Research Article

Heavy Metals (Pb and Ni) Pollution as Affected by the Brick Kilns Emissions

Muhammad Ismail[1], Tufail Ahmad[2], Shamsher Ali[2*], Shahid Ali[1], Nur Ul Haq[1] and Naveedullah[3]

[1]Sugar Crops Research Institute, Mardan, Khyber Pakhtunkhwa, Pakistan; [2]Soil and Environmental Sciences Department, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan; [3]Water Management Department, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan.

Abstract | The effect of brickworks emissions on heavy metal content of soil and plants around the brick kiln chimneys was studied in 2009-2010. The research was carried out on Peshawar Ring Road's south direction between chimneys of bricks preparation that were named A and B with distance of 300 m. The kilns were positioned such that Southern direction of chimney of A was north for the chimney B. A total of 36 (18+18) soil and wheat leaf samples were collected in four directions. Samples were collected at varying distances (100, 200,300 meters) from chimneys. Similarly, samples of dust were also collected for analysis of heavy metals in available locations around the chimneys in 16 plastic buckets. They were placed 3 m high from ground. The laboratory analysis of wheat leaf samples showed that the concentration of Pb and Ni in chimney A and B as 2.90 and 1.8, 13.11 and 14.7 mg kg^{-1} respectively. The concentration of Pb and Ni at this stage is not in toxic range however with the continuous addition may pose a severe threat in future. Similarly, soil sample analysis revealed AB-DTPA extractable Pb and Ni for chimney A and B as (0.11- 0.13, 14.2 and 15.0 mg kg^{-1}) respectively. Here again the Pb and Ni do not show toxicity, yet it cannot be ignored for future with persistent addition. Likewise, the collected dust samples showed a huge load of pollution amounting to 23.8 to 46.0 g m^{-2} $month^{-1}$ (dustfall 50 m away from chimney). The samples collected for dust indicated that Ni and Pb are absorbed by the surroundings at the rate of 1.35 and 0.09 mg m^{-2} $month^{-1}$, respectively just 50 m away from chimney of brick kilns.

Received | February 18, 2019; **Accepted** | August 21, 2020; **Published** | September 18, 2020
***Correspondence** | Shamsher Ali, Department of Soil and Environmental Sciences, AMKC instead of Sugar Crops Research Institute, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan; **Email:** shamsherali@aup.edu.pk; mismailqazi@yahoo.com
Citation | Ismail, M., T. Ahmad, S. Ali, S. Ali, N.U. Haq and Naveedullah. 2020. Heavy metals (Pb and Ni) pollution as affected by the brick kilns emissions. *Sarhad Journal of Agriculture,* 36(3): 1001-1009.
DOI | http://dx.doi.org/10.17582/journal.sja/2020/36.3.1001.1009
Keywords | Heavy metals, Pb, Ni, Brick Kilns, Soil pollution

Introduction

The world today is, no doubt, at the climax of technological development. A lot has been done for the betterment of mankind in every walk of life but environmental pollution has also grown by leaps and bounds because of anthropogenic activities. The industrial advancement has added many pollutants to the Mother Nature. That's why the concept of environmental impact assessment of development projects has been initiated, in the third world countries also. The pollution because of brick kilns industry is a bead on the same string. As far as Pakistan is concerned the brick kilns manufacturing units are in close proximity to the agricultural lands and as such is adding more and more pollutants to the food chain. The dust released by the same activity is affecting the local flora and fauna in a steady and silent way due to heavy metals. Untouched soils contain heavy metals naturally and as a matter of fact plants require small quantity of some metals in order to complete their life cycle. Some of the metals exist as pure metals while others may be found in alloyed form. Different sources add heavy metals to our surroundings e.g. industrial wastes emitted into the air, wastes of animal and man in solid or liquid form, activities of mining and agro-chemicals (Gerard, 1996). Heavy metals are metals or metalloids with a density of ≥ 5 mg kg^{-1}. They cannot be destroyed and keep on moving by various anthropogenic processes from one part of the soil to another. Many agencies are responsible for their movement from one place to another. In semi-arid regions, the earth is usually without vegetation cover. This makes the soil loose and prune to erosion. In addition, human activities of plowing, heavy grazing of grasslands make the soil conditions favourable for its contamination by the agency of heavy metals. Thus they have posed a serious threat to the humans all over the world. The most dangerous aspect of heavy metals is that they enter the food chain and ultimately reach the human body. Dust is initially raised when particle become dislodged by aerodynamic stress of fast blowing winds (Parkinson, 1956). This ultimately results in bombarding of some particles on surface of earth when the comparatively bigger particles fall indirectly after getting some speed horizontally. The particles are dislodged in form of dust. Analysis of dust reveals that they may also have traces of heavy metals. Aryal *et al*. (2013) studied the heavy metals (Ni, Cu, Zn, Pb, and Cd in the particles (<10 µm) in the urban atmosphere in industrial city of Ulsan, South Korea. The emissions from industry outlets, chimneys, and polluted liquids slowly and gradually add heavy metals to the mother soil. The brick kiln manufacturing process also plays a role in addition of heavy metals especially to the micro environment i.e. the surrounding vegetation, soil and humans (Brumsack, 1977). The use of rubber and low grade fuel coal ultimately emits smoke which adds pollutants to the surroundings. However, the soil conditions and climatological features are considered significant criterion in measurement of soil pollution by heavy metals. The vegetative cover of soil may not allow the inward movement of these pollutants. Some of the sources creating pollution include smoke of automobiles, emissions from brick kiln chimneys, hospital and industrial wastes. The emissions from brick kiln chimneys pose a serious threat to environment producing SO_x NO_x CO_x. They also produce hydrocarbons and dust as particulates. All these are badly affecting the environment (Brumsack, 1977).

