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RESEARCH PAPER

Brick Kilns Air Pollution and its Impact on the Peshawar City

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Abstract
In recent times, the brick kiln contributes to air pollution is one of the most emerging issues worldwide. In this research work, the Peshawar city, ambient air quality was measured, using a fixed air monitoring station to evaluate the impact of gaseous emission from brick kilns on ground level. In this study, the portable gas analyzer (PG-250) was used to quantify brick-based emitting carbon monoxide (CO), sulfur dioxide (SO_2) and nitrogen oxide (NOx) from 3 brick kilns in the city of Peshawar. It was noticed that the average concentration of SO_2 and NOx exceeds the National Environmental Quality Standards (NEQS) of Pakistan specifically, in terms of air quality. The brick kilns in District Peshawar have shown negative effects on the environment. It is necessary to take various measures to monitor the brick kiln embosom regularly before it becomes a significant risk for individuals. In conclusion, the impact of air pollution on physical activity and sedentary behavior at a specific time may be different.

Keywords: Air pollution; Brick kilns; Sulfur Dioxide; Nitrogen Oxide; Carbon Monoxide

INTRODUCTION

In different parts of the world, air pollution has become a major health risk. The air pollution is due to the interaction between, gases (NO_2), and particulate matters (PM) having diameter less than μm (PM2.5) or less than 10 μm (PM10) and, when these particulate matters and gases combine with ozone in the presence of sunlight, it produces irritating photochemical cocktail known as smog (Yu, et al., 2021). In different parts of the world, particularly, in Asia, brick kiln is a traditional industry in manufacturing bricks. India is the world's second-largest market for bricks (Maithel, 2003). Though environmental pollution is mainly caused by small-span trade, the brick kiln is a developing industry because the usage of bricks is generally expanding due to rapid urbanization and economic growth. The products used to make brick are river silt or

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soil clay containing fine particles. Around 70% of coal is used in brick kilns containing high levels of Sulfur dioxide and black carbon, 24% sawdust and the remaining 6% wood and others as fuel (Bhanarkar, et al., 2002; Pariyar, et al., 2013). In addition, carbonaceous materials such as bagasse, rice husk, wood and sawdust are also used as part or replacements for coal in some areas.

The manufacturing of bricks causes environmental degradation due to the release of large amounts of gaseous and particulate contaminants. All brick kiln operations, from the earth, digging to the unloading of fired bricks from the kiln, leave the whole workplace dusty. The emissions of the stack and, in addition, the fugitive dust produce air pollution in the brick kiln. The pollution of brick kilns mainly consists of organic matter, fine coal constituents, and gases including carbon monoxide (CO), sulfur dioxide (SO_2) and nitrogen oxide (NOx), etc. The quantity of dust evolving through non-fire places through the kiln is too large and this creates a dusty environment in brick kiln territory and this becomes large and aggravated by the high speed of wind (Bhanarkar, et al., 2002; Skinder, et al., 2014).

Air pollution through brick kilns varies during firing batch as for 1,000 bricks normal emissions were 0.64-1.4 kg for particulate matter (PM), 0.52-5.9 kg for SO_2 and 6.35-12.3 kg for CO (Le, et al., 2010). The total emissions during brick, manufacturing in the territory of Greater Dhaka is about 302,000 ton of CO, 3,300 tons of $PM_{2.5}$, 15,500 tons of SO_2 and 6,000 tons of black carbon. 3.5 billion bricks per annum give 18 million tons of CO_2 emission (Guttikunda, et al., 2013).

