Sarhad J. Agric. Vol.28, No.2, 2012

EFFECT OF BRICK KILNS EMISSIONS ON HEAVY METAL (Cd and Cr) CONTENT OF CONTIGOUS SOIL AND PLANTS

MUHAMMAD ISMAIL* DOST MUHAMMAD** FARID ULLAH KHAN*** FAZAL MUNSIF** TUFAIL AHMAD** SHAHID ALI* MUHAMAD KHALID* NUR UL HAQ* and MUSHTAQ AHMAD*

* *Sugar Crops Research Institute, Mardan – Pakistan.*
** *Department of Soil and Environmental Sciences, Agricultural University, Peshawar – Pakistan.*
*** *Pakistan Council of Scientific & Industrial Research, Peshawar – Pakistan.*

ABSTRACT

The effect of brickworks emissions on heavy metal content of soil and plants around the brick kiln chimneys was studied in the year 2006. Two brick kilns (A and B) about 600 m away from Ring Road at Sufaid Dheri on southern side of Ring Road Peshawar were selected for this study. The two bricks kilns were North-South to each other with 300 m distance in between, such that South direction from brick kiln A was north for brick kiln B. Eighteen soil and eighteen plant samples were collected from eighteen different sites at different distances i.e. 100, 200 and 300 m from brick kiln chimney in East, West, North and South directions. In addition sixteen dust samples were also collected in plastic buckets installed at a height of 3 m in different directions of the brick kiln chimney. Concentration of heavy metals in plants was determined using the wet acid digestion method. Cd and Cr concentration in plants for Brick kiln A & B respectively were (2.03 & 1.9, 5.76 & 3.5 mg kg^{-1}). Concentration of heavy metals in soil (AB-DTPA extractable Cd, Cr for Brick kiln A & B respectively were (0.03 & 0.41, 0.10 & 0.08 mg kg^{-1}). High load of dust with 23.8 to 46.0 g m^{-2} month^{-1} at 50 m distance indicated higher pollution near the brick kiln chimneys. Heavy metals in the dust samples showed that Cd and Cr are added into environment with a rate of 0.08 and 0.52 mg m^{-2} month^{-1}, respectively at 50 m distance from brick kiln chimney.

Keywords: **Heavy metals, brick kilns, dust rate.**

Citation: Ismail, M., D. Muhammad, F.U. Khan, F. Munsif, T. Ahmad, S. Ali, M. Khalid, N.U. Haq and M. Ahmad. 2012. Effect of brick kilns emissions on heavy metal (Cd and Cr) content of contiguous soil and plants. Sarhad J. Agric. 28(2):165-170

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. Pollution is defined as any departure from purity while environmental pollution means departure from a normal rather than a pure state. Primarily, the five types of pollution (COx, NOx, Hydrocarbons, Sulfur dioxide and Dust fall) are important from point of view of their adverse effect on human health and other food chain organisms (Khattak and Parveen, 1988). Air pollution is of special concern as it directly hits the respiratory system. Air is indispensable for the survival of all living organisms on earth including human beings without which no one can survive for a couple of minutes. Air pollution is one of the man made environmental disasters that are currently taking place all over the world. 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. Various sources of pollution include automobile's smoke, brickworks emissions, industrial smog, hospital wastes, etc. Among these sources, brick kiln's emission which produces CO_x, NO_x, SO_x Hydrocarbons, and particulates (dust) are adversely affecting the environment of its surroundings (Brumsack, 1977, De-Sarker, and Kundu, 1996; Rahman *et al*. (2000) Bhanarkar *et al.,* 2002). The releases of toxic substances from these brick kilns are adversely affecting soil, plant, amenity and heritage in their vicinity. Animals and people residing in nearby areas are also affected being the most serious for women, children and brick workers (Bhanarkar *et al*. (2002).

In KPK, Peshawar, Charsadda, Mardan, Bannu, D.I. Khan, and Swat districts are famous for making bricks. But Peshawar, Charsadda and Mardan are the major producers of bricks. Some 450 brick kilns are located in and around Peshawar conurbation. The major sources of pollution in Peshawar are vehicular emissions and brick kiln emission. The brick kiln uses coal, wood, tyres and furnace oil. The coal, fuel gas and tyres combustion in brick kilns produce air pollutants like COx, SOx, NOx and particulate. The acid deposition creates a serious threat to human health also, since it contaminates not only the breathing air but also the drinking water and even food. Acid rain has also become a point of major concern because of the increase in the concentration of pollutants in air.

