International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Toxicological Impact of Brick Kiln Emissions on the Liver of Brick Kiln Workers and Residents

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Abstract:
Pakistan is the third-largest brick-producing nation in South Asia, behind China and India. In Pakistan, there are over 20,000 brick kilns and 1.8 million brick kiln employees, 50% of them are in Punjab. Brick kilns in rural Punjabi communities like district Narowal still use antiquated methods and are subject to bad laws, which has a negative impact on people's health. A cross-sectional study was carried out in the Narowal district from January 2021 to January 2022 to examine the toxicological effects of brick kiln emissions on the liver. The participants were divided into three groups based on their demographic profiles in order to examine the relationship between appropriate liver function indices, such as ALT, AST, ALP, and bilirubin, and demographic factors like age, BMI, smoking index, and length of employment among exposed (residents and workers) and control groups. The outcome demonstrated that exposed workers and residents had mean ALT (p, 0.001), AST (p, 0.001), and ALP (p, 0.002) levels that were considerably higher than reference values. Bilirubin, a measure of the liver, remained negligible. Blood chemistry tests cannot establish the presence of liver disorders. Therefore, molecular-based follow-up investigations are required to assess the health concerns related to emissions from brick kilns.

Introduction

Bricks have been played a crucial role in the construction of buildings (Zhang et al., 2018). Pakistan, which produces 45 billion bricks annually, is the third-largest brick-producing nation after China and India (Saed et al., 2017). Brick kiln industries in Pakistan contribute 1.5% of the overall GDP. Pakistan has 20,000 brick kilns with 1.8 million workers (Ishaq et al., 2010; Kamal et al., 2014). In Punjab, there are 10,347 brick kiln sites with 249,682 workers, and 87,133 families employed at brick kiln locations and only the Narowal district has 181 brick kilns, with 2100 brick kiln workers according to the survey report of LHRD. The primary cause of air pollution and public health are these brick kilns. Due to a lack of adequate space allocation, they are frequently built next to roadways or near agricultural area, and their emissions endanger the lives of workers as well residents (Ercelawn and Nauman et al., 2004). Mostly brick kilns use lignite and inexpensive fuel in which about 70% of firewood, 24% of dust, 6% of wood, and cheap coal (Son et al., 2012; Brunekreef et al., 2009). The brick kiln emission contains heavy metals such as Cd, Hg, As, Al, Cr, Cu, Pb, and Ni as well as oxides of S, N, and C, which affect human health and environment. CB is produced by incomplete combustion which has both physical and climatic interaction (Bond et al., 2013).Presence of SO2, CO, CO2, NOx, and PM in brick kiln emission have a detrimental impact on both human health and environment (Alam, 2019). Inhalation of SO2 can harm the liver. The liver's microsomal electron transport system is similarly perturbed by exposure to NO2 (Takahashi et al., 1986).

Due to their stability, xenobiotic nature, and lack of biodegradability, heavy metals released from brick kilns are particularly dangerous. If taken once, they may stay in the body. Even at trace quantities, heavy metals like Cd, As, and Pb can be extremely hazardous (Miller et al., 2003). Once within the body, these heavy metals create complex chemicals in the cells and tissues that cause diseases. Consuming these heavy metals can lead to hepatic dysfunction since they are absorbed into the body and become part of the liver (Bhargava et al., 2017). Acute Pb toxicity may cause the liver to malfunction, which can lead to illness and even death. Liver damage might result from excessive Cu uptake (Anarado et al., 2019). Chromium is a metal that penetrates the body through the lungs and is linked to liver damage. When it builds up in the liver, it has a negative impact on people's health (Kim et al., 2019). Hepatotoxic effects are also brought on by exposed to Hg and As due to the disruption of liver enzyme control (Deng et al., 2013). Every year, thousands of people died due to hazardous chemicals emited from brick kiln (Alam, 2019). Particulate matter (air pollutants) led to liver genotoxicity and lung inflammation (Liu et al., 2005). The heart, liver, airways, and testicles all showed reduced levels of lipid peroxidation after exposure to PM 2.5, demonstrating that it is a systemic contaminant that is carried by the air (Bourdon et al., 2012).

