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Original Article

Environmental health effects of brick kilns in Kathmandu valley

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Abstract

Introduction: Brick kilns operating in Kathmandu valley are known to be a leading cause of air pollution. The main objective of this study was to assess the effect of brick kilns on environment and human health. This study has been done at Duwakot VDC in Bhaktapur.

Methods: This study was conducted during brick kilns operating and not operating periods. Different methods were used for data collection, such as household environmental health survey, school health examination, and air quality measurement for total suspend particles, particulate matter of size less than 10 microns, Sulphur Dioxide, Oxides of Nitrogen, and Carbon Monoxide.

Results: A total of 330 individuals were interviewed during household environmental survey and majority of them expressed about smoke related respiratory discomfort at home and surrounding. Out of 141 school children who underwent thorough physical health examination, 79 students were from Ganesh Public School (located near to brick kilns) and 62 were from Nabin English School (far away from brick kilns). Statistically significant high odds ratios for respiratory problems like tonsillitis (4.17 95% CI 2.05, 8.45) and acute pharyngitis (4.08 95% CI 2.01, 8.33) were observed among the students from Ganesh Public School. Average value of particulate matter of size less than 10 microns and total suspend particles for the pre operation time was 0.029 mg/m³ and 0.033 mg/m³ respectively whereas, it reached 0.050 mg/m³ and 0.056 mg/m³ respectively during the brick kiln operation time.

Conclusion: The concentration of various air pollutants was higher during the operation of brick kilns at Duwakot. Similarly, the health status of the school children attending the school close to the vicinity of the brick kilns was worse compared to the students attending the school away from the brick kilns.

Key words: Environmental Health, Air Pollution, total suspend particles (TSP), particulate matter of size less than 10 microns (PM_{10}), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_x), Carbon Monoxide (CO), Brick Kilns, Duwakot, Nepal

Bhaktapur district is one of the main important economic as well as cultural centres of Kathmandu valley. The district occupies an area of about 119 sq. km and is situated at an altitude in between 1372 and 2166 m. The total population of the district is approximately 225,461, among which, about 53.35% live in the urban areas. The district's population growth rate is 2.71 percent per annum, which is slightly higher than the country's population growth rate. The total number of households in the district is about 41,253 and the average household size is 5.47. The population density comprises of 1895 persons per square kilometre.

Brick making is one of the traditional crafts in Kathmandu Valley. In recent years, with increasing urbanisation and the demand for construction materials for development work, brick kilns have grown both in numbers and capacity. Most brick kilns in the Kathmandu Valley operate from the month of December till May.

According to a study conducted by the World Bank in 1996, the main contributing sources for total suspend particles (TSP) in the valley are cement factory (36%), brick kilns (31%), domestic fuel combustion (14%), road resuspension (9%) and vehicle exhaust (3.5%). However, for the particulate matter of size less than 10 microns (PM_{10}) concentration, which is of a more concern as these particles can enter the respiratory system; contribution of brick kilns was found to be more than other sources. The share of brick kilns was 28%, domestic fuel combustion (25%), cement factory (17%), vehicle exhaust (12%) and road resuspension (9%).[1]

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Emission from brick kilns comprises of fine dust particles, hydrocarbons, Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_x), Fluoride compounds, Carbon Monoxide (CO) and small amount of carcinogenic dioxins if rubber tyres were used as fuel.[2] Studies show that inhalation of even relatively low concentrations of fine particles could affect lung function and lead to increases in cardiovascular and respiratory diseases. Higher amount of CO, which is produced in these kilns due to poor kiln design that results in incomplete combustion of coal, could also increase incidence of heart disease. Epidemiological studies done in different places around the world have found the evidence that increase in rate of bronchitis, asthma, decreased lung function, pharyngitis, cough, eye irritation, fibrosis, emphysema, allergic rhinitis, low birth weight are linked with deteriorating ambient air quality.[3-7]

Very few studies have been done to indicate that Bhaktapur's brick industries are polluting the environment. Moreover, majority of the studies done in that field in Nepal were limited to the measurements of ambient air pollutants using high volume samplers.[8] There is no study found in Nepalese literature about the measurement of air pollutants at the individual level using low volume sampling pumps. So, there was a need for more studies to firmly establish the linkages between pollution from brick kilns and its impact on local environmental quality and human health at the individual level. Kathmandu Medical College (KMC) has therefore decided to conduct a field-based study to assess the impact of brick kilns in one particular village in Bhaktapur district.