Peshawar is located between 34° 1' 33.3012" N and 71° 33' 36.4860" E and is surrounded by Charsada in the north, Kohat in the south, Nowshera in the east, and Mohmand and Khyber agencies to the west. The district's total area is 1,259 square Kilometers, with fertile plain and no proper forests. The average monthly fall of winter rain is 16.5 cm, while the mean fall of summer rain is 19.1 cm. The mean monthly winter sun shines 6.7 hours/ day, while 8.8 hours/ day in summer. The current study was carried out using a portable gas analyzer (PG-250) to monitor existing levels of SO_2, NOx and CO from the stacks of brick kilns. In addition, the concentration of these contaminants at ground level was predicted using the automated fixed air monitoring station (Horiba Japan) located on the rooftop of the EPA-Peshawar Building. In this study, the predicting risk area of brick kiln and emission of different gaseous are studied in detail.

MATERIAL AND METHODS

In this study, one brick kiln located at Sorezaiinqelab road and two situated at Pandu were selected for stack analysis. We chose this field as an area of interest because of the extremely high concentration of air contaminants in these regions. Stack emission studies have been conducted according to standard methods for brick kiln chimneys (Brenchley, Turley, Yarmac, 1974). The Pakistan National Air quality standards are given in Table 1.

The highly reliable and flexible gas analyzer PG-250 (Horiba, Japan) determined SO_2, NO_x and CO. It is a portable analyzer for the analysis of exhaust gases from stacks. The analyzer uses the Chemiluminescence principle to measure NO_x and NDIR for SO_2 and CO analysis. Using certified standard gases for SO2, NOx and CO, PG-250 was calibrated before sampling. The velocity of flue gas was determined with the help of Pitot tube S-type.

The ambient air quality was monitored by a fixed air monitoring station located on the rooftop of the EPA building in Peshawar city, more than 14 m from ground level. The gas analyzers were placed in an air-conditioned laboratory. Teflon lines were used as a sampling inlet to isolate ambient air and mitigate reactivity with monitoring species. The ambient air was passed through the distribution system where humidity is trapped before entering the sample through the sample bulkhead of the individual analyzers. The principles of measurement and the calibration method are common and have already been discussed in a few reports (Beig, et

Table 1. Pakistan National Air quality standards

Parameters	Ambient Air Quality standards (Pakistan, NEQS)
Carbon Dioxide (CO_2) 24 hour	5 ug/m^3
Nitrogen Dioxide (NO_2) 24 hour	80 ug/m^3
Sulfur Dioxide (SO_2) 24 hour	120 ug/m^3
Ozone (O_3) 1 hour	130 ug/m^3
Lead (Pb) Annual	1 ug/m^3
Particulate matter (PM 10) 24 hour	150 ug/m^3
Particulate matter (PM 2.5) 24 hour	35 ug/m^3

al., 2007; Lal, et al., 2000; Naja, et al., 1996). For the best execution of trace gas analyzers, daily zero settings and weekly span controls have been conducted. The trace gas data of the analog waveform is transformed into digital values through the method of data acquisition and stored in the computer. The average value was recorded for 15 minutes. The raw data files are then extracted into individual time series and separated.

RESULTS AND DISCUSSIONS

Nowadays, air pollution is a threat to human life, the environment and worldwide (Aslam, et al., 1994; Pawar, et al., 2010; Pope Iii, et al., 2002). The current study shows the distribution of carbon monoxide (CO), sulfur dioxide (SO2) and nitrogen oxide (NOx) emitted from brick kilns in the city of Peshawar city. The major roles played in such gaseous emissions is wind speed and wind direction as shown in Figure 1.

