Gases such as CO, SO_2 and H_2S are continually released into the atmosphere through natural activities, e.g. volcanic activity, vegetation decay and forest fires. Besides, tiny particles of solid and liquid are distributed throughout the air by winds, volcanic explosion and other similar natural disturbances. In addition to these natural pollutants, there is man made pollutant gases, mists and particulates and aerosols. Air pollutants are present in atmosphere in concentration that disturbs the dynamic equilibrium in the atmosphere and thereby affect man and his environment[1].

Environmental pollution is a serious problem in many developing countries, especially for those in the process of rapid industrialization and urbanization with increasing populations. Faisalabad, the third largest city of Pakistan with (31°24'N, 73°05'E) is plagued of atmospheric pollutants, including lead, calcium, zinc, carbon monoxide and ozone as well as many other hazardous pollutants that impact on human health[2,7,8,11,12].

The problem of air pollution is becoming more acute not only in the developed countries of the world but also in developing countries like Pakistan, India and China. The centers are especially in the grip of hazards of air pollution. The developed countries have already suffered the considerable loss of property and life. As a result of this hazard many people regard air pollution as a problem that will not go away, but one that could get worse in the future. It is increasingly being appreciated that the general effects of air pollution produce deterioration in air quality of the environment. The nature and severity of air pollution are

Received date: 2014-01-19 **Accepted date:** 2014-11-29

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influenced by climate, weather, industry, traffic density, heating practice and topography [4,5].

The population of Faisalabad was 2,152,401 in 1951, which had jumped to 5,429,547 during 2000, an increase of 150% in 49 years showing in an average increase of 3.2% per annum. The total increase in 49 years is 1000%, which is 21.3 % per annum. The current population has been growing steadily and is projected to exceed 5.5 million by the year 2010 according to the city district government of Faisalabad. The vehicle on the city roads has increased many folds. Presently, 35,540 vehicles are traveling on the roads of Faisalabad. There are almost six thousands Industries in and around Faisalabad, which are contributing heavily to the environmental pollution[3].

As part of the 5-year plan, the Pakistani Government introduced the Pakistan Clean Air Program (PCAP) for improving ambient air quality. The PCAP highlighted vehicular emissions, industrial emissions, burning of solid waste and natural dust as major sources of urban air pollutants in Pakistan. That proposed a number of short and long term measures, which require action at all levels of government. The current air quality monitoring framework and facilities are completely inadequate in scale, technical capacity and operational methods. It was not until March 2007 that the Pakistan Environment Protection Agency commenced the operation of the first main declaration monitoring site in Bhawalnagar, Punjab for measuring PM_{10}, TSP (total suspended particulates), SO_2 and NO_2. In March 2007, under the aid granted from the Government of Japan, continuous air quality monitoring was investigated in Karachi, Lahore, Faisalabad, Quetta, Peshawar, and Islamabad [6].

The study was conducted to compare the ambient air quality with the standards of United States Environmental Protection Agency (USEPA) and National Environmental Quality Standards (NEQS). The total suspended particles and levels of NOx, SOx, COx in air were analyzed in the Environment Protection Department (EPD) laboratory Faislabad, Pakistan.

2 Materials and method

2.1 Site selection

In this study, twenty four sites were randomly selected from different areas of Faisalabad. These sites were selected keeping in view of the security of sampler, availability of power, easy accessibility, etc. However, sampling was sometimes interrupted due to power failure, load shedding or motor breakdown. Figure 1 shows the selected site GIS map generated by using the Geographical Positioning System (GPS) meter.

