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Original Research

Inhabitants Close to Main Roads on Outskirts of Metropolitan Cities are Exposed More to SO_x; *Eucalyptus* Tree as Bioindicator

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Abstract

Fifty samples of *Eucalyptus* tree leaves were collected in such a way that 25 samples were collected from the vicinity of roads where traffic density is high and 25 samples were collected away from roads where traffic density is low or almost negligible. The purpose was to assess whether inhabitants away from main roads on the outskirts of metropolitan cities are exposed to the same amount of SO_x as those who live close to main roads using the *Eucalyptus* tree as a bioindicator. The mean concentration values showed alarming differences of accumulation for both types of areas, which concluded that the inhabitants close to the main roads on average are exposed to more than double (2.23 times) SO_x as those away from the roads.

Keywords: air pollution, oxides of sulfur, vehicular pollution, *Eucalyptus*, big city dilemma

Introduction

Within the last two decades, the developing countries of Asia have undergone substantial growth in urbanization, motorization, and energy use [1]. The unexpected rise in motor vehicle use is now problematic for the environments of such developing countries (Fig. 1) [2] where emission control technologies and strategies are not being adopted [1]. Among the developing countries, Pakistan's mega cities (Karachi, Lahore, Peshawar, etc.) are now facing high SO_x concentrations in addition to other pollutants. On the other hand, due to strict emission control laws and implementations, concentrations of air pollutants, specifically SO_x, are now decreasing steadily in developed (European) countries [3-4].

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In 2001 the Pakistan Environmental Protection Agency (PEPA) observed the highest SO_2 concentrations (115 μg/m^3) in Lahore as compared to other less populated cities of Pakistan, i.e. Rawalpindi (78.6 μg/m^3) and Islamabad (73.4 μg/m^3) [5]. In 2007 the Pakistan Space and Upper Atmosphere Comission (SUPARCO), after a year-long baseline air quality study (for 48 hrs mean Conc.), also reported relatively higher concentrations of SO_2 (57.6 μg/m^3) in Lahore as compared to Rawalpindi (41.9 μg/m^3) and Islamabad (52.4 μg/m^3), but equivalent to Karachi (57.6 μg/m^3) [6]. Such concentrations of SO_2 on the highways of Pakistan (for a 72 hr-long sampling) were found to be 0.04-0.26 μg/m^3, which are negligibly small as compared to the mega cities [7].

It is clear from the above reports and some specific studies on SO_2, performed in Lahore only [8-9], that the

atmosphere of Lahore is not SO_x-free and is unhealthy. So the main purpose of this study was to assess and justify that the effect of air pollutants (specifying SO_x) is not symmetrical in this effects on all residents of such mega cities and varies subjected to residence and emission source.

To assess SO_x concentrations, the *Eucalyptus* tree was selected as a bioindicator because of its common availability in the region. Furthermore, being in contact with the environment, this tree is able to record even prolonged effects and is a more reliable sampler [10].

Leaf surfaces of roadside trees are exposed to various trace metals and gaseous contaminants discharged from the vehicles. Road side plants, therefore, are major recipients of all emitted pollutants and consequently can be affected by absorbing polluting elements either directly through their leaves or through dissolved salts in the soil [11].

Fig. 1. An outskirt road of Lahore, Pakistan.

Materials and Methods

Study Area

Lahore (Lat.: 31º15′-31º45′ N and Long.: 74º01′-74º39′ E) covers a total land area of 1,014 km^2 with a population of approximately 10 million [12], and is the capital of Punjab province, Pakistan.

Collection of Samples

The sampling was done in the months of April, May, and June 2010. A total of 50 samples of leaves of *Eucalyptus* tree were collected from the selected main roads and zones of Lahore (Fig. 2).

