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[Article]

Risk Evaluation of Brick Kiln Smoke to *Acacia arabica*

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ABSTRACT

Risk analysis is an important technique to estimate impacts on the environment for adopting effective measures to avoid risks. This field study was conducted to investigate the risk of brick kiln (BK) smoke on the shoots of *Acacia arabica*. Different phenotypic parameters including morphology and growth of shoots and epidermal imprints of the leaves were studied in the vicinity of a brick kiln situated 500 meters away from Lahore-Raiwind Road, Lahore, Pakistan. Results show that smoke exposure has posed differential effects on shoots i.e. some shoots of same tree remained normal, others died and still others were badly affected by the smoke. Moreover, the number of leaves and fresh weight in the smoke affected shoots significantly reduced as compared with normal ones. The study of the epidermal imprints of the leaves of these normal and smoke effected shoots revealed that the mean values of the stomatal size of both adaxial and abaxial surfaces of the normal and smoke effected leaves were not statistically significant. However, the number of stomata on both epidermal layers of smoke effected leaves was significantly reduced as compared with normal ones. This study showed that due to the exposure to BK smoke, the growth of *Acacia arabica* trees in the field was significantly suppressed.
Key words: *Acacia arabica,* brick kiln smoke, foliar characteristics, growth characteristics, Risk analysis

INTRODUCTION

Regulation, handling and bioremediation of hazardous materials require an assessment of hazard or risk to some living species other than human being, or assessment of risk to entire ecosystem. Assessment endpoints are values of the ecosystem that are to be protected and are identified early in the analysis. Such endpoints may include life cycle stages of a species, reproductive patterns or growth patterns. Ecosystem risk assessment is at its dawn and this area of environmental sciences still requires extensive work in the industrialized nations of the world for the sustainability of global ecosystem.

The use of fired bricks goes back more than three thousand years, and bricks are still the preferred house construction material in most countries around the world. In Pakistan, the brick kilns sector is a large user of energy and also employs a large number of workers, due to the labor intensive manual bricks-making process. Suitable clays for manufacturing green bricks exist almost everywhere in the country, and the bricks making process can be done with simple manual methods. Brick kilns are generally found in clusters situated on the outskirts of main cities and towns (Northwest Frontier Province Environmental Protection Agency, NWFP-EPA, 2004). Pollution control/abatement is one of the core areas of the Pakistan National Conservation Strategy (NCS) approved by the Government. One of the emerging environmental issues is gradation of ambient air quality particularly in urban areas. Various surveys show that air pollution levels in cities have either crossed safe limits or have reached the threshold values. The most serious issue of air quality in Pakistan is the presence of excessive suspended particulate matters (SPM) present in the ambient air. The major sources of SPM are vehicles, industry, burning of solid waste, brick kilns and natural dust (Environment

Division, Government of Pakistan, 2006)

In Pakistan one of the most common sources of air pollution is old-fashioned brick kilns, which are spread, in the whole country and release poisonous smoke in the environment. According to a careful estimate there are many thousands of brick kilns working at present throughout the country. Old rubber tyres, low-quality coal, wood and used oil is used in these kilns as fuel. Consumption of these fuels, combined with inefficient combustion process produces a large quantity of hazardous gaseous that is injurious to the health of the community living in the surroundings the kilns as well as the workers of the kiln (NWFP-EPA, 2004).

Air pollution is most dangerous among all type of pollutions because man and even plants need fresh air for their normal metabolic pathways. Honjyo *et al*., (1980) in a study found that the trees in the polluted area show vital decay. Rao (1985) argued that pollutants and their combinations cast toxic effects on plants.

Acacia arabica (Babul or Kikar) belongs to taxonomic family Leguminoseae (Fabaceae). It makes natural vegetation of Punjab and Sindh Provinces in Pakistan, and is cultivated in drier parts and fallow lands throughout Pakistan. Its wood is used for making posts, rafters, beams, carts, yokes, ploughs, etc. In Afghanistan used for sleepers and can be employed in making Persian wheels, clod crushers, boat building, axles, naves, turnery purposes, tops, Hookah stems, presses, sticks and stamps etc. Besides, this species has some medicinal values as used for cleaning teeth because of antiseptic properties, and yields a kind of gum used in different traditional medicine. Its barks and pods give valuable tanning materials.