These toxic elements of the brick kilns are badly disturbing plants, soil, and of course humans in the nearby areas. It is worth mentioning that women and children, among the brick workers, are soft targets for chimneys' emissions (Bhanarkar *et al*., 2002). In order to assess the estimated pollution load to the surroundings, by agency of brick kilns, a study was carried out at Peshawar, Pakistan. This work was initiated to determine the toxic elements like Pb and Ni, in the surrounding (soil and plants) of coal fired brick kilns located on southern side of Ring Road, Peshawar. Briefly the main objects of this study were:

1. Approximation of the pollutants i.e. Pb and Ni content of plants and soil as exaggerated by emissions of brick kiln chimneys in four directions in increasing distances from point source.
2. Determine the rate of dust fall around chimneys and estimation of Pb and Ni in the dust samples.

Materials and Methods

Site selection

The brick kilns that were surrounded by agricultural land were ideal for the said study. For this reason, brick kilns near Ring Road, Peshawar were selected as they were surrounded by cropped area. Two brick kilns (A and B) at *Sufaid Dheri* were selected for determining particular heavy metals. The production capacity of brick kilns were also taken into account.

Geoposition and properties of selected brick kilns

The selected brick kilns (A and B) were located at a distance of about 600 m from the main Ring Road, Peshawar on the southern side at village *Sufaid Dheri* (Figure 1). The chimneys of the selected bricks kilns were positioned such that there was a distance of 300 m in between them. Their position was North South to each other (Figure 2). The height of each chimney was about 23 feet from ground surface. This was a fact that both of the brick kilns were not isolated and therefore pollution source for the soil and plants may include vehicular emissions from the nearby road but major source must be pollution from the two brick kilns. Dust fall collectors were placed at available structures i.e. roof of room etc.

Sufaid Dheri, Peshawar, Khyber Pakhtunkhwa

Figure 1: *Map showing the experimental site.*

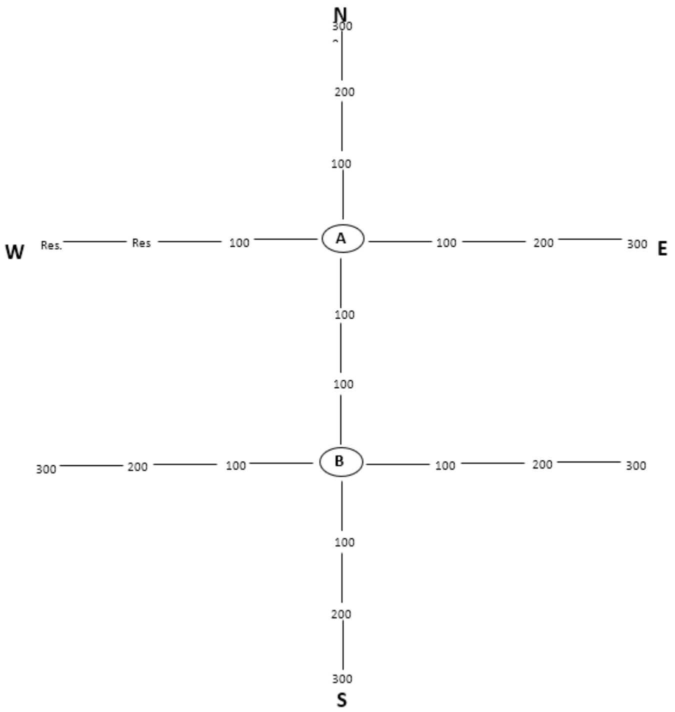

Figure 2: *Position of the brick kiln A and B and soil sample sites and distance in meters.*

Fuel sources (Coal and Rubber)

The brick kilns under study used different types of coal for baking of bricks. The one was high quality coal with high heat production capacity while the other one was low quality coal and thus cheap in price. However, they used both in combination for the baking of bricks. In addition, they also used rubber in the baking process. It was also found by the kiln owners that about 75 tons of coal is used for baking of 400,000 bricks in one month. Similarly, 3-4 tons of rubber was also used in the same process.