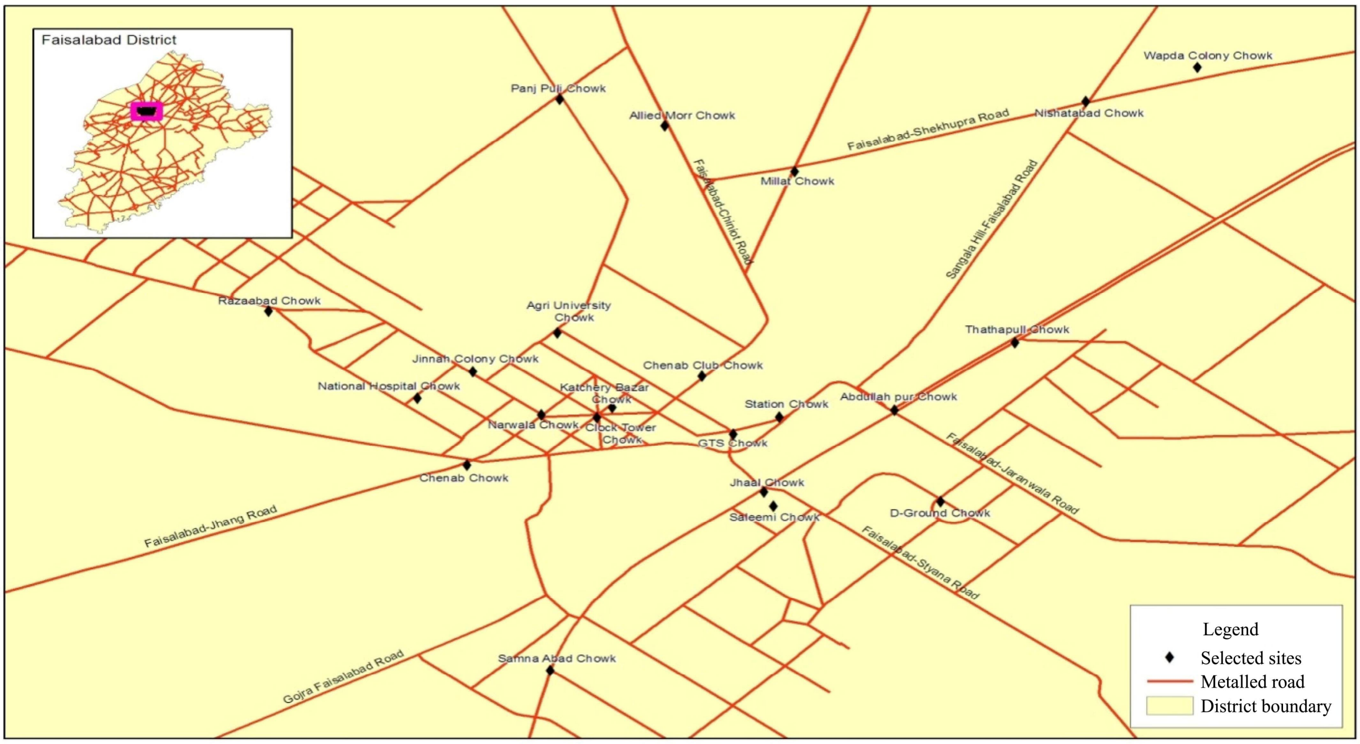

Figure 1 Selected sites in Faisalabad city by using the GPS meter

Samples were collected and analyzed for the month of June, July and August 2010. The field work comprises of sample collection where as levels of NOx, COx and SOx were determined respectively in the Laboratory of Environment Protection Department, Faisalabad. Table 1 defines specific air pollutant with associated health effects on the monitoring site's source of emission.

Table 1 Specific air pollutants and associated health effects

Air pollutant	Potential health effects
Total Suspended Particles(TSP)	• Wheezing and exacerbation of asthma Respiratory Infection • Chronic bronchitis and chronic obstructive pulmonary disease(COPD) • Exacerbation of COPD • Excess Mortality, Including form • Cardiovascular Disease
Carbon Oxides(COx)	• Low birth weight (fetal COHb 2%-10% or higher) • Increase in perinatal deaths • Reduction in ability of the circulatory system to transport O_2
Nitrogen Oxides (NOx)	• Aggravation of Cardiovascular Disease • Increase susceptibility to respiratory pathogens
Sulfur Oxides (SOx)	• Increased prevalence of chronic respiratory disease • Increased risk of acute respiratory disease.