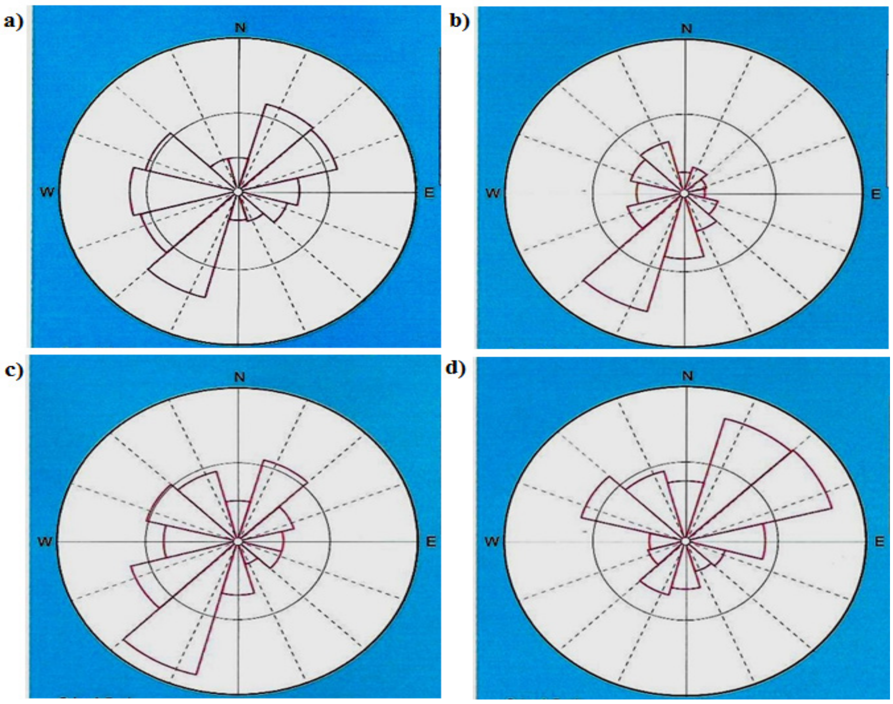

Fig. 1. The wind rose to show monsoon period wind direction b) observed wind direction in spring c) winter d) fall

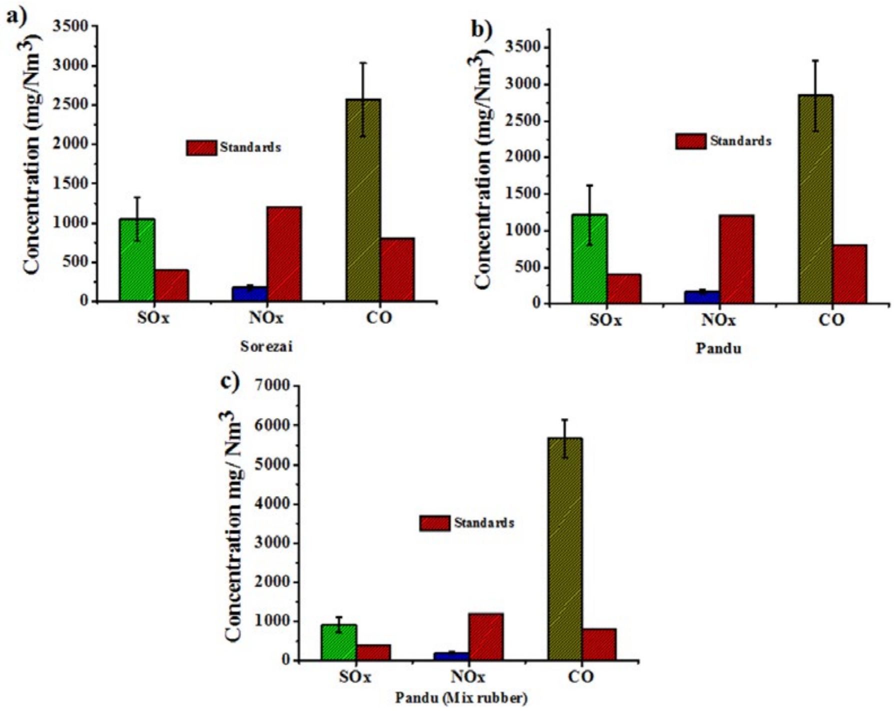

Fig. 2. (a-c) Average concentration of SO_X, NO_X and CO in the brick kiln; Sorezai (a), Pandu (b) and Pandu (mix rubber).