This study was done in Duwakot Village Development Committee (VDC) that is located approximately 1 km north of Salla Ghari, Arniko Highway, in Bhaktapur District along the road to Kathmandu Engineering College. Duwakot is a popular place for brick kilns. There were 9 Bulls Trench Kilns and 2 fixed chimneys in the VDC. Among them, five kilns were located in the ward No.1 and six in the ward No.2. Some of these kilns have been operating for more than last 15 years.

The main objective of this research study was to assess the impact of brick kilns on environment and human health. The specific objectives of the study were:

1. To conduct a questionnaire health survey among the residents in areas with brick kilns and those without kilns in the vicinity.
2. To conduct a health check of children studying in a school close to brick kilns and to compare their health status with children studying in schools where there are no kilns in the area from the same VDC.
3. To conduct the samplings and analysis of the air quality for different pollutants at the individual level.
4. To interact with local people to understand their views on the impact of brick kilns on the local environment and human health.

Methodology

This study was conducted during the period of June 2004 to September 2005 at Duwakot VDC. The southern belt of the VDC, where wards 1 and 2 had brick kilns and wards 3, 4, 5 and 6 that were located close to the brick kilns, were defined as the affected area, and the northern belt (wards 7, 8, and 9), which did not have brick kilns, were defined as the control area in the study (Fig 1). Different methods have been used to gather information on the environment and health impacts of Bhaktapur's brick kilns.

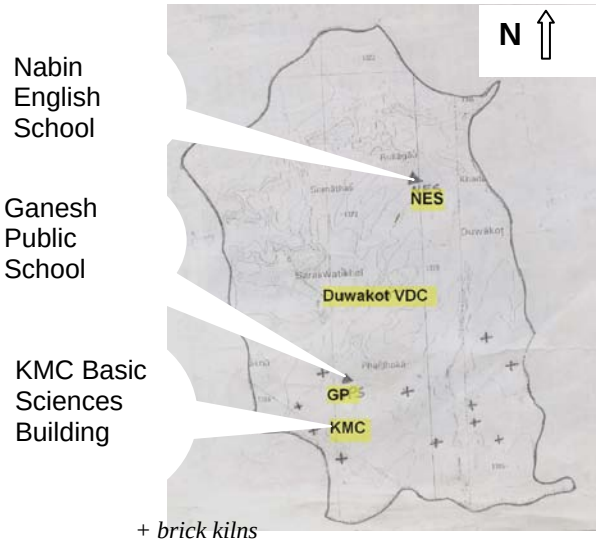


Fig 1: Map of Duwakot VDC

These include the following:

1. Household Environmental Health Survey

A structured questionnaire has been used to gather information on households in area with brick kilns and without. Information about types of house, education, smoking habit, occupations, types of fuels used for cooking, respiratory problems were obtained. Altogether 330 questionnaires were taken

for study and the survey was conducted directly through household visits by the staff and students from the Kathmandu Medical College. Random convenient sampling methodology was applied.

2. School Health Examination

A thorough medical examination of 141 school children was done using a structured questionnaire to find out the health effects due to environmental hazards. Among 141 school children, 79 children were studying in Ganesh Public School that was located close to brick kilns and 62 school children were studying at Nabin English School located in ward no. 9 without any brick kilns in the vicinity. All students under fifth grade present in the schools during the days of physical health examinations were included in the study. In the present context, group of individuals having the risk factor was taken as the students studying in Ganesh Public School and the students studying in Nabin English School were taken as the group without risk factor or relatively much lower risk. The children studying in both schools were from similar socio-economic background.