The liver is the largest gland and a crucial organ in the human body. It is involved in metabolite emission, detoxification, glycogenesis, albumin formation, and the generation of coagulation factors. Lead exposure in the workplace has been linked to abnormal liver function and oxidative stress in liver tissue (Onyeneke et al., 2016). Similar to the Liver Function Test, liver enzymes and total bilirubin are used to assess the health of the liver (Green et al., 2002). When their quantities surpass the usual values, the usage of heavy metals can result in both non-carcinogenic concerns such neurological association, liver illness, and nuisance risks as well as carcinogenic risks like various types of cancer (EPA, 2000).

The primary benefit of this study is to investigate the physical and environmental issues brought on by the terrible emissions from different kinds of factories in Pakistan. According to reports, the main cause of smog and respiratory ailments in Pakistan is brick kilns. For this reason, the administration of the Province of Punjab ordered that brick kilns be shut down for four days each week throughout the winter. Despite this, there is growing number of skin and respiratory problems. The pollutants from brick kilns are thought to be the primary causes of these issues, according to specialists. This study's main goal was to assess how well clay brick workers and locals in NAROWAL who had been exposed to brick kiln emissions at work were doing with regard to their hepatic functions. The purpose of this study is to determine how these hazardous emissions affect human liver health. The effects of brick kiln emissions on human livers have received little attention in Pakistan, although the overall effects on the body have been the subject of numerous sorts of research. It contributes to the body of literature by investigating the potential systemic impacts of brick kiln emission further. Among brick kiln employees in Narowal, this is the first study of its kind to be conducted.

Metarials and methods

Study design

The present study was conducted in physiology at the faculty of biological science, university of Sialkot, Sialkot Pakistan. To study the effects of brick emission on the liver, different brick kiln sites Selected in different regions of district Narowal, Punjab Pakistan. Blood samples and data collection started from January 2021 to January 2022.

Selection of brick kiln sites

Different brick kiln sites from Narowal were selected for the present study. Different brick kiln sites were visited for the sake of permission of brick kiln owners. About 40 brick kilns were visited but only 25 brick kiln site owners permitted the collection of blood sampling and participation in the present study.

Questionnaire design

After a detailed literature review and keeping in view the variables and indicators of the demographic and health surveys, a questionnaire was designed. The questionnaire comprised both open-ended and closed-ended questions to obtain both qualitative and quantitative data. The questionnaire was divided into the following parts

- **Socio-demographic part:** In which include name, age, sex, education, and height, and weight, type of work, residency, and location of brick kiln, working duration, monthly wages, and working experience.
- **Smoking habits:** In which include smoking habits, types of smoking, and smoking routines.
- **Medical history:** This includes any liver disorder or any other diagnosed disease.

Participant selection

Random participants were selected from brick kiln sites and the resident's people near brick kiln sites. The people who lived in the same district served as a control group. The participants were interviewed with a detailed questionnaire to collect information about their socio-demographics, smoking habits, and medical history. After the collection of data, the subjects were classified into three groups.

- Brick kiln workers (Group I)
- Resident people (Group II)
- Control group (Group III)

Body mass index

BMI= weight (kg)/ height (m2)

The body mass index was calculated in the form of a ratio of weight in kilograms and height in meters squared.

Blood sampling

Blood samples were collected by the vein puncture in a 5ml syringe with the help of an expert male nurse for the analysis of liver function test LFT which included

- Albumin
- Total protein
- ALP
- ALT
- AST
- Bilirubin

Liver function test LFT

Liver function tests ‘’ (LFTs or LFs)’’ also known as the hepatic panel, are groups of blood tests that give information about the condition of a patient's liver (Lee et al., 2009).

These tests are helpful for the detection of liver disease and also help to maintain the extent of liver damage (Kwo et al., 2017).

Results

A survey was conducted to collect the exact data for the result in district Narowal, more than 40 brick kiln sites were visited for that purpose. A survey has three sections.

1. Socio-demographic profile of the respondents
2. Smoking habits profile of the respondents
3. Health profile of the respondents.