It was observed that during the wind cycle, air pollutants settle around the sources and are transported into neighboring areas. The mean SO_2 concentrations at the road sites for Sorezai Inqelab were 1045 mg/Nm^3. Similarly, NO_x values at the respective sites were found to be 178 mg/Nm^3 and CO values were 2565 mg/Nm^3 as shown in Figure 2 a-c.

Different stack heights were used for the three brick kilns, in the 6-8 m. The internal diameters of the stacks, ranging from 0.4 to 0.7 m, are almost similar to each other. The stacks' flue gas temperatures were in the 55-60 ^oC range; similarly, the velocities of the flue gas were in the 6-8 m/s range. The mean SO_2 concentrations at the road sites for Sorezai Inqelab were 1045 mg/Nm^3. Similarly, NO_x values at the respective sites were found to be 178 mg/Nm^3 and CO values were 2565 mg/Nm^3 as shown in Figure 2 a-c. This brick kiln used Hangue coal as fuel.

Similarly, as shown in Figure 2b, data was collected for SO_2, NO_x and CO at Pandu. They used Dera Adam Khel's coal for brick cooking. During the study, we found that the mean values of SO_2 were 1214 mg/Nm^3, NO_x 165 mg/Nm^3 and CO 2843 mg/Nm^3 respectively. In addition to coal, rubber and tyres are added to enhance firing and to obtain reddish-brown bricks. Similar trends have also been found with the combustion of coal and mixed rubber, playing an important role in increasing the concentration of CO in the stack of flue gases. In this analysis, the levels of SO_2, NO_x and CO were 917 mg/Nm^3, 195 mg/Nm^3 and 5672 mg/Nm^3, respectively (Figure 3c). Compared to existing standards, as laid down by Pakistan's National Environmental Quality Standards (NEQS), the concentrations of SO_2 and CO at both sites were beyond the acceptable limits. In addition, biomass is responsible for the release of gases such as SO_2, NO_x and CO from conventional brick industries. The levels of SO_2 depend heavily on the Sulfur content of the coal used for firing.

The formation of NO is favored at high temperatures, usually attained during intense combustion processes. It is also produced by a photolytic reaction. The levels of NO_2 are primarily dependent on chemical reactions and not on direct emissions (Mayer, 1999). In brick making, nitrogen oxide emissions are mainly caused by the oxidation of nitrogen in the atmosphere