Samples Collected Near Roads

Twenty-five samples from outskirt roads of Lahore were collected where traffic density is high. Barki road to India and G. T. Road to India were not included, as the traffic density is low and the roads end at the Indian border (see map). The other selected roads spread throughout Pakistan and are known to be the busiest. The roads are as follows:

1. Multan road to Multan / [Road-A]
2. Raiwind road to Raiwind / [Road-B]
3. Main Ferozepur road to Kasur / [Road-C]
4. G.T road to Islamabad / [Road-D]
5. Sheikhupura road to Faisalabad / [Road-E]

Samples Collected Away from Roads

Twenty-five samples were collected from selected zones away from the main roads with minimum or some-

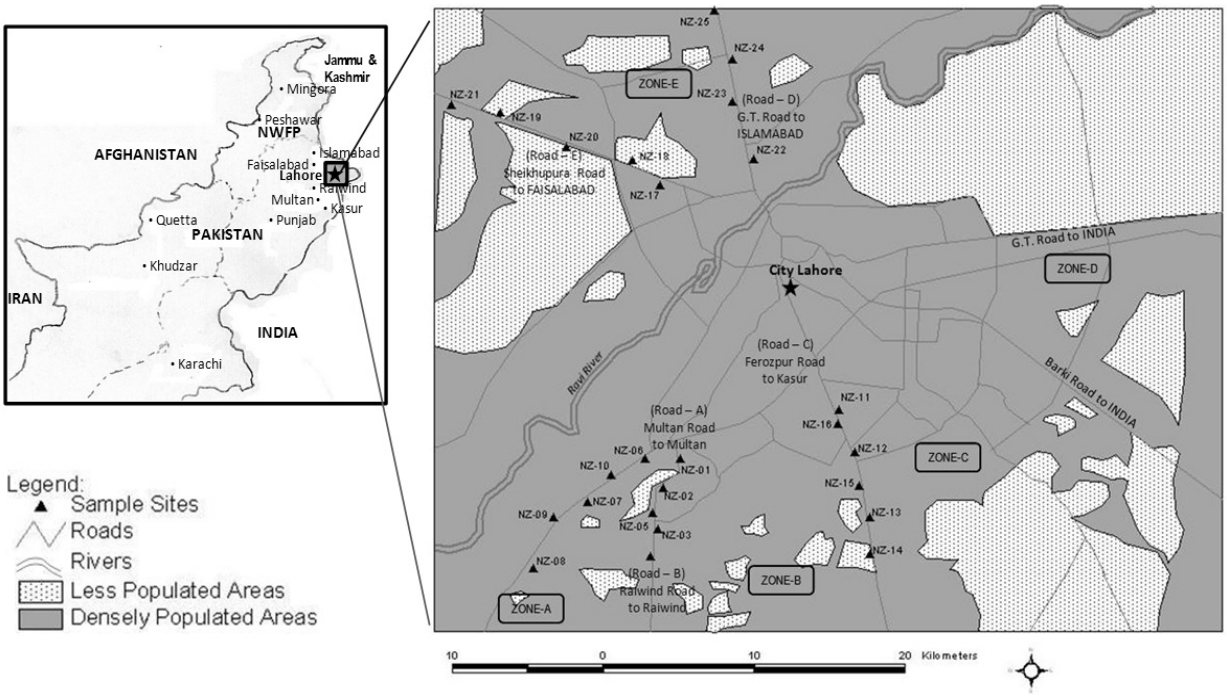

Fig. 2. Map of sampling site.

what negligible traffic density to establish a comparison. The selected areas were divided into five zones. Each zone covers a minimum area of 16 km^2, which may include various villages and towns. A minimum 5 samples were collected from each zone (see map provided). The detail of each zonal area is shown below

1. Bhubtian Village, Canal Gardens, Bahria Pyramides / [Zone-A]
2. Halloki, Waraich, Rasul Pura, Kacha / [Zone-B]
3. Bhalloke, Qureshi Wala, Thela, Ahlu, Harpalke / [Zone-C]
4. Wahga Town, Bhuttian Village, Lila Pur, Bhanuchak / [Zone-D]
5. Ferozwala, Kot PindiDas, Shamke, Pindi Machhian, Sekam / [Zone-E]

Preparation of Plant Samples

The sample preparation technique for plants involves many steps, including washing, drying, grinding, and storage. The plant samples were prepared according to the method recommended by Jones and Amma [13, 14]. According to this method the samples are washed, dried at 75ºC for 24 hrs, and finely ground with a wooden mortar to pass through a 2 mm nylon mesh sieve. All the samples were finally stored in air-tight plastic bags. The plant samples were digested with concentrated HNO_3 and $HClO_4$ until the digest was reduced to a few ml of clear white residue. The residue was dissolved in HCl (1:1), diluted, and filtered to prepare a test solution that can be used for sulfur determination [15]. All the samples, so prepared, were packed in air-tight plastic bottles and preserved for further analysis.