Soil samples

Soil samples (0-30 cm depth) from 18 sites around the kilns, were collected at 100 m, 200 m and finally at 300 m in South, West, East and North directions from each kiln (Figure 2). Heavy Metals Pb, and Ni were determined using method given by (Havlin and Soltanpour, 1981). 10 gm of soil sample was mixed with 20 ml of AB-DTPA extracting solution for 15 min on a reciprocal shaker at 180 cycles/minute with flask kept open. The extract was then filtered through Wattman No. 42 filter paper. The filtrate was then analyzed for Cu, Zn, Fe, Cr, Cd, Ni, Pb and Mn using Atomic Absorption Spectrophotometer.

Dust fall collector

Several suitable sites (preferably roof top) were selected, where a dust fall collector was placed for the dust fall sampling. A total of 16 dust fall collectors (plastic bucket of 23.6 cm mouth top diameter, 25 cm height and 20 cm base diameter) were positioned at 3 to 4 m height, where roof top was not available around the brick kiln chimney in East, West, North and South within a radial distance of 50 m from the chimney A and B. However only two buckets were installed at a distance of 4 m from the chimney. Almost 2 liters water was poured in sampling bucket in order to avoid the received dust from blustering out and left for 27 days. The buckets were taken off and the material was transferred to plastic pots in departmental laboratory (Soil and Environmental Sciences, The University of Agriculture, Peshawar). The pots were kept in open space and the residue was collected after water evaporation. The difference of initial weight of pots i.e. empty pots and final weight when all the water was evaporated were taken to help know the rate of dust fall. AB-DTPA extractable Pb and Ni in dust were determined by the method given by (Havlin and Soltanpour, 1981).

Plant sampling

Plant samples from the same 18 sites were also collected (Figure 2). Wheat (*Triticum aestivum*) leaves at tillering stage were collected. Plant samples were oven dried (70 °C), ground and then analyzed using the wet acid digestion method. One gram leaf sample was taken and further digested with 10 ml concentrated HNO_3 (one night treatment). Perchloric acid was also added at the rate of 4 mL per sample. The samples were heated on hot plates until about 3 ml clear solvent was left. The digest was initially filtered and then diluted to 50 ml when it got sufficiently cool and finally analyzed by Atomic Absorption spectrophotometer for Ni and Pb.

Results and Discussion

Dustfall

The analysis of collected dust samples showed dust load from 23.8 to as high as 46.0 g m^{-2} $month^{-1}$ at 50 meters distance from chimney of brick kilns. This indicated increased pollution of brick kilns' emissions. Average dust fall rate of Brick kiln A was 26.2, 32.8, 31.1 and 29.0 g m^{-2} $month^{-1}$ in Eastern, Western, North and Southern directions respectively as shown in Table 1. The Brick kiln B revealed a load of 41.8, 42.5 g m^{-2} $month^{-1}$ in eastern and southern directions respectively. In kiln B about 120 m away, the dust fall rate was 32.5 g m^{-2} $month^{-1}$ and highest value was found in the bucket which was placed just besides chimney in kiln B, the rate was as high as 64.7 g m^{-2} $month^{-1}$. As a matter of fact the input of Pb and Ni from observed amount of dust at 50 m distance from chimney will range from 0.05 to 0.12 mg m^{-2} $month^{-1}$ with mean of 0.09 and 0.75 to 3.51 mg m^{-2} $month^{-1}$ with mean of 1.35 mg m^{-2} $month^{-1}$ respectively as shown in Table 2. The highest amount of Pb and Ni concentration was 0.22 and 3.56 mg m^{-2} $month^{-1}$, respectively, was observed at the site closest to chimney as shown in Table 2. Khan *et al.* (1990) attributed the increase in rate of dust fall in Islamabad from 8.35 to 10.0 tons km^{-2} mo^{-1} in 1989 and 1990, respectively due to rocks weathering, desertification, increasing industries and traffic. In addition, Aryal *et al.* (2013) studied the heavy metals (Ni, Cu, Zn, Pb, and Cd in the particles (<10 µm which is dust particle in other words) in the urban atmosphere in industrial city of Ulsan, South Korea. While the monthly average dust falls in the city of Karachi ranged from 13.0 to 15.7 tons km^{-2} mo^{-1} (Beg at al., 1991). Similarly, the overall average dust fall rate at Peshawar has increased from 1993 to 1998 with a value of 27.65 tons km^{-2} mo^{-1} (Khan *et al*., 2002). The same can be reproduced as 27.65 g m^{-2} mo^{-1}. This means that 18.35 g m^{-2} mo^{-1} is added to the environment even without Chimney. It was found that dust fall rate 50 m away from chimney was high as compared to the dust fall rate in Karachi, Islamabad and Peshawar. Although, the vehicular emissions might have added to the increased rate of dust fall, but, for sure, the bigger source for the emissions in this area was the kiln chimney's emissions.