Socio-demographic profile

According to the study, 10.9% of respondents were under 20 years old; 16% were >20 and <30; 21.4% were between the ages of >30 and <40; and 51.7% were beyond the age of 40. Among the respondents (93.6% workers and 6.4% residents), 96.4% were men and 3.6% were women. Of the respondents, 55.1% were illiterate while 8.4% had completed the metric exam, 26.5% had passed the middle exam, and 10% had passed the primary exam (Table 4.1). The survey found that the majority of respondents (93.6%) were workers and also lived nearby villages. 6.4% of respondents who answered the question about residents had lived in or close to the research area for more than 20 years (Table 4.1). Nearly half of the population, 48.25%, resided <1km ; 33.7% of respondents were 1 km and 18.1% were 2-5 km away from brick kiln sites. Of the workers, 28.9% made bricks, 24.1% transported bricks, 13.3% arranged bricks, 25.3% worked with coal, 4% were supervisors, and the other 4.4% did other jobs. 10% of workers worked for <7 hours, whereas 83.7% of workers worked for <6 hours, and 6.3% worked >7 hours. The majority of the workforce had long employment histories; 47.7% had worked for >10 years, 31.7% for <10 years, 12.8% for <5 year, and 7.8% for <1 year. A total of 75.7% of the responders were under 5 feet tall, while only 24.3% were over 5 feet tall. Among all the respondents 9.9% weighed under 40kg, 65.7% were under 50kg, and 24.4% were over 50 kg (Table 4.1).

Table 4.1: Socio-demographic profile of the respondents

Variables	**Respondents (%age)**
Age	
Below 20 year	10.9%
Below 30 year	16%
Below 40 year	21.4%
Above 40 year	51.7%
Gender	
Male	96.4%
Female	3.6%
Educational Qualification	
Primary	10%
Middle	26.5%
Matric	8.4%
Illiterate	55.1%
Occupation	
Workers	93.6%
Inhabitants	6.4%

Height	
Less than 5ft	75.7%
Greater than 5ft	24.3%
Weight	
Less than 40kg	9.9%
Less than 50kg	65.7%
Above 50kg	24.4%
Type of worker	
Brick making	28.9%
Brick transporter	24.1%
Brick arranger	13.3%
Coal workers	25.3%
Supervisor	4%
Other	4.4%
Duration of work	
Less than 6 hour	83.7%
Less than 7 hour	10%
Greater than 7 hour	6.3%
Working experience	
Less than 1 year	7.8%
Less than 5 year	12.8%
Less than 10 year	31.7%
Greater than 10 year	47.7%
Distance from brick kiln	
Less than 1km	48.2%
1 km	33.7%
2-5 km	18.1%

Smoking habits profile

The respondents' smoking habits were the subject of the survey's second section. 44.6% were active smokers while 55.4% were passive or non-smokers. All the smokers smoked only cigarette in which 68.7% smoked frequently and remaining smoked rarely (Table 4.2).

Table 4.2: smoking habits profile of respondents

Variables	**Respondents(% age)**
Smoking habit	
Smoker	44.6%
Non-smoker	54.2%

Type of smoker	
Active	44.6%
Passive	55.4%
Smoking type	
Cigarette	100%
Vine	0%
Ice	0%
smoking routine	
Frequently	68.7%
Rarely	31.3%

Health profile:

The respondents' health profiles were covered in the third section of the survey report. 48.2% of the respondents were physically unhealthy while 51.8% were physically fit. Only 44.6% of all respondents had a medical history, while the remainder were all in good health. Due to their low socioeconomic status, the respondents had no idea what real ailments they had because they had not undergone any official medical testing, but 48% felt backbone pain, 21.7% had breathing issue. Among all 75.6% had <2 year disease duration and 24.4% had >2 year. All the brick kiln sites have safe water availability. Only 3.6% workers said that they had liver disorder according to the survey report.

Table 4.3: Health profile of the respondents

Variables	**Respondents (%age)**
Physical appearance	
Healthy	51.8%
Unhealthy	48.2%
Medical history	
Yes	44.6%
No	55.4%
Type of Disease	
Backbone pain	48%
Breathing issue	21.7%
Nill	31.3%
Availability of water	
Yes	100%
No	0%
Disease duration	
Less than 2 year	75.6%
Greater than 2 year	24.4%
Liver disorder	

Yes	3.6%
No	96.4%

Table 4.4: Demographic characteristics of the studied population

	Control group (mean±S.D)	**Exposed group** (Mean±S.D)	**P value**
Age (Years)	39.87±12.023	46.91±14.722	0.053
Smoking index	10.093±13.4013	13.164±17.2658	0.008
Body mass index(BMI)	22.400±2.8400	24.146±4.0129	0.002
Employment Duration(years)	----------	14.649±13.2235	<0.001

*** T-test**

Results from the brick kiln emission study indicated that Demographic data from the study population are presented in Table 4.4.