Data on air pollution in Pakistan is insufficient (JICA Country Profile On Environment Pakistan, 1999). Although ambient air standards (Pakistan Environment Protection Ordinance, 1983) and Law on air pollution exist in Pakistan which demands curtailing the emission of toxic gases into atmosphere but strict legislation implementation is required to enforce these laws to save natural vegetation and habitats.

The present study is focused on the ecological effects caused by smoke of a brick kiln such as growth and stomatal behaviour of *Acacia arabica,* which makes the major part of natural vegetation in Punjab and Sindh provinces.

Materials and Methods

Selection of site

This study was conducted in the adjoining area of Iqbal's Brick Kiln situated at Lahore-Raiwind Road, 20 Km away from Lahore City, Pakistan. The approximate distance of the brick kiln from Punjab University, New Campus is about 22 K.M. It was a Bulls Trench kiln having chimney height of about 25 feet.

Sampling

Eight *Acacia arabica* trees were selected at random in the field area, which were present on the northeast direction on different distances from a brick kiln on Lahore-Raiwind Road Pakistan. This brick kiln worked throughout the study period. Different morphological features of the shoots of current year's growth were studied for this purpose. Similarly temperature measurements were also recorded near brick kiln and around different trees. Epidermal imprints of the leaves of the trees were taken in order to study the stomatal distribution and the effect of smoke on the aperture and number of stomata of the normal and affected leaves.

Morphological studies

Fifty shoots per *Acacia arabica* tree were picked up randomly at a specific height (5-6 feet) to rate their state of health and appearance. They were rated according to the following 3 parameters:

i) Normal shoots: The shoots having healthy leaves and without any symptoms of damage, were rated as normal.

ii) Affected shoots: The shoots having less or damaged leaves were rated as affected shoots.

iii) Dead shoots: Those shoots without leaves, looking hard and could be easily broken due to abscission layer were rated as dead.

Growth measurements

Five normal and five damaged shoots each of current year's growth were sampled at random from each of the *Acacia arabica* tree. Each of the sampled shoot was removed carefully using a pair of scissors and was transferred to a large polythene bag which was duly labeled and brought to the laboratory.

After transportation to laboratory, the fresh weight of shoots (gm), total length of shoots (cm), number of leaves and number of nodes were studied.

Epidermal Imprints

One normal and one damaged leaf were selected from each of the *Acacia arabica* trees and the epidermal imprints of the adaxial and abaxial surfaces were obtained by the help of a cellulose acetate paper and acetone. These epidermal imprints were mounted on glass slide and observed under microscope.

a) Number of stomata

Using a compound microscope number of stomata on adaxial and abaxial epidermal layers was noted from the relevant epidermal imprint in a randomly drawn line transect. Three transects were studied per slide and their mean values and standard errors were calculated.

b) Measurements of stomatal area

These were taken with the help of a micrometric eyepiece of a compound microscope. 15 measurements were taken per slide in 3 randomly drawn transects.

Temperature measurements

Temperature measurements were recorded during this field study in the month of May. The temperature on the boundary of brick kiln and on different distances was noted at a time.

Statistical analyses

Experiment was conducted by analysis of variance (ANOVA) and the data were analyzed through SPSS v.11.5. Means were separated through Least Significant Difference (LSD) test at ($p< 0.05$).

Results

Physical appearance of plants

Following are some important results regarding the physical appearance of plants obtained during experiment. It is obvious that the trees near the brick kiln receiving more smoky air (1, 2,4,5 and 6) were badly affected and had greater number of dead and smoke affected shoots, while the number of normal shoots was very less. In contrast, trees 7, 8 and 9 had a marked increase in the number of normal shoots; there was a comparatively greater reduction in the number of dead than the smoke affected shoots. So the effect of smoke is more pronounced on trees near the brick kiln (1-6) as compared to shoot growth of those trees away from it (7, 8, 9). Table 1 shows the physical appearance of the 50 shoots of current year's growth of *Acacia arabica* taken at random at a height of 5-6 feet from the ground level.