To examine the extent of heavy metal pollution, a study was conducted on specific soils that were under the direct effect of Brick kilns in selected locations of Peshawar district. This work was initiated to determine the toxic elements like Cd and Cr in the surrounding (soil and plants) of coal fired brick kilns located on southern side of Ring Road, Peshawar. In addition the study also covered the following objectives i.e.

a. Estimate the heavy metal content (Cd, Cr) of soil and plants as affected by brick kiln emissions in four directions at increasing distances from the chimney.

b. To measure particulate and dust fall rate in vicinity of brick kilns and estimated input of heavy metals (Cd, Cr) from brickworks.

MATERIALS AND METHODS

Site Selection

The selection of the brick kilns was based on the production capacity and nearness to agricultural lands based on the fact that the study comprised of determination of contamination in cropped land. For this purpose, brick kilns near Ring Road, Peshawar, Pakistan were selected as they were surrounded by cropped area. Two brick kilns (A and B) at *Sufaid Dheri* were selected.

Geoposition and Properties of Selected Bricks Kilns

The selected brick kilns (A and B) were located at a distance of about 600 m from Ring Road, Peshawar on the southern side at village *Sufaid Dheri*. The two bricks kilns were North-South to each other with 300 m distance in between, such that South direction from brick kiln A was north for brick kiln B. The height of each chimney was about 7 m from ground surface. The two brick kiln were not ideally isolated and there might have been pollution from other sources in this area like traffic (vehicular emissions) from the road but still the major source of pollution should be these two brick kiln. There were appropriate places where we placed the dust fall collectors.

Fuel Sources

The brick kilns under study used two 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.

Soil Samples

Soil samples (0-30 cm depth) from 18 sites at distances 100 m, 200 m, and 300 m in four directions (East, West, North, and South) around the kilns were collected (Fig 1). Heavy Metals Cd, and Cr were determined using method given by Halvin and Soltonpour (1981).

Dust Fall Collector

A suitable site was selected (roof of a building) 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 placed in different directions around brick kiln chimney (East, West, North and South) at a height of about 3 to 4 m from ground within a radial distance of 50 m from the chimney. However, only two buckets were installed at a distance of 4 m from the chimney. 2 liters of water was poured in each bucket in order to prevent the fallen dust from blowing out and left for 27 days. The buckets were taken off and the material was transferred to plastic pots in laboratory of Soil and Environmental Sciences, KPK Agricultural University 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 Cd and Cr in dust were determined by the method given by Halvin and Soltonpour (1981).

Plant Sampling

Plant samples from the same 18 sites were also collected (Fig. 1). Wheat (*Triticum aestivum*) leaves at tillering stage were collected. Plant samples were oven dried (70^{o}C), ground and then analyzed using the wet acid digestion method. One gram leaf sample was digested with 10 ml conc. HNO_3 (overnight treatment) and 4 mL perchloric acid was added. The samples were heated on hot plates until about 3 ml clear solution was left. After cooling, the digest was filtered and diluted to 50 ml and then analyzed for Cd and Cr, using Atomic Absorption spectrophotometer.