The health check up was started with the collection of general information followed by General Health Examination, Nutritional Status Examination, Systemic Examination, ENT Examination and Eye Examination. Doctors from the Department of Community Medicine, KMC were involved in the health examination of the students. The students requiring basic medical treatment were given available medicines free of cost. Deworming of the students was done.

3. Air Quality Measurement

In order to assess air quality in the areas with brick kilns and without, different instruments have been used to collect and analyse the samples. Measurements have been performed for TSP, PM_{10}, Sulphur Dioxide (SO_2), Nitrogen Oxides (NO_x) and Carbon Monoxide (CO) at the individual level using personal sampling pumps. Two whole day measurements were done on two different occasions; once during monsoon season when usually all brick kilns are closed (July 2004) and another when the brick kiln were operating (April 2005). Each day monitoring was performed at different locations by four sampling pumps.

3.1 Measurement of TSP and PM_{10}

In order to measure the TSP and PM10, four personal air sample pumps of Sibata Company, Japan were used.

Test Method: Four-hour stationary sampling was carried out at three different sites by maintaining a suction flow rate at 630 litre / minute. One mobile personal air sample pump was carried by the staff of KMC for 4 hours on rotation basis. Air particulate matter with size greater than 10 µm and less than 10µm were collected on two different filter papers - perforated and non-perforated; from which TSP and PM10 were measured gravimetrically.

3.2 Measurement of SO_2, NO_x and CO

Manual Gas Analyzers (Drager pump) with detector tubes were used for spot measurements of gaseous pollutant concentrations in air.

The tubes for SO_2, NO_x and CO were inserted in the Drager pump towards the pointing side and the air is sucked through the tube up to 10 strokes. Then the readings were taken from the graduation marks placed outer side of the tube for ten strokes. If the colour was not changed further ten strokes were taken in the same air and the reading was taken as before. The value obtained from the reading was further multiplied by F for the correction of the atmospheric pressure.

Data collected were entered into the database and analysed with the statistical package for social sciences (SPSS), 11th version. Descriptive data analysis, crosstabs were performed for different variables and p value and odds ratios with 95 % confidence interval were calculated where applicable. The study was approved by the research and ethical committee of the Kathmandu Medical College and informed consent were received from the concerned school administrations and study subjects.

Results

Household Environmental Health Survey

Out of the total 330 individuals surveyed, 200 respondents were from the so called brick kiln affected area (wards no. 1, 2, 3, 4, 5, and 6) and 130 respondents belonged to brick kiln unaffected or control area (wards 7, 8, and 9). Seventy six percent (76%) respondents from brick kiln area and 51% from control area were found to have smoke related respiratory discomfort at home and surroundings. Ninety five percent (95%) respondents from the affected area had suffered from some respiratory disease or common cold in last one year. Seventy two percent (72%) respondents in the brick kiln area and 36% respondents in the control area thought that brick kilns were responsible for those diseases.

Table 1 explains about the distribution of study population by age and sex. Similarly, table 2 shows the smoking habits in those populations.

Results on School Health Examination

Out of 141 students studied, 96 were male and 45 were female. The age of the students ranged from 4 to 14 years and all of them were non-smokers. Details regarding the age of the children are presented in the table 3.

General Health Examination

There was not significant difference in the general health status of students studying at these two different schools on the examination for pallor, jaundice, cyanosis and gross physical abnormality (Fig 2). (P>0.05%).

Immunization Status of the children

Distribution of immunization status in each school is presented in the figure 3 and figure 4. The difference of immunization status in those two schools were statistically insignificant ($p > 0.05$)

General Body Hygiene Condition

Hygiene of majority of the students studying at both the schools was fairly good. There was no significant difference in general hygiene of students studying at both the schools.