Ni in coal, dust, plants and soil

The analysis of dust samples, when averaged across all directions, revealed that Ni concentration ranged from 6.8 to 113.1 with mean value of 42.25 mg kg^{-1} (Table 3). The emitted gases in combination with the dust of brick kiln chimney prompted Ni pollution in several directions which can be seen in data Table 4. Data on Ni concentration in plant tissues varied with distance from brick kiln chimney and wind direction. Ni concentration gave increasing trend with increase in distance from chimney. When averaged across all direction for both brick kiln Ni increased from 13.11 to 14.7 mg kg^{-1} at 200 meters away from the chimney indicating effect of kiln induced contamination in air. Lagerwerff and Specht (1971) found Ni and other heavy metals in smoke that contaminated roadside soils and vegetation. This is also a fact that the magnitude of contamination is dependent upon the locality and intensity of pollutants. The major fuel sources were coal and rubber which makes it clear than crystal that burning them results in addition of pollutants to the mother soil. Furthermore, the polluted zones may include those areas which are several hundred meters away from the road. Comparing the wind directions, west and south at both brick kilns seems to have caused higher contamination. When averaged across the distances west and south induced higher Ni concentration in leaves, i.e. 18.9 and 13.7 mg kg^{-1} as compared to 11.4 mg kg^{-1} in east. Comparing the two brick kiln B induced higher Ni concentration in plants as brick kiln A. This may be attributed to the comparatively bigger size of Kiln B and that the age of Kiln B was more as compared to Kiln A i.e. 15 years while the Kiln A was built 12 years ago. It was found when averaged across all values brick kiln B showed Ni concentration of 14.7 mg kg^{-1} as compared to 13.11 mg kg^{-1} of brick kiln B. Ni concentration in soil showed the increasing trend as the distance from the kiln chimney increased and when averaged across directions (Table 5). Ni concentration was 13.95 and 14.82 mg kg^{-1} at 100 and 200 m distances respectively as compared to 15.36 mg kg^{-1} observed at 300 m distance which was assumed to be away from the direct effects of the chimney emissions. Comparing the wind direction, when averaged across the distances, west and south directions showed higher values i.e. 17.4 and 15.3 mg kg^{-1} as compared to 12.3 mg kg^{-1} for east. In between the two kilns the Ni concentration was 31 mg kg^{-1}. When averaged across all the values the brick kiln B induced higher Ni concentration, i.e. 15 mg kg^{-1} to the soil as compared to 14.2 mg kg^{-1} for brick kiln A. Chakraborti and Raeymaekers (1988) observed Ni and other toxic metals on dust of street, household, restaurant, top of leaves and five soil samples of Calcutta city and his results showed higher metal contents in dust samples than soil samples.

Table 1: *Dust fall rate (g m^{-2} month^{-1}) 50 m away from brick kiln chimney.*

Direction of placement of bucket with respect to chimney	Bucket 1	Bucket 2	Mean	SD
Brick Kiln A				
East	23.80	28.6	26.2	3.4
West	31.70	33.9	32.8	1.5
North	36.80	25.4	31.1	8.0
South	30.20	27.8	29.0	1.7
Brick kiln B				
East	39.20	44.4	41.8	3.7
South	46.0	38.9	42.5	5.1
Beside Chimney	64.30	65.1	64.7	0.6
South at 120 m	32.50			

Table 2: *Estimated input of heavy metals (mg m^{-2} month^{-1}) from brick kiln induced dust at 50 m distance from chimney.*

Direction of placement of bucket with respect to Chimney	Pb	Ni
Brick Kiln A		
East	0.12	2.18
West	0.19	0.75
North	0.05	0.85
South	0.08	0.85
Brick kiln B		
East	0.13	3.51
South	0.10	1.33
Mean	0.09	1.35
Along Chimney	0.22	3.56
South at 120 m	0.03	0.66

Table 3: *Concentration of Ni (µg g^{-1}) in dust samples as influenced by wind direction around Brick Kiln chimney.*

Wind direction	Bucket 1	Bucket 2	Bucket 3** at distance > 100m	Mean
Brick Kiln A				
East	111	60.4		85.7
West	33.2	13.1		23.15
North	41.4	6.8		29.1
South	16.7	43		29.85
Brick kiln B				
East	113.1	58.4		85.7
Chimney	33.5	28.7		31.1
South	10.1	12.7	40.7	11.2
Mean	81.29	29.01		

*** The only site i.e. roof of nearby house available at >100m distance from the chimney of Brick kiln B.*

Table 4: *Concentration of Ni (mg kg^{-1}) in plants as influenced by distance from brick kiln chimney and wind direction.*

Wind direction	Distance(m)			Mean	G. Mean
	100	200	300		
Brick Kiln A					
East	5		0.9	12.1	
West	22.4	Res*	Res*		
North	6.9	10.4	15.8	11.0	13.11
Brick kiln B					
East	8.8	20.4	5.1	11.4	
West	16.7	36.5	3.6	18.9	
South	19.1	19.5	2.5	13.7	14.7
Mean	13.15	23.44	5.58		
Between A and B	1.4	9.90			