Growth measurements

Data on various aspects of current year's shoot growth of the normal and smoke effected branches of *Acacia arabica* trees is given in Table 2. It is clear that the fresh weight of normal shoots in all the individual trees (except tree No.1) is higher than their smoke affected counterparts and the mean fresh weight of normal shoots of all the trees is significantly higher than smoke affected ones. It is also clear from the results in Table 2 that the number of leaves per branch was markedly higher in normal shoots as compared to smoke affected branches. The mean number of the leaves on normal shoots as compared with their effected counterparts is statistically significant ($p< 0.05$). However, the difference in the mean length and mean number of nodes of normal shoots is not statistically significant as compared with smoke effected ones.

Effects on stomatal characteristics

Data on the number and size of stomata on adaxial and abaxial leaf surfaces of normal and smoke effected branches is presented in Tables 3 and 4, respectively. Table 3(a) represents the number of stomata on adaxial and Table 3(b) on abaxial surface of normal and smoke effected leaves. A critical study of Table 3(a) and 3(b) reveals that in each individual tree

Table 1. Physical appearance of shoots aftercurrent year's growthin *Acacia arabica*(taken at random the height of about 5-7 feet)

Tree No.	Normal shoots	Smoke affected shoots	Dead shoots
1	7	28	15
2	13	23	14
4	9	24	17
5	11	19	20
6	7	19	24
7	19	22	9
8	19	21	10
9	19	21	10

Table 2. Current year growth of shoot samples of *Acacia arabica* trees (collected near the brick kiln). Means of 5 samples with their standard errors

	NORMAL					SMOKE AFFECTED			
Tree No.	Mean Fresh Weight (g)	Mean total Length (cm)	Mean number of leaves	Mean number of nodes	Tree No.	Mean Fresh Weight (g)	Mean total Length (cm)	Mean no. of leaves	Mean no. of nodes
1	2.11±0.16	24.7±2.84	29.6±2.01	16.60±0.74	1	2.51±0.72	21.16±1.91	9.80±3.41	17.40±1.73
2	1.33±0.29	15.16±1.51	26.40±4.23	10.80±1.21	2	0.89±0.36	18.84 ±1.67	4.00±1.94	10.00±0.40
4	1.10±0.43	16.70±2.19	35.80±12.27	10.00±0.80	4	0.74±0.05	12.30±2.45	5.00±1.49	11.60±1.16
5	2.40±0.76	19.96±2.12	62.60±18.46	11.60±0.92	5	1.77±0.29	15.28±2.16	25.20±7.16	13.20±7.18
6	1.56±0.54	18.82±1.24	27.60±8.31	12.80±1.94	6	0.72±0.13	17.74±3.39	8.80±1.29	10.20±0.52
7	2.09±0.39	23.62±1.21	82.80±10.31	17.40±1.08	7	1.57±0.31	21.86±2.07	23.60±6.75	14.20±6.48
8	2.39±0.22	19.86±2.25	68.40±8.44	15.20±0.65	8	1.25±0.17	23.36±0.45	12.40±3.90	15.20±1.58
9	2.70±0.07	19.98±2.82	65.80±6.89	14.20±0.65	9	1.14±0.14	19.08±1.19	14.40±2.16	20.60±2.75
Mean	1.96±0.20	19.85±1.12	49.87±7.92	13.50±0.96	Mean	1.32±0.21	18.07±1.41	12.90±2.79	14.05±1.29