Nutritional status of school children

Study on nutritional status of students studying at both the schools was carried out by conducting anthropometric measurements and calculating Body Mass Index (BMI). Based on the readings of BMI, WHO has classified nutritional status on different classes as severe malnutrition, moderate malnutrition, mild malnutrition, normal, moving towards obesity and obesity as shown in the table 4:

The outcomes of the anthropometric measurements are displayed in the Table 5. The weight of the students at Ganesh Public School ranged from 10.5 kg to 46 kg with an average of 25.37 kg. The height of the students ranged from 82 cm to 1159 cm, with an average of 118.06 cm. Similarly, the weight of the students at Nabin English School ranged from 9 kg to 30 kg with an average of 27.21 kg and the height ranged from 91 cm to 131 cm with an average height of 110.45 cm. Mean BMI of the students from Ganesh English School was 21.30, whereas, the same from Nabin English School was 25.11. So, as per the WHO standard, students from Ganesh English School have normal BMI compared to Moving towards Obesity BMI among the students from Nabin English School.

The difference in nutritional status observed was significant statistically ($P = 0.001$). BMI of the students from Nabin English School was significantly higher than the students from Ganesh Public School.

Systemic Examination

Results of the systemic examinations revealed that students from both schools were not having any evidence of clinical xeropthalmia, diseases of heart and lungs, skin and abdominal organs. Few students from Ganesh Public School were suffering from pallor, nasal abnormalities like polyps, deviated nasal septum and abdominal distension. Wax in ear was prevalent in the students from both schools.

Table 6 revealed that relatively more systemic abnormalities were present among students studying at Ganesh Public School as compared to students from Nabin English School. However, the difference is statistically insignificant ($p >0.05$).

Odds Ratios have been computed for various upper respiratory tract infections like tonsillitis and pharyngitis using binary logistic regression for comparing risks associated with exposed group of individuals (students from Ganesh Public School) with respect to relatively unexposed group of individuals (students from Nabin English School). In order to find whether the computed sample Odds ratios are statistically significant or not, 95% confidence intervals for Odds Ratios have been set up. If the intervals include value 1, then the computed Odds Ratios are considered as insignificant at 95% confidence interval. If otherwise, the values are considered as statistically significant.

As shown in Tables 7 and 8, the odds ratios for enlarged tonsil and inflamed throat were 4.17 and 4.08 respectively, which were statistically significant.

Air Quality Measurement

Average value of PM_{10} for the pre operation time was 0.029 mg/m³, whereas, it reached 0.050 mg/m³ during the brick kiln operation time. Similarly TSP value was found to be 0.033 mg/m³ during pre operation time and 0.056 mg/m³ during operation time. All measurements were done at the breathing zone level (face of the people). However, the presence of CO, SO_2 and NO_X was not detected by the Drager Pump and Tube during the brick kiln operation as well as non operating time. Table 9 gives the detail findings of the criteria pollutants.

Table 1: Distribution of Surveyed Population in Duwakot VDC

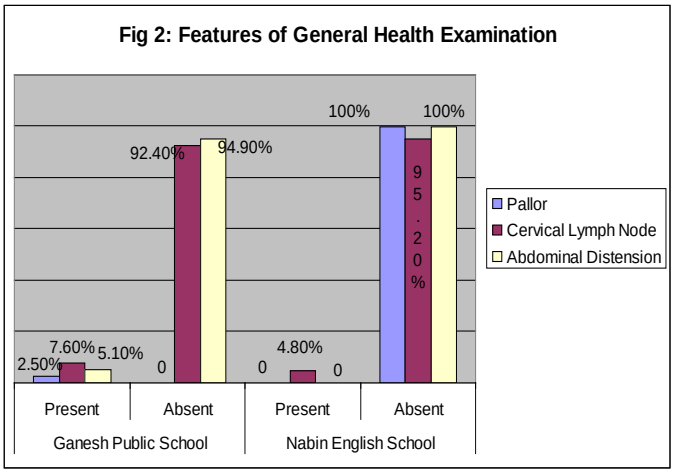
Locality	Sex	Age groups				
		0-4	5-14	15-60	> 60	Total
Brick Kiln Area	Male	8 (8.1%)	10 (10.1%)	70 (70.1%)	11 (11.1%)	99 (49.5%)
	Female	12 (11.8%)	7 (7.0%)	72 (71.2%)	10 (9.9%)	101 (50.5%)
	Total	20 (10%)	17 (8.5%)	142 (71%)	21 (10.5%)	200
Control Area	Male	4 (7.3%)	6 (11%)	39 (71%)	6 (11%)	55 (42.3%)
	Female	6 (8%)	9 (12%)	51 (68%)	9 (12%)	
	Total	10 (7.7%)	15 (11.5%)	90 (69%)	15 (11.5%)	130