**Res: Refers to residential area where no sampling could be performed.*

Table 5: *Concentration of Ni (mg kg^{-1}) in soil as influenced by distance from brick kiln chimney and wind direction.*

Wind direction	Distance(m)			Mean	G. Mean
	100	200	300		
Brick Kiln A					
East	0.8	12	10.9	7.9	
West	24.2	Res*	Res*		
North	15.4	16.2	19.9	17.2	14.2
Brick kiln B					
East	9.4	12.4	15.2	12.3	
West	10.8	25.5	15.9	17.4	
South	23.1	8	14.9	15.3	15.0
Mean	13.95	14.82	15.36		
Between A and B	5.7	31.00			

**Res: Refers to residential area where no sampling could be performed.*

Table 6: *Heavy Metals (µg g^{-1}) in coal samples used as fuel in brick kiln.*

Heavy metal	Low quality coal			High quality coal		
	Ashing	ASTM	Mean	Ashing	ASTM	Mean
Ni	8.85	4.35	6.6	9.15	4.0	6.58
Pb	1.45	1.75	1.6	1.5	1.8	1.65

Table 7: *Estimated average heavy metal load (in fly ash, smoke and particulate) in one month.*

Heavy metal	Low quality coal	High quality coal	Mean
Ni	0.50	0.49	0.49
Pb	0.12	0.12	0.12

1): Calculation is based on the assumption that 75 tons of coal is used or backing of 400,000 bricks in one month; 2): Heavy metal load from rubber use is not included. In the said brick kiln, about 3-4 tons of rubber is used in one month.

Table 8: *Concentration of Pb (μg g-1) in dust samples as influenced by wind direction around Brick Kiln chimney.*

Wind direction	Bucket 1	Bucket 2	Bucket 3** at distance > 100m	Mean
Brick Kiln A				
East	5.0	4.0		4.5
West	6.3	5.1		5.7
North	1.4	2.1		1.8
South	3.4	1.9		2.7
Brick kiln B				
East	4.0	2.3		3.2
Chimney	2.7	1.8		2.3
South	4.7	2.0	1.9	3.4
Mean	4.4	2.3		

*** The only site i.e. roof of nearby house available at >100m distance from the chimney of Brick kiln B.*

Table 9: *Concentration of Pb (mg kg-1) in plants as influenced by distance from brick kiln chimney and wind direction.*

Wind direction	Distance(m)			Mean	G. Mean
	100	200	300		
Brick Kiln A					
East	3.2	4.9	3	3.7	
West	3.3	Res*	Res*		
North	2.8	0.4	2.7	2.0	2.90
Brick kiln B					
East	3.6	2.6	0.3	2.2	
West	1.5	2.1	3.6	2.4	
South	1.1	0.3	1.5	1.0	1.8
Mean	2.58	2.06	2.22		
Between A and B	4.3	3.60			

**Res: Refers to residential area where no sampling could be performed.*

Table 10: *Concentration of Pb (mg Kg -1) in soil as influenced by distance from brick kiln chimney and wind direction.*

Wind direction	Distance (m)			Mean	G. Mean
	100	200	300		
Brick Kiln A					
East	0.06	0.06	0.12	0.08	
West	0.18	Res*	Res*		
North	0.13	0.11	0.07	0.11	0.11
Brick kiln B					
East	0.05	0.16	0.15	0.12	
West	0.13	0.11	0.15	0.13	
South	0.15	0.14	0.14	0.14	0.13
Mean	0.12	0.12	0.13		
Between A and B	0.14	0.21			