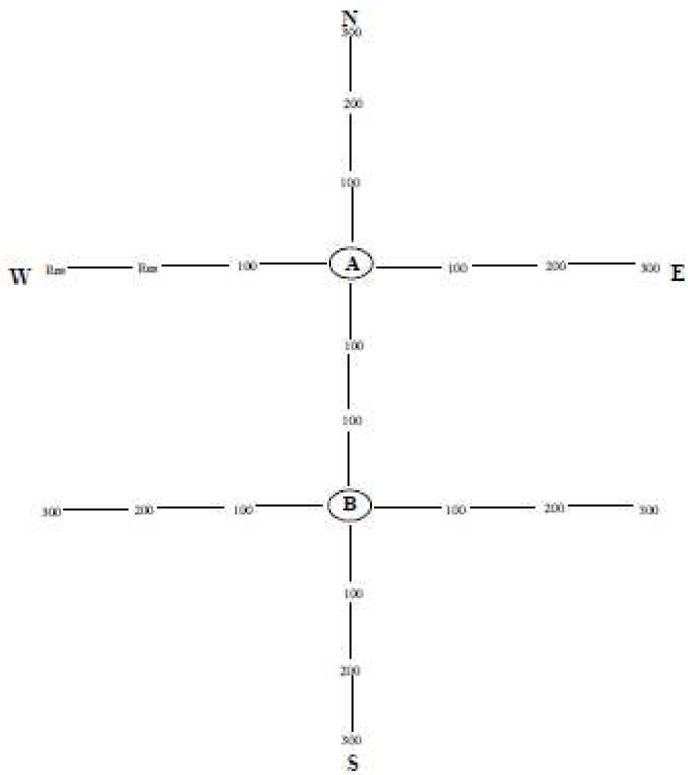

Fig. 1. Sampling pattern of collected plant and soil samples

(Figure 1 showing the soil and plant samples in four directions taken around the two brick kilns (A and B) studied in this particular research work. 100, 200 and 300 shows the distance in meters from brick kiln chimney. Res. Western side of brick kilns A refers to residential area where no sampling was possible.)

RESULTS AND DISCUSSION

Rate of Dust Fall

High load of dust with 23.8 to 46.0 g m^{-2} $month^{-1}$ at 50 m distance form brick kiln chimney indicated higher pollution potential by brick kilns' emissions. The average rate of dust in Brick kiln A was 26.2, 32.8, 31.1 and 29.0 g m^{-2} $month^{-1}$ in east, west, north and south directions respectively as shown in Table I. While in case of Brick kiln B, it was 41.8, 42.5 g m^{-2} $month^{-1}$ in east and south directions respectively. In kiln B at a distance of about 120 m, the rate of dust was 32.5 g m^{-2} $month^{-1}$ and the highest value was observed in case of the bucket installed just beside 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 Cd and Cr from observed amount of dust at 50 m distance from chimney will range from 0.04 to 0.14 with a mean value of 0.08 and 0.39 to 1.06 with a mean value of 0.52 mg m^{-2} $month^{-1}$ respectively as shown in Table II. Highest amount observed respectively for Cd and Cr concentration was 0.17 and 1.07 mg m^{-2} $month^{-1}$ at the site closest to chimney as shown in Table II. 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 desertification, weathering of rocks, increase in industry and vehicular traffic. While the monthly average dust fall in the city of Karachi ranged from 13.0 to 15.7 tons km^{-2} mo^{-1} (Beg *et al.* (1991). Similarly, the overall average rate of dust fall at Peshawar has increased from 1993 to 1998 and found to be 27.65 tons km^{-2} mo-[1] Khan *et al.* (2002). The results clearly show the increased rate of dust fall at 50 m distance from the kiln chimney as compared to the average rate of dust fall in Islamabad, Karachi and even Peshawar. Although, the vehicular emissions might also have contributed to this high dust fall rate, but the major source of emissions in this area was the Brick kiln emissions. Parkinson (1956) reported that dust storm depends on vegetative cover and winds of 35 – 45 km^{-1} may cause extensive dust storm, while according to Salam and Sowlain (1967), the increase in the average value of dust fall in residential area is attributed partly to the increase in population density.

Table I *Dust fall rate (g m^{-2} $month^{-1}$) at 50 m distance from brick kiln*

Direction of placement of bucket with respect to Chimney	Bucket 1	Bucket 2	Mean	SD
Brick Kiln A				
East	23.8	28.6	26.2	3.4
West	31.7	33.9	32.8	1.5
North	36.8	25.4	31.1	8.0
South	30.2	27.8	29.0	1.7
Brick kiln B				
East	39.2	44.4	41.8	3.7
South	46.0	38.9	42.5	5.1
Beside Chimney	64.3	65.1	64.7	0.6
South at 120 m	32.5			

Table II *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	Cd	Cr
Brick Kiln A		
East	0.08	0.49
West	0.14	0.49
North	0.06	0.39
South	0.14	0.40
Brick Kiln B		
East	0.04	0.79
South	0.08	1.06
Mean	0.08	0.52
Along Chimney	0.17	1.07
South at 120 m	0.03	0.31