Analysis of Samples

The concentration of sulphur in the samples was determined using the turbidimitric method developed by Chesnin and Yien [16]. In this method, in an aliquot of the sample test solution $BaSO_4$ turbidity is developed in the presence of sodium acetate-acetic acid buffer (pH 4.8) and gum acacia by dissolving $BaCl_2$ crystals. The absorbance of the $BaSO_4$ turbidity is then measured at 420 µm wavelength on a spectrophotometer. The contents of sulphur were estimated using the standard calibration curve method.

Results and Discussion

Urban air quality studies of big cities in Pakistan have [6, 8, 9, 17] concluded that they are polluted. The city district government of Lahore has reported a strong correlation between urban air pollution and human health [17], which is also evident by 1,250 annual deaths out of total 63,000 deaths each year in Lahore [21]. So it is quite clear from previous studies conducted in Lahore that the atmosphere of Lahore is not healthy. The main purpose of our study was to assess whether people living away from the main roads, within the vicinity of the city, are also the same sufferers.

Table 1. The individual and mean concentrations of sulphur (S) in samples collected from the main roads on the outskirts of the study area (Lahore).

Sr No.	Sample ID	Location	Total concentration (ppm)	% of sulphur in the sample	Mean concentrations in the Zones (ppm)
1	SZ-01	Road A	252	0.0252	321.6
2	SZ-02		336	0.0336	
3	SZ-03		312	0.0312	
4	SZ-04		360	0.0360	
5	SZ-05		348	0.0348	
6	SZ-06	Road B	200	0.0200	231.2
7	SZ-07		196	0.0196	
8	SZ-08		244	0.0244	
9	SZ-09		276	0.0276	
10	SZ-10		240	0.0240	
11	SZ-11	Road C	88	0.0088	149.6
12	SZ-12		176	0.0176	
13	SZ-13		232	0.0232	
14	SZ-14		168	0.0168	
15	SZ-15		84	0.0084	
16	SZ-16	Road D	200	0.0200	163.2
17	SZ-17		204	0.0204	
18	SZ-18		228	0.0288	
19	SZ-19		100	0.0100	
20	SZ-20		84	0.084	
21	SZ-21	Road E	320	0.0320	232.8
22	SZ-22		264	0.0264	
23	SZ-23		196	0.0196	
24	SZ-24		120	0.0120	
25	SZ-25		264	0.0112	

The mean of the mean concentrations is 220±31 (SE, n=5).

Alarmingly, the final results (Tables 1 and 2) showed that the leaves of roadside *Eucalyptus* trees absorbed SO_x more than twice (2.23 times) as much compared to the samples collected from different zones away from the main roads. The same exposure is expected for people and vegetations. Being unaware of toxicity, it is a trend in the region that people try to purchase land close to the main roads not only for business purposes but also for residences, even though the land is more expensive. Furthermore, the same exposure is expected on daily commuters who have to spend more than 8 hrs on the roads. These workers have been found to readily catch respiratory diseases [18, 19].

Table 2. Individual and mean concentrations of sulphur (S) in the samples collected from areas (zones) away from the main roads of the study area (Lahore).