**Res: Refers to residential area where no sampling could be performed.*

Pb in coal, dust, plants and soil

The analyzed coal samples showed 1.6 μg g-1 for the low quality coal and 1.65 μg g-1 for high quality coal (Table 6). Dust samples average across all directions, revealed that Pb concentration (Table 8) ranged from 1.4 to 6.3 mg kg-1with a mean value of 3.35 mg kg-1. It was found that the emitted gases coupled with dust from kiln chimney caused Pb pollution in many directions. Data on lead concentration in plant tissues varied with distance from brick kiln chimney and wind direction. A decreasing trend was observed in the Lead concentration as the distance from chimney increased. When averaged across all direction for both brick kiln Pb reduced from 2.58 to 2.06 and 2.22 mg kg-1 at 200 and 300m distance from chimney respectively indicating effect of brick kiln induced contamination in air. Comparing the wind directions, east and west at both brick kilns seems to have caused higher contamination when averaged across the distances east and west induced higher Pb concentration of 2.2 and 2.4 mg kg-1 as compared to 1.0 mg kg-1 in south. Comparing the two brick kiln A induced higher Pb concentration in plants as compared to brick kiln B. when averaged across all values brick kiln A showed Pb concentration of 2.90 mg kg-1 as compared to 1.8 mg kg-1 of brick kiln B. The concentration of Pb as found in soil samples (Table 9) showed the increasing trend as the distance from the kiln chimney increased and when averaged across directions Pb concentration was 5.85 and 5.88 mg kg-1 at 100 and 200 m distances respectively as compared to 6.30 mg kg-1 observed at 300 m distance. Comparing the wind direction, when averaged across the distances, west and south directions showed higher values i.e. 6.3 and 7.2 mg kg-1 as compared to 6.1 mg kg-1 for east. In between the two kilns the Pb concentration was 10.30 mg kg-1. When averaged across all the values the brick kiln B induced higher Pb concentration, i.e. 6.6 mg kg-1 to the soil as compared to 5.28 mg kg-1 for brick kiln A. The Pb in air is an important source of the Pb contamination of environment. Shahid *et al.* (2016) found that metals can be accumulated in plant leaves through foliar transfer after deposition of atmospheric particles on the leaf surfaces. Brumsack (1977) found Pb along with other toxic metals in soil and grass samples, collected around brick kilns of the Gottingen area situated in West Germany. He extrapolated the results to the entire German Federal Republic, that Pb and Zn amount to as much as 50-100 t/y range. He concluded that environmental pollution by heavy metals emissions from brick kilns is almost equal to those released by burning of coal.

Effect of soil heavy metal build up on plant uptake

Accumulation of heavy metals as influenced by respective soil concentration was analyzed. Soil and Plant Ni showed that there is positive correlation between soil Ni and plant uptake. The soil concentration of heavy metals also increased plant uptake with r^2 0.22 (Figure 3). Rahman *et al.* (2000) determined Pb, Cd, and some metals in Rawalpindi - Islamabad region by using technique of moss monitoring. It was found that samples collected from sites which were far from the pollution source contained less concentration of the metals as compared to moss samples which were in close proximity of the coal-fired brick kiln.

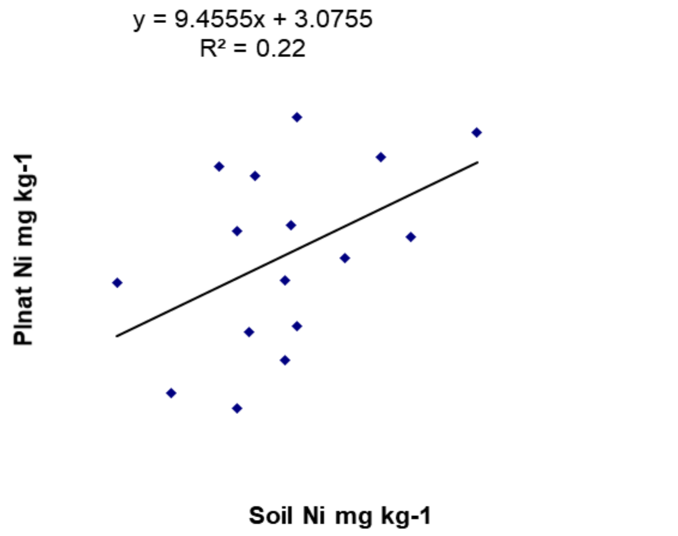

Figure 3: *Relationship between AB-DTPA extractable Ni (mg kg^{-1}) in Soil and Plant.*

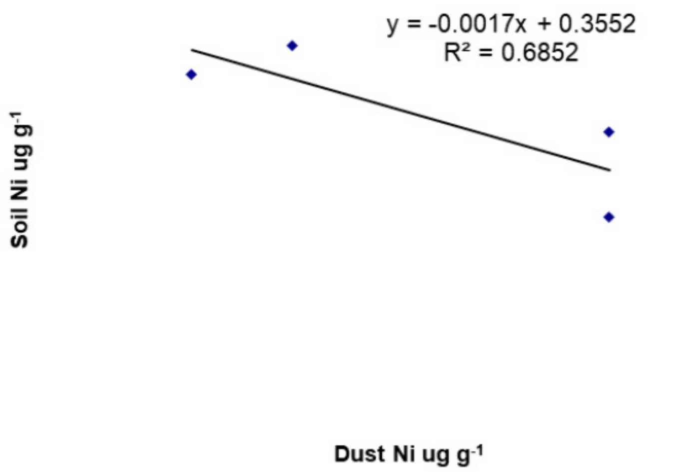

Figure 4: *Relationship between AB-DTPA extractable Ni (mg kg^{-1}) in Dust and Soil.*

Effect of dust fall concentrations on soil and plants

Dust vs soil: Accumulation of heavy metals in soil as influenced by dust concentration was observed at 50 m distance around the chimneys. Results of Ni showed a negative correlation with r^2 value of 0.68 (Figure 4). This can be attributed to the variable wind speed and direction and variation in characteristics and buffering capacity of soils around the brick kilns.