Cd n Dust, Plants and Soil

The analyzed dust samples, when averaged across all directions, revealed that Cd concentration ranged from 0.2 to 6.3 with a mean value of 2.65 mg kg^{-1} Table III. Wind direction and brick kiln chimney distance effect on the Cd concentration in plants is clear from the data Table IV When averaged across all directions of both brick kilns Cd concentration was highest at 300 m i.e. 2.26 mg kg^{-1} while at 200 m distance from chimney it was low i.e. 1.44 mg kg^{-1} indicating effect of brick kiln induced contamination as the distance from kiln chimney increased. Comparing the wind directions, east and south at both brick kilns seems to have caused higher contamination. When averaged across the distances east and south induced higher Cd concentration of 1.7 and 3.1 mg kg^{-1} as compared to 0.8 mg kg^{-1} in west. Comparing the two, brick kiln A induced higher Cd concentration in plants as compared to brick kiln B. When averaged across all values brick kiln A showed Cd concentration of 2.03 mg kg^{-1} as compared to 1.9 mg kg^{-1} of brick kiln B. Cadmium concentration in soil Table V varied with the increasing distance from the kiln chimney and when averaged across directions maximum concentration was observed at 200 m distance i.e. 2.88 mg kg^{-1} while at 300 m distance the concentration decreased to 1.58 mg kg^{-1}. The concentration of Cadmium in between the two brick kilns was also high i.e. 2.7 mg kg^{-1} owing to the combined effect of both the chimneys. While the east and south directions showed values 2.4 and 2.1 mg kg^{-1} as compared to 1.3 mg kg^{-1} when averaged across the distances. The brick kiln A induced higher Cadmium concentration i.e. 2.88 mg kg^{-1} to the soil as compared to 1.9 mg kg^{-1} for brick kiln B. (Little and Martin, 1972) found solid particles containing heavy metals in smoke from tyres and in other emission. Similarly industrial processes involving metal smelting and refining often caused large aerial inputs of heavy metals to neighboring soil and vegetation. The degree of contamination by air decreases rapidly with distance from the source and depends upon the wind speed and direction, marked increase in the levels of metals in soils have been found up to 11 km from the source in the direction of prevailing winds.

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

Direction of placement of bucket with respect to Chimney	Bucket 1	Bucket 2	Bucket 3** at distance > 100m	Mean
Brick Kiln A				
East	5.5	1.1		3.3
West	6.3	2.2		4.25
North	1.9	2		1.95
South	4.9	4.4		4.65
Brick kiln B				
East	1.6	0.2		0.9
Chimney	2.7	0.9		1.8
South	0.7	2.4	1.9	1.67
Mean	3.4	1.9		

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

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

Direction of placement of bucket with respect to Chimney	Distance(m) from the Chimney			Mean	G.Mean
	100	200	300		
Brick Kiln A					
East	1.8	0.3	1.1	1.1	
West	5.3	Res.*	Res.*		
North	0.1	2.8	2.8	1.9	2.03
Brick kiln B					
East	3.3	0.2	1.7	1.7	
West	0.4	0.2	1.9	0.8	
South	1.9	3.7	3.8	3.1	1.9
Mean	2.13	1.44	2.26		
Between A and B (Brick kilns)	1.1	1.20			

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

Table V *Concentration of Cd (mg kg $^{-1}$) in soil as influenced by distance from brick kiln chimney and wind direction*

Direction of placement of bucket with respect to Chimney	Distance(m) from the Chimney			Mean	G.Mean
	100	200	300		
Brick Kiln A					
East	0.036	0.09	0.036	0.05	
West	0.03	Res.*	Res.*		
North	0.066	0.092	0.054	0.07	0.06
Brick kiln B					
East	0.086	0.008	2.4	0.83	
West	0.054	0.016	0.5	0.19	
South	0.036	0.082	0.5	0.21	0.41
Mean	0.05	0.06	0.70		
Between A and B (Brick kilns)	0.05	0.01			

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

Cr in Dust, Plants and Soil

The analyzed dust samples, when averaged across all directions, revealed that Cr concentration ranged from 2.1 to 30.4 with a mean value of 16.6 mg kg^{-1} as shown in Table VI.