Sr No.	Sample ID	Location	Total concentration (ppm)	% of sulphur in the sample	Mean concentrations in the Zones (ppm)
1	SZ-AR-01	Zone A	40	0.004	122.5
2	SZ-AR-02		100	0.0100	
3	SZ-AR-03		104	0.0104	
4	SZ-AR-04		174	0.0174	
5	SZ-AR-05		194	0.0194	
6	SZ-AR-06	Zone B	184	0.0184	101.2
7	SZ-AR-07		4	0.0004	
8	SZ-AR-08		150	0.0015	
9	SZ-AR-09		88	0.0088	
10	SZ-AR-10		80	0.6080	
11	SZ-AR-11	Zone C	200	0.0200	102.4
12	SZ-AR-12		20	0.0020	
13	SZ-AR-13		144	0.0144	
14	SZ-AR-14		20	0.0020	
15	SZ-AR-15		128	0.0128	
16	SZ-AR-16	Zone D	8	0.0008	87.2
17	SZ-AR-17		16	0.0016	
18	SZ-AR-18		72	0.0012	
19	SZ-AR-19		228	0.0228	
20	SZ-AR-20		112	0.0264	
21	SZ-AR-21	Zone E	78	0.0078	78.2
22	SZ-AR-22		122	0.0122	
23	SZ-AR-23		32	0.0032	
24	SZ-AR-24		64	0.0064	
25	SZ-AR-25		95	0.0095	

The mean of the mean concentrations is 98±8 (SE, n=5).

Road A is considered to be one of the busiest outskirt roads of Lahore because it connects the entire southwestern area of Punjab province to Lahore. This road has the highest concentrations (Table 1) of sulfur in the samples collected. Road B is relatively less congested with traffic and connects Lahore to Raiwind town, which is within the regime of the Nawaz family, a political family of Pakistan, and also facilitates the large Sunder industrial estate of Lahore. The results (Table 2) show that Zone A, sandwiched by roads A and B, has the highest concentration of sulfur compared to similar zones. However, it is less than roadside concentration. This shows that the areas close to more congested roads are relatively more affected.

Road C also is considered a busy road, but the traffic density decreases on this road as it shifts to defense housing authority (DHA) earlier (see map provided). So samples collected from Zone B, between roads B and C, has less sulfur concentration as compared to those collected in Zone A. Zones C and D, which are close to the Indian border, have very small traffic load so the concentration of sulfur in the samples collected is comparable or negligibly higher. The unchecked vehicular emission is a disaster for human health, particularly in big cities of Pakistan. According to the Health Effects Institute "More than half of 16.7 million deaths worldwide from cardiovascular diseases occurred in developing countries in 2000. The burden of disease is particularly heavy in Southeast Asian countries (including India, Pakistan, Bangladesh, Nepal, and Sri Lanka) which represent a quarter of the developing world's population" [20].

Roads D and E are also major outskirt roads that connect Lahore to the northwestern part of the country. Road D is less commonly used due to the motorway, but Road E is extensively used not only by light vehicles but also by heavy ones because this road connects many small and big industrial units. Surprisingly, the concentrations of sulfur collected from Zone E shows relatively lower concentrations, even less than concentrations tested in samples collected in Zones C and D. Moreover, overall concentration of this zone is less than in samples taken on roads.

Conclusions

The results of analysis of sulphur in the leaves of *Eucalyptus* tree show that the concentration of sulphur is higher in samples collected from the roadside trees than in those collected away from roads. The samples collected from the roads show concentrations in the range 88-360 ppm, with average concentrations of 220 ppm, whereas the samples collected away from the roads from different zones vary in the range between 4-228 ppm, with average concentrations of 98 ppm (Tables 1 and 2).

An exact correlation among the zones under the influence of different roads could not be established, but by this study it is clear that the areas away from the outskirt roads have relatively lower concentrations of SO_x, and roadside inhabitants are at more risk.

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References

1. COLBECK I., NASIR Z. A., ALI Z. The State of ambient air quality in Pakistan – a review, Environ. Sci. Pollut. Res. **17**, 49, **2010**.