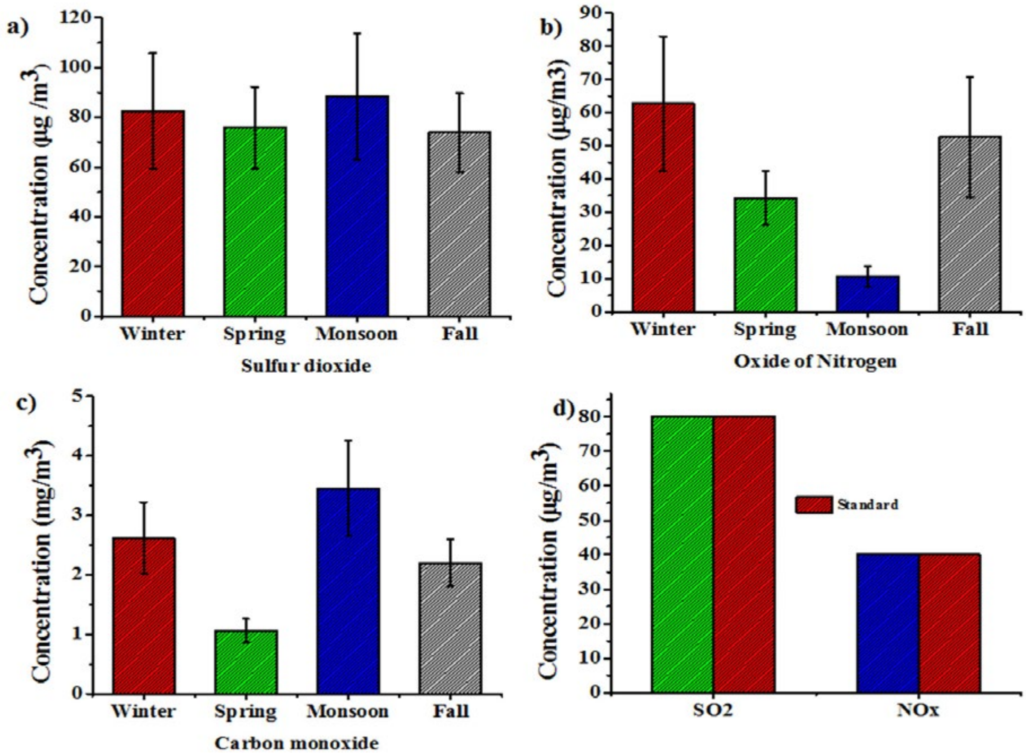

Fig. 3. Seasonally averaged concentration of trace gases, (a) SO_2, (b) NO_x, (c) CO and (d) annual average of SO_2 and NO_x

through burning, and thus NO_x emitted from the brick kilns plays a major role in the formation of ozone. In addition to the presence of NO_x, it is very critical that NO_2 is the only possible ozone source in the brick kiln areas (Amison, 1992; Pauls, 1989). To incorporate the flue gas data of brick kilns located approximately 4-8 km southeast of the monitoring station, 1-year ambient air data was obtained from this station. Wind speeds are typically much greater at or above 200 m than those found at ground level. Due to the flue gas velocity and temperature, the release of the emissions at the stack height plus some uplift determines the movement of the emissions and their vertical diffusion towards the ground. There is a wide difference in meteorological conditions in the subcontinent between the monsoonal and non-monsoonal months. The dry and wet deposition and the atmospheric concentrations of different contaminants are also influenced by this difference. Throughout the one-year study period, southeast winds dominated. The highest percentage of the time that the wind blew from the predominant direction was about 42%. Zero was the number of calm winds. The wind velocity was 4-7m/sec. We present the seasonal average concentrations in Figure. 3, i.e., December, January, February for winter, March, April, May for spring, June, July, August for summer (monsoon), and September, October and November for the fall season.

The highest expected SO_2 concentrations were 82.61 µg/m^3 and 88.42 µg/m^3 in the winter and monsoon seasons, respectively, as can be seen in these figures, while 75.85 µg/m^3 and 73.89 µg/m^3 were in spring and fall. The annual average concentration of SO_2 exceeds the Pakistan NEQS of 80 µg/m^3. The data shows that the worst pollutant concentration occurred in the monsoon, winter and spring seasons, which is higher than in the other season due to the wind blowing from the southeast side, where the brick kiln market is situated. The NO_x plots are also shown in Figure 3, where the average maximum concentrations for winter, spring, monsoon and fall were 62.69 µg/m^3, 34.23 µg/m^3, 10.54 µg/m^{3}and 52.66 µg/m^{3}respectively. NO_x also surpasses the annual average level set by Pakistan EPA. To investigate the high concentration of NOx, a stack