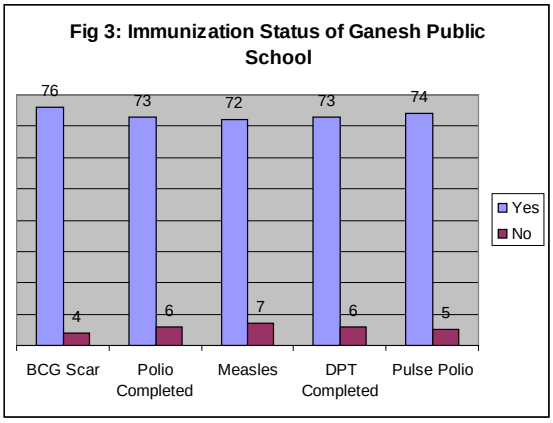
Table 2: Distribution of Population by Smoking Habit

Locality	Smoking habits	Age groups						Total
		5-14		15-60		> 60		
Brick Kiln Area	Non-smokers	9	7	55	50	3	4	128
	Smokers	1	0	10	20	6	4	41
	Ex-smokers	0	0	5	02	2	2	11
	Total	10	7	70	72	11	10	180
Control Area	Non-smokers	6	9	29	40	1	4	89
	Smokers	0	0	10	5	5	4	24
	Ex-smokers	0	0	0	6	0	1	7
	Total	6	9	39	51	6	9	120

Table 3: Age of the school children

SCHOOL		AGE
Ganesh Public School	Mean	8.28
	Minimum	4
	Maximum	14
	Std. Deviation	2.320
	Std. Error of Mean	.261
Nabin English School	Mean	7.82
	Minimum	4
	Maximum	12
	Std. Deviation	2.301
	Std. Error of Mean	.292





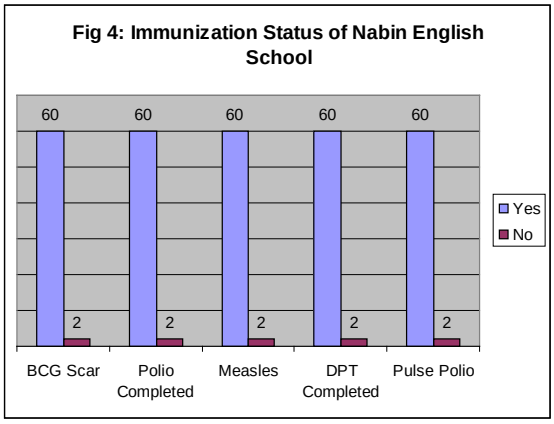


Table 4: The International Classification of underweight, overweight and obesity according to BMI[9]

BMI	Remarks
< 16	Severe Malnutrition
16 – 16.99	Moderate Malnutrition
17 – 18.49	Mild Malnutrition
18.50 – 24.99	Normal
25 – 29.99	Moving Towards Obesity
≥ 30	Obesity

Table 5: Distribution of BMI among the students of two schools

	Ganesh Public School	Nabin English School	Std. Error of Difference	P value
Mean BMI ±SD	21.30±4.96	25.11±6.15	0.94	0.001

BMI = Weight in Kg/ (Height in m)^2

Table 6: Systemic examination of students

		School		Total Students (141)
		Ganesh Public School	**Nabin English School**	
Pallor	No	77	62	139
	Yes	2		2
Wax in ear	No	21	25	46
	Yes	58	37	95
Nasal abnormality	No	75	62	137
	Yes	4		4
Abdominal distension	No	75	62	137
	Yes	4		4
Enlargement of cervical lymph nodes	No	73	59	132
	Yes	6	3	9