L.S.D. (P<0.05) between mean values of fresh weight of the sampled shoots of two treatments=0.45 the difference between two means=significant
L.S.D. (P<0.05) between mean values of total length of the sampled shoots of two treatments=4.31 the difference between two means=non-significant
L.S.D. (P<0.05) between mean values of number of leaves of the shoots of two treatments=16.01 the difference between two means=significant
L.S.D. (P<0.05) between mean values of number of nodes of the shoots of two treatments=2.40 the difference between two means=non-significant

number of stomata both on both leaf surfaces of normal shoots was markedly higher than their smoke effected counterparts and in the same way the mean values of stomatal number of adaxial and abaxial leaf surfaces of normal shoots are significantly higher ($p < 0.05$) than their respective smoke effected counterpart shoots. As far as the pore length of the stomatal apertures is concerned, it was almost equal to their smoke affected counterparts, especially tree number 1, 5 and 6, however the situation was just the opposite in tree 9 (Table 4 a and b). As regards the pore area of stomata in the leaves of normal shoots, it was higher than their respective smoke affected counterparts (except in tree 9), response was especially marked in tree number 1,5,6 and 8. Table 4(a). Poor response to smoke was found on pore area of stomata on abaxial surfaces of all plants. In trees 1, 2, 5 and 6, stomatal pore area of leaves on normal shoots is markedly higher than their smoke affected counterparts. However, the reverse situation was observed in trees7, 8 and 9.

Temperature measurements

Table 5 shows the temperature values measured near the brick kiln on the two sides of the trees and at place between each tree and brick kiln at a specific time. The results show that there is no significant difference ($p>0.05$) between the temperatures on various above-mentioned sites.

Discussions

Brick production can be harmful to the environment and may deplete local sources of fuel wood; increase deforestation and associated environmental impacts (such as soil erosion), leaving less wood for future use (Takaaki, *et al.,* 1980).

In view of potential hazards of brick kiln smoke and ecological consequences, studies were conducted on *Acacia arabica* under field conditions near the brick kiln. It was found that trees growing near brick kiln had greater number of dead and smoke affected shoots as compared with ones away from it. The physical appearance and vigor of the shoots improved proportionate to the increase in distance from kiln as obvious from Table 1. This was the first positive indication of the intense effect of smoke of the brick kiln on the near most trees.

The smoke from brick kiln contains dust,

Table 3(a). Number of stomata observed in transects of the adaxial leaf epidermis of *Acacia arabica*

Slide No.	NORMAL	Slide No.	SMOKE AFFECTED
	Number of Stomata		Number of Stomata
T_1N_2	103.00±8.14	T_1A_2	93.33±14.67
T_2N_2	96.00±7.63	T_2A_2	79.00±7.09
T_4N_2	116.66±2.02	T_4A_2	57.33±2.18
T_5N_2	96.66±11.62	T_5A_2	75.66±5.81
T_6N_2	81.33±3.84	T_6A_2	66.66±5.36
T_7N_2	130.33±15.40	T_7A_2	99.00±5.00
T_8N_2	108.00±6.65	T_8A_2	99.00±5.00
T_9N_2	96.00±7.63	T_9A_2	91.66±8.96
Mean	104.74±5.36		85.37±4.97

L.S.D. (P<0.05) between mean values of number of stomata of the sampled leaves of two treatments=16.39 so the difference between two means=significant

Table 3(b). Number of stomata observed in transects of the abaxial leaf epidermis of *Acacia arabica*

Slide No.	NORMAL	Slide No.	SMOKE AFFECTED
	Number of Stomata		Number of Stomata
T_1N_1	84.33±0.88	T_1A_1	56.00 ±4.04
T_2N_1	90.00±4.04	T_2A_1	72.00±5.03
T_4N_1	95.33±4.33	T_4A_1	65.66±2.33
T_5N_2	105.00±9.53	T_5A_1	63.66±6.38
T_6N_1	85.00±3.05	T_6A_1	72.00±2.51
T_7N_1	106.66±3.28	T_7A_1	81.66±4.33
T_8N_1	90.66±2.40	T_8A_1	47.00±1.15
T_9N_1	90.33±6.38	T_9A_1	53.66±5. 69
Mean	90.08±2.85		69.16±6.99