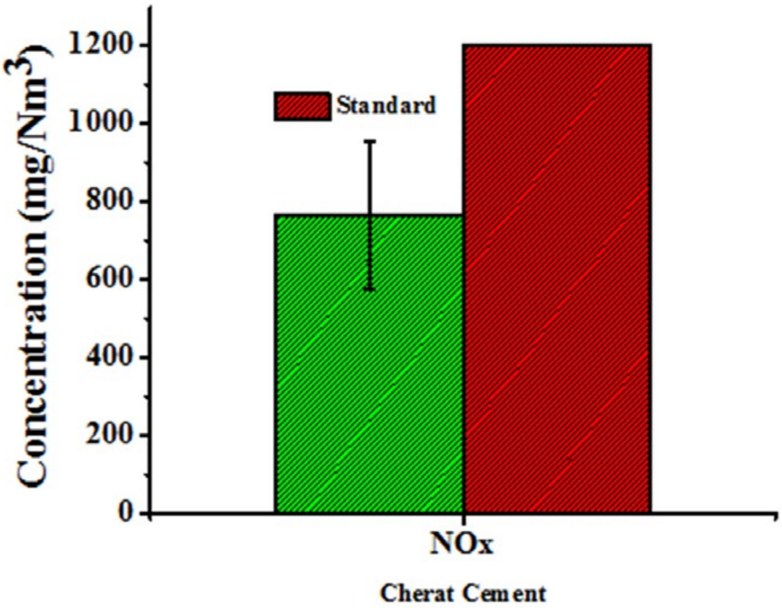

Fig. 4. The average concentration of NOx in Cherat cement factory.

Table 2. Concentration of trace gases during different seasons

Gas Name	Winter	Spring	Monsoon	Fall
Sulfur dioxide(µg/m^3)	82.61	75.85	88.42	73.89
Oxides of Nitrogen(µg/m^3)	62.69	34.23	10.54	52.66
Carbon monoxide(mg/m^3)	2.62	1.06	3.45	2.20

analysis of the Cherat cement factory was carried out (Figure. 4).

This cement factory is located about 22 km south of the city of Peshawar. The PG-250 analyzer evaluated the NOx emissions from the cement plant stacks, which were found to be 764 mg/Nm^3. However, Pakistan's NEQS allows for NOx emissions of up to 1200 mg/Nm^3 from the coal-fired source, but the annual average concentration was found maximum than the Pakistan ambient air quality standards. The prevailing direction of NO_x dispersion was from the south and east directions, where the average wind speed was 5 m/sec. So, it could be likely that the Cherat cement industry is the main source of this pollutant. Similarly, the concentration of CO was found to be 2.62 mg/m^3, 1.06 mg/m^3, 3.45 mg/m^{3}and 2.20 mg/m^{3}respectively. These pollutants do not surpass the Pakistan NEQS. The detail of gases concentration during different seasons is given **Table 2.**

From April to August, the southeast monsoons from the Arabian Sea begin to blow and scatter pollutants upwards in the northwest, resulting in a broader distribution of pollution. There is a great deal of variability in the patterns of monsoons and weather that may not only influence the patterns of pollution but there is also increasing evidence that monsoonal patterns may be affected by emissions from transport and industrial processes (Amison, 1992; Lau, et al., 2009). The main governing factors that can move air pollutants from one location to another are meteorological parameters such as humidity, wind speed, wind direction and temperature. Overall, we believe that about 60% of the overall exposure to gaseous contaminants was within 4-8 km of the brick kilns, and another 40% of the exposure occurred within 10-30 km of the brick kilns.

CONCLUSIONS

In Peshawar city, the majority of pollutants containing NO_x and SO_2 were transported by southwest wind and the highest concentrations were predicted in the monsoon and winter, respectively. The present data indicate the concentration effects of pollution on brick kilns and Cherat cement plants are relatively high. Long-term exposure to pollutants in significant populations results in critical effects on public health. In addition, a significant proportion of the concentration and health effects of brick kilns and cement industries tend to be contributed flue gaseous also linked to large current emission rates of CO, NOx, SO_2 and as well to high range transfer of secondary pollutants. In conclusion, the emission rates of CO, NOx, and SO_x will result in serious health and environmental effects on the health of the peoples of Peshawar city.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interest 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 have been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

ABBREVIATIONS

PG-250	Portable Gas Analyser-250
CO	Carbon monoxide
SO_2	Sulfur dioxide
NOx	Nitrogen oxide
NEQS	National Environmental Quality Standards
PM	Particulate matter
$PM_{2.5}$	PM diameter less than μm
PM_{10}	PM diameter less than 10μm
NO_2	Nitrogen Dioxide
WHO	World Health Organization
NDIR	Non-Dispersive InfraRed
EPA	Environmental Protection Agency

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