2. HOPKE P K., COHEN D D., BEGUM B A., BISWAS S K., NI B., PANDIT G G., SANTOSO M., CHUNGY S., DAVY P., MARKWITZ A., WAHEED S., SIDDIQUE N., SANTOS F L., PABROA P. C. B., SENEVIRATNE M. C. S., WIMOLWATTANAPUN W., BUNPRAPOB S., VUONG T B., DUY HIEN P., MARKOWICZ A. Urban Air quality in the Asian region. Sci. Total Environ. **404**, 103, **2008**.
3. SZYDA J., WIERZBICKI H., STOKLOSA A. Statistical modelling of changes in concentrations of atmospheric NO_2 and SO_2. Pol. J. Environ. Stud. **18**, (6), 1123, **2009**.
4. VESTRENG V., MYHRE G. FAGERLI H., REIS S., TARRASON L. Twenty five years of continuous sulphur dioxide emission reduction in Europe. Atoms. Chem. Pyts. **7**, 3663, **2007**.
5. Pak–EPA/JICA. 3 cities investigation of air and water quality (Lahore, Rawalpindi & Islamabad), JICA-Pak-EPA, June 2001: Available at http://www.environment.gov.pk/pub-pdf.3city-inv.pdf. accessed on 3 July **2008**.
6. GHAURI B., LODHI A., MANSHA M. Development of baseline (air quality) data in Pakistan. Environ. Mont. Asess. **127**, 237, **2007**.
7. ALI M., ATHAR M. Air pollution due to traffic, Air quality monitoring along three sections of national highway N-5, Pakistan. Environ. Monit. Asses. **136**, 219, **2008**.
8. ATHAR M., ALI M. Impact of transport and Industrial emissions on the ambient air quality of Lahore city, Pakistan-II. Progress in Environ. Sci. & Tech., **2**, (Pt. A), 817, **2009**.
9. SAMI J., NASIR M., IQBAL J. A study of vehicular sulfur dioxide and nitrogen dioxide emission at Lahore, Pakistan, Sci. Int. (Lahore), **15**, (2), 213, **2003**.
10. SALAMI S. J., AYODELE J. T., AGHO M. O. *Eucalyptus camaldulensis* a bioindicator of sulfur, zinc and lead in Jos, Nigeria, ChemClass Journal. **2**, 81, **2005**.
11. ALTAF W. J. Effect of motorway traffic emissions on roadside wild-plants in Saudi Arabia. J. Radioanalyt. & Nuclear Chem. **217**, (1), 91, **1997**.
12. JASON B., ISSAM A., SAEED S. in Lahore "Laid back Lahore faces a frightening future" fifth paragraph, the observer, the Guardian (London), Sunday 08 March **2009**. www.guardin.co.uk/world/2009/mar/08/pakistan-lahore-terrorism.
13. JONES (JR.) J. B. Plant tissue analysis for micronutrients. Soil Sci. Soc. Am., Madison, Wisconsin, USA. **44**, 319, **1972**.
14. AMMA M. K. Plant and soil analysis. Rubber research institute, Rubber board, Kottayam – 686009. Keral, India, **1990**.
15. RICHARDS R. A., (Ed). Diagnosis of Improvement of Saline and Alkali Soils. USDA Hand Book 60. Oxford & IBH Publishing Co. New Dehli, **1954**.
16. CHESNIN L., YIEN C. H. Turbidimitric determination of available sulphates. Soil Sci Soc Proc Amer, **15**, 149, **1950**.
17. AMER A., IHSAN U. B. Minimizing human health effects of urban air pollution through quantification and control of motor vehicular carbon monoxide (CO) in Lahore, Environ Monit Assess, **135**, 459, **2007**.
18. KANITZ S., SPERATI G., BALESTRA V. Epidemiological studies of the effect of exposure to air pollution on road workers, Giornale di igiene e medicin a preventive, **10**, (2), 129, **1969**.
19. DTONI A., LARESE FILONE F., FINOTTE L. Respiratory diseases in a group of traffic Police officers: Results of 5 years fellow up. Giornale italiano di medicina del lavaro, **27**, (3), 380, **2005**.
20. HEALTH EFFECTS INSTITUTE USA. Health effects of outdoor air pollution in developing countries of Asia: A literature review. Special report, **15**, 30, **2004**.
21. The daily times, January 21, Page-7, **2006**. Link; http://www.dailytimes.com.pk/default.asp?page=2006\01\21\story_21-1-2006_pg7_10.