L.S.D. (P<0.05) between mean values of number of stomata of the sampled leaves of two treatments=6.19 so the difference between two means=significant

a byproduct of brick production that may cause hazardous effects upon the nearby vegetation. After settling down on leaves and shoots the dust can clog stomatal openings to interfere with the normal gaseous exchange and thus exerting considerable bearing on photosynthesis (Creed, *et al.,* 1973). Hence air pollutants can be viewed as additional stress agents that can limit tree growth and productivity in concert with other stresses (Winner, 1994). In present study we found that growth of *Acacia* trees growing near the brick kilns grew poorly, moreover their stomatal characteristics were also severely affected. Dust is most prevalent and dangerous when clay is extracted and finished bricks are transported following the firing process. In order for air pollution exposure to be accepted as the cause of forest decline, it is necessary to establish that the forest communities are exposed to these pollutants. Forests can receive pollutants through dry deposition, wet deposition, or exposure to acidic cloud vapor (Irwin and Williams 1988; Johnson and Taylor, 1989).

In further laboratory study of the branches of current year's growth of above mentioned trees given in Table 2 it was found that due to the effect of the brick kiln smoke on the branches of *Acacia arabica* trees significant reduction in the fresh weight and in the number of leaves occurred. While a slight increase in number of nodes and reduction in the length of shoots was negligible. During the microscopic studies of the epidermal imprints of both surfaces of the normal and smoke effected leaves of these trees it was found that number of stomata were significantly reduced in the smoke effected leaves of *Acacia* trees (Tables 3 a and b). Some of the epidermal cells including stomata were badly injured and lost their shape and identity caused by the deleterious effects of brick kiln smoke. Chaudhari and Rao (1984)

Table 4(a): Mean values for the measurements of stomatal aperture in adaxial leaf surface of *Acacia arabica* trees

	NORMAL				SMOKE AFFECTED		
Tree No.	Mean pore length(μ)	Mean pore width(μ)	Mean pore area(μ2)	Tree No.	Mean total Length (cm)	Mean number of leaves	Mean Fresh Weight (gm)
1	18.89±0.39	1.76±0.09	33.24±1.64	1	17.94±0.30	1.48±0.07	26.55±2.32
2	17.27±0.61	1.72±0.09	29.66±2.09	2	16.81±0.72	1.68±0.09	28.34±2.15
4	17.49±0.67	1.67±0.11	29.53±2.33	3	17.13±0.62	1.48±0.12	25.09±2.06
5	17.76±0.74	1.60±2.12	28.23±1.95	5	17.37±0.53	1.10±0.09	19.10±1.95
6	16.92±0.48	1.61±0.11	27.37±2.10	6	17.14±0.34	1.29±0.10	22.11±1.89
7	16.63±0.45	1. 46±0.12	23.85±1.88	7	16.26±0.56	1.43±0.10	23.25±1.64
8	18.97±0.37	1.54±0.12	29.13±2.48	8	17.49±0.46	21.32±0.12	23.29±23.29
9	18.19±0.35	1.34±0.13	24.37±2.56	9	16.45±0.56	1.56±0.08	25.66±2.04
Mean	17.41±0.25	1.59±0.04	27.62±0.72	Mean	17.12±0.17	1.43±0.06	24.55±1.30

Based on total of 15 measurements (5 per transect; 3 transects in all) L.S.D. ($P<0.05$) between mean values of area of stomatal pore of the sampled leaves of two treatments=3.66 the difference between two means= non-significant

Table 4(b): Mean values for the measurements of stomatal aperture in abaxial leaf surface of *Acacia arabica* trees

	NORMAL				SMOKE AFFECTED		
Tree	Mean pore length(μ)	Mean pore width(μ)	Mean pore area(μ2)	Tree No.	Mean total Length (cm)	Mean number of leaves	Mean Fresh Weight (gm)
1	18.57±0.49	1.81±0.13	33.61±2.55	1	18.20±0.40	1.50±0.15	27.30±2.76
2	16.49±0.53	1. 57±0.10	27.42±2.27	2	14.82±0.71	1.28±0.12	19.59±2.83
4	18.01±0.68	1.59±0.14	29.14±3.19	3	16.66±0.62	1.44±0.14	24.00±2.52
5	17.90±0.45	1.60±0.11	28.89±2.16	5	18.92±0.48	1.34±0.11	25.45±2.24
6	17.41±0.60	1.52±0.10	26.55±2.22	6	17.21±0.46	1.40±0.09	23.18±1.86
7	16.49±0.43	1. 27±0.11	20.71±1.79	7	17.36±0.47	1.56±0.11	26.08±2.05
8	18.41±0.51	1.46±0.13	26.92±2.72	8	20.64±0.57	1.40±0.14	**28.62±3.10**
9	18.05±0.39	1.18±0.11	21.21±2.00	9	18.14±0.62	1.44±0.11	25.83±2.10
Mean	17.44±0.23	1.44±0.05	26.14±1.37	Mean	17.59±0.55	1.40±0.03	24.66±0.95