2.2 Procedure for sampling

High volume air sampler was used for the collection of suspended particles and lead concentration. An air sample was collected for a demotic of 24 hours at an average flow rate of 40 cfm (1.13 m^3/min). In other words, suspended particulate matter trapped on each filter at the 24 h composite. The samplers were operated thrice a week basis. The intake dimension and normal flow rate were believed to limit aerosol collection to particulate matter less than 100 μm in a diameter. The unit will normally be operated for 24 h duration, although other sampling periods might be used depending on the expected concentration of suspended particulates. Glass fiber filters were used because of their gradual head loss to build up characteristics and non-hygroscopic properties. The collection of oily particles or sampling during foggy condition may lead to decrease a sampling flow rate which was avoided during sampling. At the end of the sampling operation filter were folded in such a way that surfaces containing the deposit face each other. The filter was weighted to get a net deposit weight. It replaced in is closeable air tight polythene bag after being approximately labeled, and will preserve in a freezer until the time of processing. The levels of NOx, COx and SOx were analyzed by ambient air kit and gas analyzer meter. A total 24 samples were collected for each parameter and analyzed in the laboratory of Environment Protection Department (EPD) during this study. Table 2 defines the list of parameters, instruments/methods and model used in laboratory.

Table 2 List of parameters, instruments/method and model

Parameters	Instrument/Method	Model
Total Suspended Particles	High Volume Air Sampler	HV-500/Japan
Level of COx	Gas Analyzer/Non-dispersive infrared detection	Kane Automotive Auto 2-2,4-2&5-2
Level of SOx	Gas Analyzer/Ultraviolet Fluorescence Method	Kane Automotive Auto 4-1&5-1
Level of NOx	6500-Smoke meter/Gas Phase Chemiluminescence	6500-Smoke (Opacity) meter

3 Results and discussion

Results defined the concentration of total suspended particles, levels of NOx, COx and SOx according to sampling dates. A result of total suspended particles, levels of NOx, COx and SOx are also presented in a graphical diagram. All the results were compared with the permissible limits given by National Environmental Quality Standard (NEQS) and United States Environment Protection Agency (USEPA) respectively for ambient air, which are applicable in different parts of the world.

3.1 TSP concentration in different areas of Faisalabad City

Figure 2 defines total suspended particle concentrations in the air are beyond the safe limits of 260 μg/m^3 set by USEPA and 400 μg/m^3 by NEQS standards respectively. The study shows that only 12.5% values are within the USEPA standards, and Eighty percent values are within the NEQS standards of ambient air quality. TSP concentrations range normally from 160 to 506 μg/m^3.

3.2 Levels of NOx in different areas of Faisalabad City

Figure 3 shows the level of NOx in the range of 26 μg/m^3 to 64 μg/m^3. It was finally compared with the allowable limits according to NEQS and USEPA standards of 40 μg/m^3 and 32 μg/m^3, respectively. The maximum and minimum levels of NOx are 64 μg/m^3 and 26 μg/m^3. The fifty percent values of level of NOx are within admissible limits according to NEQS standards and eighty five percent values are beyond the permissible limit of USEPA standards.