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

Direction of placement of bucket with respect to Chimney	Bucket 1	Bucket 2	Bucket 3 at distance > 100m	Mean
Brick Kiln A				
East	11	25		18
West	14	15.7		14.85
North	8.7	18.1		13.4
South	14.4	13.1		13.75
Brick kiln B				
East	20	18.1		19.05
Chimney	30.4	18.5		24.45
South	2.1	23	19.1	14.7
Mean	14.4	18.8		

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

Combusting gases and dust from brick kiln chimney induced Cr contamination in all direction as evident from the data as shown in Table VII. Data on Cr concentration in plant tissues varied with distance from brick kiln chimney and wind direction. Cr concentration gave decreasing trend with increase in distance from chimney. When averaged across all directions for both brick kiln Cr reduced from 5.03 to 4.68 and 3.58 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 Cr concentration of 4.7 and 2.1 mg kg^{-1} as compared to 3.6 mg kg^{-1} in south. Comparing the two brick kiln A induced higher Cr concentration in plants as brick kiln B. When averaged across all values brick kiln A showed Cr concentration of 5.76 mg kg^{-1} as compared to 3.5 mg kg^{-1} of brick kiln B. Chromium concentration in soil as shown in Table VIII varied with the increasing distance from the kiln chimney and when averaged across directions maximum concentration was observed at 200 m distance i.e. 6.60 mg kg^{-1} while at 300 m distance the concentration decreased to 2.48 mg kg^{-1}. When averaged across the distances east and south directions showed values 5.8 and 3.6 mg kg^{-1} as compared to 2.4 mg kg^{-1}. When averaged across all the values, the brick kiln A induced higher chromium concentration i.e. 5.08 mg kg^{-1} to the soil as compared to 3.9 mg kg^{-1} for brick kiln B that is attributed to the wind direction and heavy input of aerial deposits. Ali *et al*. (1992) collected soil, weed, vegetation and dust samples from an agricultural area of Cairo that also has a number of industrial complexes, and analyzed their heavy metal concentrations. High levels of Cr and other heavy metals were found in soil, plant and dust samples. Results indicated that plants absorbed the metals through their roots and root foliage.

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

Direction of placement of bucket with respect to Chimney	Distance(m) from the Chimney			Mean	G.Mean
	100	200	300		
Brick Kiln A					
East	4.6	4	7.6	5.4	
West	2.9	Res.*	Res.*		
North	9.5	10.8	0.9	7.1	5.76
Brick kiln B					
East	6.8	2.2	5.1	4.7	
West	3	1.5	1.9	2.1	
South	3.4	4.9	2.4	3.6	3.5
Mean	5.03	4.68	3.58		
Between A and B (Brick kilns)	3.8	4.30			

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

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

Direction of placement of bucket with respect to Chimney	Distance(m) from the Chimney			Mean	G. Mean
	100	200	300		
Brick Kiln A					
East	0.07	0.26	0.07	0.13	
West	0.21	Res.*	Res.*		
North	0.05	0.03	0.03	0.03	0.10
Brick kiln B					
East	0.07	0.22	0.05	0.12	
West	0.03	0.07	0.05	0.05	
South	0.08	0.08	0.06	0.07	0.08
Mean	0.09	0.13	0.05		
Between A and B (Brick kilns)	0.042	0.014			

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

CONCLUSION AND RECOMMENDATIONS

It was concluded from the study that high load of dust with 23.8 to 46.0 g m^{-2} month^{-1} at 50 m distance from brick kiln chimney resulted in higher pollution potential due to which heavy metals (Cd and Cr) are added to the environment at a slow rate of 0.08 and 0.52 mg m^{-2} month^{-1} consistently.

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. Deptt. Air Pollution, National Res. Center, Dokki, Cairo, Egypt. J. Envir. Sci. & Health. Part A, Envir. Sci. & Engg. 27(5): 1293-1304.

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

Bhanarkar, A.D., D.G. Gajghate and M.Z. Hasan. 2002. Assessment of air pollution from small scale industry. Envir. Monit. Assessment. 80: 125–133.

Brumsack. H.J. 1977. Potential metal pollution in grass and soil samples around brickworks. Environ. Geol. 2(1): 33-41.

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. Nature Conserv. (Muzaffarnagar). 8(1): 27-30.

Khan F.U., B. Shakila, E.G. Ghauri, and M. Ahmad. 2002. Air pollution in Peshawar. Pak. J. Sci. Indust. 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. Annual Report (1987-88) Deptt. of Soil Sci. Agric. Univ. Peshawar, Pakistan.

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.

Parkinson, G.R. 1956. Sources of dustfall particulates. Bull. Amer. Met. Soc.

Rahman, U., M.A. Awan, S.T. Hassan, 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. Radioanalyt. & Nuclear Chem. 246(2): 331.336

Salam, M.S.A. and M.A. Sowliem. 1967. Dust deposition in Cairo, Egypt. Atom. Envir. 1(3): 271.