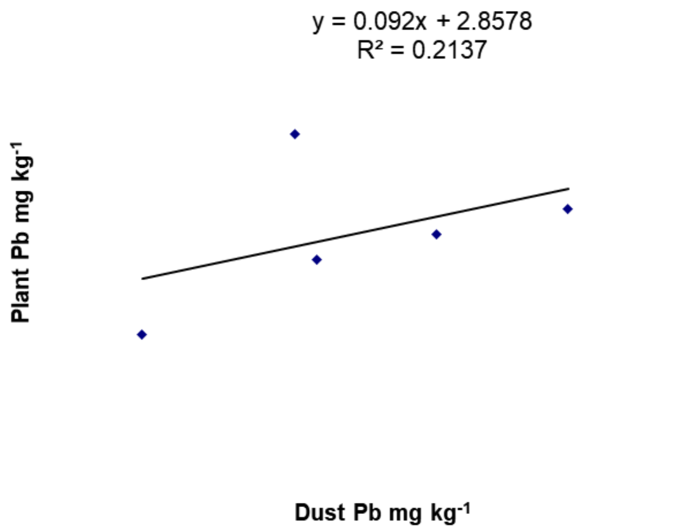

Figure 5: *Relationship between AB-DTPA extractable Pb (mg kg^{-1}) in Dust and Plant.*

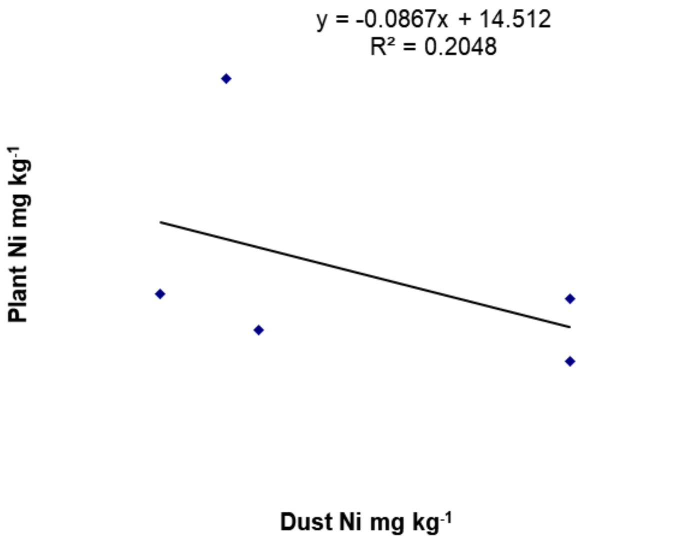

Figure 6: *Relationship between AB-DTPA extractable Ni (mg kg^{-1}) in Dust and Plant.*

Dust vs plant: The heavy metals in plants at 50 m distance revealed that Ni concentration decreased as the dust concentration increased. Hence there is a remarkable consequence of these emissions on the plant's heavy metal content near the brick kilns. Results for Pb showed correlation with r^2 value of 0.21 (Figure 5) which is a sign of the accumulation of metals by the plants. While the r^2 value for the Ni was 0.20 (Figure 6). The heavy metal load from the chimney is absorbed by plants irrespective of its buildup in the soil. Ali *et al*. (1992) collected samples of soil, weed, vegies and samples of dust from the agricultural area located in Cairo that has many industrial regions, and further analyzed them for heavy metals. It was seen that the rate of heavy metals including Cr was high in the collected plant, dust and soil samples. Results showed that absorption of heavy metals by plants occurred in roots and above ground portions.

The concentration of Pb and Ni, in plants and soil, at this stage is not in toxic range however with the continuous addition may pose a severe threat in the future.

Conclusions and Recommendations

The study was conducted to evaluate the effects of brick kiln chimneys on surrounding soil and plants. The estimated input of heavy metals Ni and Pb were determined using Atomic Absorption Spectrophotometer. Fuel sources were also analyzed. It was found that dust rate ranged from 23.8 to as high as 46.0 g m^{-2} $month^{-1}$ at 50 meters distance from the chimney of brick kiln. This in turn resulted in higher contamination of environment due to which heavy metals Ni and Pb are added to the environment at a slow rate of 1.35 and 0.09 mg m^{-2} $month^{-1}$ consistently. Although the heavy metals were found in non-toxic range yet studies of this nature are required lest these emissions become noxious. Furthermore, these brick kilns were only 15 years old with low production capacity. It is expected that older ones with bigger production may yield results in the toxic range.

Novelty Statement

The study is innovative as no previous work was found to estimate the heavy metals pollution caused by the brick kiln especially in Peshawar which is producing a huge number of bricks not only to meet the demands of Peshawar but also for Khyber Pakhtunkhwa. However, the sources for heat production i.e. (poor quality rubber and coal) are essentially the sources of environmental pollution.