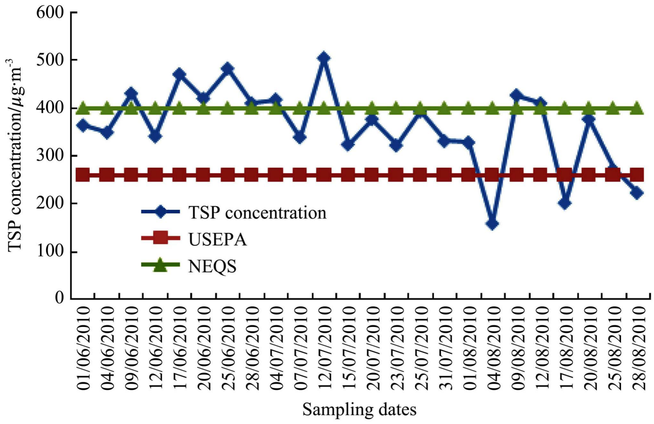

Figure 2 TSP concentrations in different areas of Faisalabad

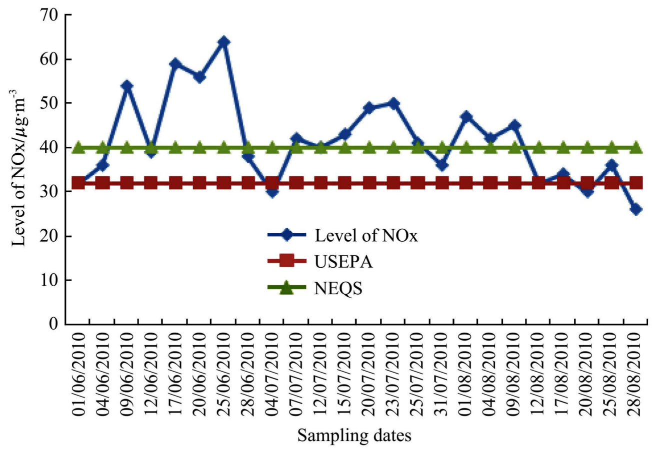

Figure 3 Level of NOx in different areas of Faisalabad

3.3 Levels of SOx in different areas of Faisalabad City

Figure 4 shows the level of SOx in the range of 110 μg/m^3 to 139 μg/m^3. It was finally compared with the allowable limits according to NEQS and USEPA standards of 120 μg/m^3 and 80 μg/m^3, respectively. The maximum and minimum levels of SOx are 139 μg/m^3 and 110 μg/m^3. The thirty percent values are within the permissible limits of NEQS standards and hundred percent values are beyond the permissible limits of USEPA standards.

3.4 Levels of COx in different areas of Faisalabad City

Figure 5 depicts the level of COx in the range of 5.5 mg/m^3 to 18.2 mg/m^3. It was finally compared with the allowable limits according to NEQS and USEPA standard of 10 mg/m^3 and 10 mg/m^3 respectively. The maximum and minimum levels of COx are 18.2 mg/m^3 and 5.5 mg/m^3. Eighty percent of the values are beyond the permissible limits of NEQS and USEPA standards.