Table 7: Comparison of enlarged tonsil among the students from Ganesh and Nabin School:

School	Tonsil		OR (95% CI)
	Enlarged	Not Enlarged	
Ganesh Public School	55	24	4.17 (2.05, 8.45)
Nabin English School	22	40	Reference

Table 8: Comparison of inflamed throat among the students from Ganesh and Nabin School:

School	Throat		OR (95% CI)
	Inflamed	Not Inflamed	
Ganesh Public School	58	21	4.08 (2.01, 8.33)
Nabin English School	25	37	Reference

Table 9: Average Level of Air Pollutants in Duwakot VDC

Date	Time	Pollutants (mg/m^3)				
		PM_{10}	TSP	SO_2	NO_x	CO
29th and 30th July 2004 (Brick kilns not operating)	10:00-17:30	0.029	0.033	ND*	ND*	ND*
20th and 21st April 2005 (Brick kilns operating)	10:00-17:30	0.050	0.056	ND*	ND*	ND*

** Not Detected*

Discussion

Brick kilns are known to be a leading cause of ambient air pollution. The levels of TSP and PM10 are major problems in Kathmandu because these levels are significantly higher than WHO guidelines and particulate matters cause health problem, particularly in the respiratory system.[1]

The primary reason for air pollution and health hazards is the use of poor quality fuel in inefficient and outdated technology such as Bull's Trench kilns. Most of the brick kilns use Assam coal, which contains high level of sulphur. Burning of this coal produces high level of sulphur dioxide. It not only has bad effect on human health, but also damages the metallic chimneys of kilns so they don't last long. According to a study, 70 percent of the fuel used by brick kilns is coal, 24 percent is saw dust and the remaining 6 percent is wood and others.[10] The consequences of exposure to ambient air pollutants is very hazardous to human health as it can cause a number of respiratory and other health effects leading to high mortality and morbidity.[11] Tinier the particulate matter deeper inside the respiratory tract it goes. School children are more vulnerable due to their continuous physiological growth and enhanced susceptibility to such exposures. Inclusion of school children for thorough health examination was based on the same ground.

The school children involved in our study were from similar socio economic background and their general hygiene status was similar. However, systemic examination of the children revealed that the children studying in Nabin English School located far away from the vicinity of the brick kilns were having better health status compared to the students from Ganesh School.

Household environmental health survey in our study revealed that significantly higher number of residence (76%) from the brick kiln operating areas had complaints about smoke related discomforts. Ninety five percent (95%) respondents in the affected area had suffered from some respiratory disease or common cold in last one year compared to 51% respondents from the control area.

Ambient air quality monitoring conducted in Tikathali VDC of Lalitpur district showed that levels of air pollutants like TSP, PM10, Sulphur Dioxide (SO2) and Nitrogen Oxides (NOx) were three times higher during the brick kiln-operating season than during off-season. Average value of PM_{10} for the pre operation time was 217.95 µg/m^3 where as it reached 602.16 µg/m^3 during the brick kiln operation time. Similarly TSP value has been found to be 265.49 µg/m^3 during pre operation time and 633.78 µg/m^3 during operation time.[8] However, they did not conduct the air quality monitoring at the breathing zone level using low volume sampler. All those measurements were done using high volume samplers.

The results of monitoring done in this study were not as high as in that study as the measurements were done with low volume samplers. The levels of the TSP and PM_{10} monitored during both brick kiln operating and off season periods were within permitted exposure limits. Nevertheless, though insignificant, the level of TSP and PM_{10} was relatively higher during brick kiln operating time. The presence of CO, SO_2 and NO_X was not detected by the Drager Pump and Tube during the brick kiln operation as well as non operating time. Ambient air quality monitoring using high volume sampler could not be performed in this study due to budgetary constraints.