Author's Contribution

Muhammad Ismail conducted the research and collected the data. Tufail Ahmad helped in collection and analysis of data. Shamsher Ali helped technically, did proof reading and overall management of research article. Shahid Ali helped in data collection. Nur Ul Haq also helped in data collection. Naveedullah helped in statistical analysis

Conflict of interest

The authors have declared no conflict of interest.

References

Ali, E.A., Y.H. Ibrahim and N.M. Nasralla. 1992. Contamination of the agricultural land due to industrial activities southern of Greater Cairo. Dept. Air Pollution, National Res. Center, Dokki, Cairo, Egypt. J. Environ. Sci. Health. A, Environ. Sci. Eng., 27(5): 1293-1304. https://doi.org/10.1080/10934529209375797

Aryal, R., A. Kim, B.K. Lee, M. Kamruzzaman and S. Beecham. 2013. Characteristics of atmospheric particulate matuer and metals in industrial sites in Korea. Environ. Pollut., 2(4): 10-21. https://doi.org/10.5539/ep.v2n4p10

Beg, M.A., S.N. Mahmood and A.H.K. Yousafzai. 1991. Environmental problem of Karachi: Part. III. Estimation of dust fall. Pak. J. Sci. Ind. Res., 34: 2-3.

Bhanarkar, A.D., D.G. Gajghate and M.Z. Hasan. 2002. Assessment of air pollution from small scale industry. Environ. Monit. Assess., 80: 125-133. https://doi.org/10.1023/A:1020636930033

Brumsack. H.J., 1977. Potential metal pollution in grass and soil samples around Brickworks. Environ. Geol., 2(1): 33-41. https://doi.org/10.1007/BF02430663

Chakraborti, D. and B. Raeymaekers. 1988. Toxic metals in dust and characterization of individual aerosol particles. Deptt. of Chem., Jadavpur Univ., Calcutta, India. Int. J. Environ. Anal. Chem., 32(2): 121-133. https://doi.org/10.1080/03067318808078422

De-Sarker, D. and S. Kundu. 1996. The effect of air pollution caused by brick kilns in West Dinajpur District WB apropos of surrounding flora. J. Nat. Conserv., (Muzaffarnagar). 8(1): 27-30.

Gerard, K., 1996. Agricultural pollution. Environmental engineering. McGraw-Hill Publishing Company, United Kingdom. pp. 420-421.

Havlin, J.L. and P.N. Soltanpour. 1981. Evaluation of the NH_4HCO_3 DTPA Soil test for Fe, Zn, Mn, Cu. Soil Sci. Soc. Am. J., 45: 70-77. https://doi.org/10.2136/sssaj1981.03615995004500010016x

Isermanm, K., 1977. Method to reduce contamination and uptake of Pb by plants from car exhaust gases. Environ. Pollut., 12: 199. https://doi.org/10.1016/0013-9327(77)90053-2

Khan F.U., B. Shakila, E.G. Ghauri and M. Ahmad. 2002. Air pollution in Peshawar. Pak. J. Sci. Ind. Res., 45(1): 1-6

Khan, Z.A., Y. Kalim and S.S.H. Zaidi. 1990. The rate of dust fall at Islamabad. Sci. Technol. Dev., 9(1): 35.

Khattak, J.K. and S. Parveen. 1988. Co-operative research programme on micronutrients in Pakistan. Ann. Rep. (1987-88) Dept. Soil Sci. NWFP Agric. Univ. Peshawar.

Lagerwerff, J.V. and N.W. Specht. 1971. contamination of road side soil and vegetation with Cd, Ni, Pb and Zn. Environ. Sci. Technol., 4: 583-588. https://doi.org/10.1021/es60042a001

Little, P. and M.H. Martin. 1972. A survey of zinc, lead and cadmium in soil and natural vegetation around a smelting complex. Environ. Pollut. 3: 241-254. https://doi.org/10.1016/0013-9327(72)90007-9

Parkinson, G.R., 1956. Sources of dustfall particulates. Bulliton of American Metal Society.

Rahman, U., M.A. Awan, S.T. Hassan and M.M. Khattak. 2000. Mosses as indicators of atmospheric pollution of trace metals (Cd, Cu, Pb, Mn and Zn) in the vicinity of coal-fired brick kilns in north-eastern suburbs of Islamabad, Pakistan. J. Radioanal. Nucl. Chem., 246(2): 331-336. https://doi.org/10.1023/A:1006782710160

Salam, M.S.A. and M.A. Sowliem. 1967. Dust deposition in Cairo, Egypt. Atom. Environ., 1(3): 271. https://doi.org/10.1016/0004-6981(67)90003-0

Shahid, M., Dumat, Camille, Khalid, Sana, Schreck, Eva, Xiong, Tiantian, Niazi and N. Khan. 2016. Foliar heavy metal uptake, toxicity and detoxification in plants: A comparison of foliar and root metal uptake. J. Hazard. Mater., 325: 36-58. ISSN 0304-3894. https://doi.org/10.1016/j.jhazmat.2016.11.063