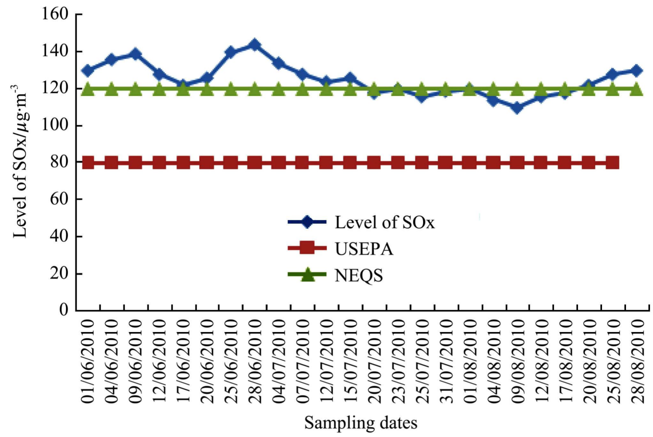

Figure 4 Level of SOx in different areas of Faisalabad

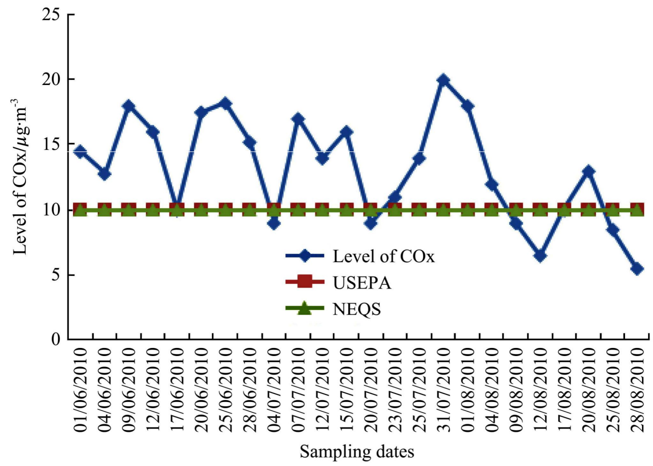

Figure 5 Level of COx in different areas of Faisalabad

In comparative study public concern has led to calls for the Chinese government to establish a more stringent air quality policy that includes particulate matter control. Additionally, strong support exists for each provincial capital and municipality to begin monitoring particulate matter levels. As from latest study, 74 Chinese cities have announced plans to publish particulate matter levels in real time[13]. A long-term plan was announced by the Beijing municipal government to reduce annual average particulate matter concentrations to 35 μg/m^3. The plan calls for reducing particulate matter concentration to 60 μg/m^3 by 2015 and 50 μg/m^3 by 2020. In the future, China will increasingly face air pollution issues due to the rising consumption of fossil fuels. As a result, strengthening air pollution control policies have become increasingly necessary not only for coal based power plants, but also for other sectors. Based on California's experience, air pollution control requires collaboration between the governments of affected regions[14]. Regulating particulate matter pollutants in Beijing alone will not solve the smog issue. Instead, establishing regional air quality management coordination systems in developed cities such as Beijing and its surrounding suburbs will be necessary[15]. With the rapid urbanization and economic development in China and the resulting rise in air pollutant emissions, there is a need to establish regulations to limit air pollutant emissions. The similar steps should also be taken by the Pakistan Environment Protection Agency to reduce the sources of TSP, NOx, SOx and COx concentrations in the Faisalabad. The main sources of air pollution are the lack of management to handle the solid waste, which is carried without following any engineering principles. The waste is usually dumped along road sides and in the open plots without providing any earth cover. The waste is picked up by the blowing winds to increase the TSP concentration in the atmosphere. To keep the TSP concentration within the standards, special attention must be given to upgrade existing solid waste management system on purely engineering basis. The serious illness in infants is due to the conversion of nitrate to nitrite by the body, which can interfere with the oxygen-carrying capacity of the blood, known as methemoglobinemia. Especially in kids, when nitrates compete successfully against molecular oxygen, the blood carries met hemoglobin (as opposed to healthy hemoglobin), giving rise to clinical symptoms. Long term elevated exposures to nitrates, and nitrites can cause an increase in the kidneys' production of urine (diuresis)[7]. The largest sources of SO_2 emissions are from fossil fuel combustion at power plants. Smaller sources of SO_2 emissions include industrial processes such as extracting metal from the burning of high sulfur containing fuels by locomotives, large ships, and non road equipment. SO_2 is linked with a number of adverse effects on the respiratory system[8]. Carbon monoxide is poisonous gas formed when carbon in fuels is not burned completely. It is a product of motor vehicle exhaust, which contributes about 60 percent of all CO emissions nationwide. High concentrations of CO generally occur in areas with heavy traffic congestion[9].

4 Conclusions

In conclusion, it is a challenge to attribute secondary particle formation to specific emission sources. The TSP and NOx, COx, SOx are dangerous pollutants, harmful to human health and have the potential to destroy the environment. Mostly TSP, especially those containing sulfates, nitrates, and many organic compounds, are created through secondary industrial and manufacturing processes. Characterizing the chemical reactions that take place in the atmosphere to determine the source of fine particles is complicated. The study suggest that in Faisalabad, Pakistan, the high frequency of smoggy days (June to August) are strongly associated with high levels of total suspended particles and levels of NOx, COx, SOx. The concentrations of total suspended particles, levels of NOx, SOx and COx are 160 $\mu g/m^3$ to 506 $\mu g/m^3$, 26 $\mu g/m^3$ to 64 $\mu g/m^3$, 110 $\mu g/m^3$ to 139 $\mu g/m^3$ and 5.5 mg/m^3 to 18.2 mg/m^3 , respectively. Major sources of TSP and NOx, SOx, COx concentrations include vehicle exhaust, coal combustion from the utility industry and industrial processes and the cement manufacturing process. Furthermore, that all mobile vehicles must be phased out to check the TSP, levels of NOx, SOx, COx concentrations and bacterial pollution. The monitoring of ambient air of city should be taken up by provincial EPA (Environment Protection Agency). To reduce the traffic volume government of Pakistan should provide clean, efficient, cheap and reliable public transport so that people prefer to use public transport.

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