Though the level of different air pollutants were not significantly high at the breathing zone level, the health survey done during this study clearly showed that people living near brick kilns are more likely to suffer from illnesses related to the pollution caused by the kilns, compared to people living in areas without the kilns. Health examination of children studying in the schools showed that the health of the children exposed to emission from brick kilns was worse than the health of the children in the control area. That health effect could be due to continuous exposure to relatively low concentrations of fine particles. Odds ratios for enlarged tonsil (4.17) and inflamed pharynx (4.08) among the students from Ganesh School were statistically significant.

Ambient air samplings were done only twice, once during the brick making season and once during the off season. The health examination was consisted of inspection by the medical doctors. Detail tests were not performed. Similarly, the account of indoor air pollution from biomass smoke was not ruled out in the study. Various studies have proved that solid biomass smoke can cause respiratory diseases like URTI, LRTI, COPD, sinusitis, otitis media, asthma etc.[12,13] The study was also confined to a limited area. These were the main limitations of the study. The author would like to suggest conducting a similar study with the inclusion of many study areas that can represent the overall ambient air pollution due to brick kilns in Nepal. At present, various sophisticated tools with highly accurate measurements are available in the market.

Conclusion

Ambient air pollution due to brick kilns in the rural areas is a real problem. The study has revealed that the health status of the children attending the school located in the area without the brick kilns was better than those of the children from the school with brick kilns in the vicinity. The level of different air pollutants in the ambient air was higher during the operation of brick kilns.

A wide range of interventions are available to reduce ambient air pollution due to brick kiln in Nepal. Measures like shutting down illegal kilns, introduction of cleaner technologies such as vertical shaft kilns and fixed chimney kilns, substitution of traditional kilns with newer technologies, suggesting standards for emission from brick kilns will significantly reduce the air pollution as well as lower cost of production because of savings in fuel consumption. Similarly, provisions should be made that brick kilns are constructed away from the residential areas. Programmes should be instigated to ensure that the local people, brick kiln owners and the workers in the kilns are aware of the environmental and health impacts of the kilns. Proper steps should be taken to prevent the students who have to stay long hours in classrooms without proper ventilation from exposure to various chemical hazards present in the emissions from brick kilns.

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References

1. The World Bank, URBAIR Urban Air Quality Management Strategy in Asia: Kathmandu Valley Report, New York, USA, 1997.
2. Assessment of the Applicability of Indian Cleaner Process Technology for Small Scale Brick Industries of Kathmandu, Metropolitan Environment Improvement Programme, Kathmandu, 1995.
3. Pope CA et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. Journal of the American Medical Association, 2002; 287:1132– 1141.
4. Schwartz J. Air pollution and hospital admissions for respiratory disease. Epidemiology, 1996; 7(1): 20–28.
5. Pope CA, Dockery DW. Acute health effects of PM10 pollution on symptomatic and asymptomatic children. The American review of respiratory disease, 1992; 145: 1123–1128.
6. Donaldson K. et al. Ambient particle inhalation and the cardiovascular system: potential mechanisms. Environmental health perspectives, 2001; 109(Suppl 4): 523–527.
7. Bobak M. Outdoor air pollution, low birth weight, and prematurity. Environmental health perspectives, 2000; 108: 173–176.
8. Tuladhar B, Raut AK, Clean Energy Nepal: Environment & Health Impacts of Kathmandu's Brick Kilns, June 2002, Kathmandu
9. WHO Global Database on Body Mass Index (http://www.who.int/bmi/)
10. Environment and Public Health Organisation, Status of Brick Kilns in the Kathmandu Valley, ENPHO, Kathmandu, 2001.
11. World Bank 2003, 'Health Impacts of Outdoor Air Pollution'. South Asia Urban Air Quality Management Briefing, paper No. 11
12. Joshi SK. Solid Biomass Fuel: Indoor air pollution and health effects. Kathmandu University Medical Journal (KUMJ), 2006; 4 (2): 141- 142.
13. Shrestha IL, Joshi SK. Situation Analysis of Indoor Air Pollution and Development of Guidelines for Indoor Air Quality Assessment and House building for Health. Nepal Health Research Council, July 2004