The exposed and control groups were matched in age, BMI, and smoking history. The mean duration of employment for the exposed workers was 14.649±13.2235 years. On average, they worked 12-hour shifts, 5 days a week. (We did not observe workers regularly using protective equipment OR workers did not report regularly using protectiv1e equipment). In the sample, 51.8% of all exposed workers were physically healthy. Of these cases, 48.2% were diagnosed as unhealthy (Table 4.4)

Table 4.5: Liver functions, AST, ALT, ALP, and Bilirubin in exposed and control workers

	Control group	**Exposed group**	**P**
Aspartate aminotransferase (AST)	34.73±12.731	44.69±19.015	0.054
Alanine transaminase (ALT)	36.33±12.315	43.31±23.438	0.021
Alkaline phosphtase (ALP)	252.20±48.802	276.49±89.687	0.020
Billirubin	0.773±0.1831	0.663±0.2276	0.001

t-test

ALP: alkaline phosphatase

AST: aspartate aminotransferase

ALT: alanine aminotransferase

T-test was used to compare the liver functions parameters with the control group. In the exposed workers, the mean level of liver function tests except for Bilirubin, ALT, AST, and ALP was significantly higher in the exposed group compared to the control group (Table 4.5). Bilirubin was significantly lower in the exposed group compared to the control group (Table 4.5).

Table 4.6: Demographic data, liver functions in the exposed and control groups.

	Control group	Workers	Residents	Fdf (2, 47)	p-value
Age (years)	39.87±12.023	46.96±14.627	46.80±15.754	.683	0.010
Smoking index	10.093±13.4013	13.030±16.7464	13.500±19.4465	.821	0.046
Body mass index (BMI)	22.400±2.8400	24.432±4.3972	23.430±2.9113	1.943	0.055
Duration of employment	.000±.0000	12.988±12.3835	46.800±15.7537	32.707	<0.001
Alanine transferase (ALT)	36.33±12.315	34.36±16.327	65.70±24.185	3.782	0.030
Aspartate aminotransferase (AST)	34.73±12.731	37.72±9.529	62.10±25.536	14.152	<0.001
Alkaline phosphtase (ALP)	252.20±48.802	255.52±80.122	328.90±94.844	1.353	0.048
Billirubin	.773±.1831	.628±.2189	.750±.2369	.135	0.874

Data were presented as Mean±SD
Multivariate analysis of variances (MANOVA)
***P value, 0.05**

Multivariate MANOVA was used to compare the means of control group with exposed workers and residents. A statistically significant difference was found between groups regarding liver functions. A post hoc test for the ANOVA showed that the mean level of ALT was higher significantly in workers of exposed group, and lower in the residents compared to control group (P, 0.030). AST level was higher significantly in exposed group workers and residents compared to control group (P, <0.001). ALP level was also higher significantly in exposed group workers and residents compared to control group (P, 0.048) (Table4.6).

Table4.7: Pearson correlations in the exposed workers measured parameters with age, smoking index, body mass index (BMI), and duration of work

	ALT	AST	ALP	Billirubin
Age r	.010	.200	.051	-.177
p- value	.945	.164	.726	.219
Smoking Index r	-.049	.044	-.152	-.016
p-value	.737	.759	.291	.914
BMI r	-.199	.096	-.062	-.080
P-value	.167	.507	.668	.581
Employment duration r	.514**	.602**	.303*	-.065
p-	**<.001**	**<.001**	**.002**	.655

value				

****. Correlation is significant at the 0.01 level (2-tailed).**

***. Correlation is significant at the 0.05 level (2-tailed).**

Pearson correlation between different variables in the exposed group (Table 4.7) revealed a significant positive correlation between ALT and duration of employment (P, <0.001) and between AST and duration of employment (P, <0.001). ALP is also significantly positively correlated with duration of employment (P, 0.002) (Table 4.7). The analysis was done by Statistical Package for Social Science Version 18.0 software program (SPSS version 18.0) and a P value < 0.05 was considered statistically significant.

Disscusion

Occupational exposure to brick kiln emission in our study increased the risk of hepatic dysfunction in the exposed workers who showed the significant elevation of liver enzymes except billirubin. Numerous studies revealed that the liver enzymes ALT, ALP, and AST in exposed employees and residents varied significantly depending on their age, body mass index (BMI), smoking status, and length of employment at brick kiln sites, among other variables (Kamiike et al., 1989; Green, 2002; Aryapuraviraja et al., 2008).