Based on total of 15 measurements (5 per transect; 3 transects in all) L.S.D. ($P<0.05$) between mean values of area of stomatal pore of the sampled leaves of two treatments=3.66 the difference between two means= non-significant

Table 5: Temperature measurements around the brick kiln and the trees of *Acacia arabica* present in the area of study

Tree No.	Temperature on the boundary of brick kiln in °C & (°F)	Temperature in between the tree and brick kiln in °C & (°F)	Approx. Distance from brick kiln In feet	Temperature of the side of the tree towards brick kiln in °C & (°F)	Approx. Distance from brick kiln In feet	Temperature of the side of the tree away from brick kiln in °C & (°F)	Approx. Distance from brick kiln In feet
1	33°(91.4°)	33°(89.6°)	50	33°(86.0°)	98	31.5°(88.7°)	102
2	33.2°(91.4°)	33°(89.06°)	125	33.5°(86.0°)	153	32.0°(89.6°)	256
4	33°(91.7°)	33°(89.6°)	160	32.0°(89.0°)	250	29.5°(85.1°)	254
5	33.1°(91.58°)	33°(89.6°)	160	31.0°(87.8°)	260	32.0°(89.6°)	262
6	33.3°(91.9°)	33°(89.24°)	170	32.0°(89.0°)	296	32.0°(89.6°)	298
7	33°(91.4°)	33°(91.58°)	260	32.0°(89.0°)	572	29.9°(35.3°)	574
8	33.2°(91.76°)	33°(89.6°)	265	31.5°(88.7°)	585	32.0°(89.6°)	585
9	33°(91.4°)	33°(89.78°)	265	30.5°(86.9°)	590	29.1°(84.3°)	592

also mentioned these sorts of findings in their research work on the leaf epidermis of *Lycopersicon* sp.

The measurements on the stomatal pore area (both on upper and lower surfaces) of normal leaves displayed greater values as compared with the mean pore area of the smoke effected leaves in general but the differences were not statistically significant (Table 4(a) and 4(b)). Garg (1980) reported after the analysis of scanning electron micrographs that air pollution caused a reduction in the size of stomatal pore of 7 flowering plants. The temperature measurements in the field study area showed that temperature around all the trees and brick kiln was almost similar (Table 5). It was clear after this that temperatures of the brick kiln was not the cause of damage to the trees.

Elevated levels of the trace gases SO_2, NOx, CO_2 and O_3 resulting from industrial emissions have well-documented physiological effects on trees (Keller, 1984; Ceulemans and Mousseau, 1994; Matyssek *et al.*, 1995). With the exception of CO_2 these trace gases are toxic to plants and cause reductions in tree growth (Matyssek *et al.,* 1995). These gases enter leaves almost exclusively through the stomata and impact the internal physiology of the tree through effects on mesophyll tissue. The resultant reductions in photosynthetic processes in tree leaves are the primary mechanism of direct effects of these pollutants on tree growth and productivity. Indirect effects of these pollutants arise from the chemical changes that emitted pollutants undergo in the atmosphere resulting in ozone (0_3) production and wet and dry deposition of sulfur and nitrogen compounds with subsequent cascade effects on various components of the forest ecosystem (Schulze *et al.*, 1989; Taylor *et al.*, 1994).

Conclusions

It is obvious after this study that the brick kiln smoke directly caused visible injury to the trees of the *Acacia arabica.* The continued uptake of the gaseous pollutants through leaf stomata eventually resulted in cellular damage, which is manifested through effects on the foliar characteristics.

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