In our study, serum ALT was significantly elevated in all worker groups (p, 0.032). ALT is a helpful biomarker for hepatic injury and is present in a variety of soft tissues, but it is most frequently associated with the liver (Kim, 2008). It was also clear in our study that all exposed groups' exhibit significantly higher serum AST activity (p, 0.001).

Fatty liver is the first symptom of liver disease. As it worsens, it develops into cirrhosis of the liver, liver cancer, and hepatitis. Blood chemistry tests cannot detect liver illness, however in clinical settings; ALT is most frequently utilized as a biomarker of liver impairment. ALT, AST, and GGT in the liver function test might be raised by organ disease in addition to the liver (Green, 2002). As a result, different biochemical indicators of liver function, such as bilirubin and albumin of alkaline phosphates, should be assessed in order to maximize sensitivity (MEL, 2009). Due to the impact of brick kiln emission, the duration of workers' employment was significantly positively connected with ALT. This outcome was supported by numerous authors. (Krier et al., 2009; Ritis et al., 1965; Wroblewski, 1959; AGA, 2002).

The cytoplasmic enzyme known as ALT is used to transfer an amino group from alanine transferase. Although it can be found in many tissues, ALT is frequently linked to the liver. As a result, ALT is a reliable biomarker of hepatocellular damage (Kim, 2008). An amino group is transferred from aspartate using the enzyme AST. The mitochondria contain more than 80% of the AST, with the remaining 20% found in the cytoplasm. So, although mitochondrial AST (mAST) stays in the inner areas of a damaged cell, cytosolic AST (cAST) quickly manifests in the blood from an injured cell. mAST in the blood thus represents the more severe cell necrosis or damage (Kamiike et al., 1989).Particularly affected in cases of alcoholic hepatitis are the mitochondrial AST so rises more than ALT (Kim, 2008). In our study ALT and AST both were increased, elevated AST and ALT are indicators of liver damage (Kim, 2008; Minuk et al., 1998; Yuen et al., 2005; Jamali et al., 2008; Mohamadnejad et al., 2003; Prati, 2002).

On the other hand in our study, brick kiln emission had no effect on the level of bilirubin in the exposed workers. No appreciable change in serum bilirubin was also noticed in previous study (Dey et al., 2015; Chong et al., 2013). In our study ALP (p, 0.002), ALT (p, <0.001) and AST (p, < 0.001) were significantly positively correlated with the duration of employment.

This investigation focused on the consequences of brick kiln emissions. The findings show that the mixed exposure group's liver function index was higher than that of the control group. The heavy metals released by the brick kiln could be the cause of this rise. Thus, it can be hypothesised that the liver is more hazardous from brick kiln emissions than from other sources. Numerous research have been done on the impact of brick kiln emissions on various human organs (joshi and dudani, 2008; Guttikunda et al., 2009; Hofer, 1994).

Contrarily, other writers noted that even a normal liver function test does not guarantee that a patient is free of liver disease. Consequently, some people with moderate liver disease may be among the general population who are assumed to be in good health (Pratt, 2000; Prati et al., 2002). Additionally, the enzymes AST and ALT are found in cells and are released into the blood in cases of cell necrosis or injury. As a result, from the standpoint of the meaning of AST and ALT in a liver function test, the term "function" is inaccurate (Kim, 2008) because they are biomarkers that identify the degree of cellular "damage." In spite of the fact that the AST and ALT are within normal range, a recent prospective cohort research by Kim et al. (2004) found a correlation between the death rate from liver illness and the elevation of AST and ALT.

Due to the epidemiological methodology used in this investigation, there were some restrictions. We were unable to perform a liver biopsy on the consenting groups with abnormal liver enzymes. We only focused on the exposed population's long-term exposure because they had lived in the contaminated area since birth, and we paid no attention to their gender or occupation. Future research may be based on a clinical approach of the current findings regarding liver enzymes and brick kiln emissions.

Conclusion

When it comes to air pollution, brick kiln emissions are the main cause of environmental degradation and worker health issues. Brick kiln emissions contain a variety of harmful substances, including carbon black, particulate matter, heavy metals, and gas oxides. The liver physiology of employees and residents is disturbed by long-term exposure to particulate matter and gaseous contaminants. The findings demonstrated that exposed workers and residents' blood levels of serum ALP, ALT, and AST were rising. On the other hand, there was no discernible change in serum bilirubin. This study proved that exposure to brick kiln emissions over an extended period of time lead to liver toxicity, which was seen as a marked increase in the blood levels of ALT, AST, and ALP.

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