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Evaluation of Health Status of Turkish Ceramic Workers

Türk Seramik İşçilerinin Sağlık Durumlarının Değerlendirilmesi

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ABSTRACT

Objectives: The aim of this study was to evaluation of health status of Turkish ceramic workers (n=99). For this purpose, leukocyte (WBC), hemoglobin (HGB), haematocrit (HCT), thrombocyte (PLT), alanine aminotransferase (ALT), aspartate aminotransferase (AST), creatinine (CR), arsenic (As) and mercury (Hg) levels were investigated in workers and their controls (n=81). Also spirometry tests, chest radiographs and workplace dust measurement were analyzed.

Methods: As and Hg levels determined by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). AST, ALT and CR levels were analyzed by Konelab Prime 60i auto-analyzer while Hb, PLT, WBC numbers and HCT percentages were measured by Coulter LH780. Chest radiographs of workers were taken by using a short exposure time with high voltage technique. Standard spirometry measurements of workers and controls were done with a dry seal spirometry Dust samples were collected with badge dosimeter and analyzed by gravimetrically.

Results: In this study, WBC, PLT, AST, ALT, CR, As and Hg levels of workers higher while HGB and HCT levels lower than the controls. 38 workers were diagnosed with silicosis, 9 workers were suspected to have silicosis, whereas 52 workers were found to be healthy. Average value of FEV1/FVC ratios was found to be 81.430±5.314 (Mean ± SD) for workers and 81.31±5.22 (Mean ± SD) for controls. The mean concentration of respirable total dust in workplace was 3.58 mg/m^3

Conclusion: Ceramic workers must be considered as risky persons as their working conditions affect many organs and systems in their body such as liver, kidney and hematopoetic system.

Keywords: Ceramic workers; silica; hematopoetic system; liver; kidney

ÖZ

Amaç: Bu çalışmanın amacı Türk seramik işçilerinin (n=99) sağlık durumlarını değerlendirmektedir. Bu amaçla, işçiler ve kontrol grubunda (n=81) lökosit (WBC), hemoglobin (HGB), hematokrit (HCT), trombosit (PLT), alanin aminotransferaz (ALT), aspartat aminotransferaz (AST), kreatinin (CR), arsenik (As) ve cıva (Hg) düzeyleri incelenmiştir. Ayrıca, solunum fonksiyon testleri, göğüs radyografileri ile işyerindeki toz ölçümü de analiz edilmiştir.

Gereç ve Yöntemler: As ve Hg düzeyleri, İndüktif Olarak Eşleştirilmiş Plazma-Kütle Spektrometresi (ICP-MS) ile ölçülmüştür. AST, ALT ve CR düzeyleri Konelab Prime 60i otomatik sistem ile analiz edilirken; Hb, PLT, WBC sayıları ve HCT yüzdeleri Coulter LH780 hematolojik analiz sistemi ile ölçülmüştür. İşçilerin göğüs radyografileri kısa maruziyet süreli, yüksek voltaj tekniği ile çekilmiştir. İşçilerin ve kontrol grubunun solunum fonksiyon testleri kuru pistonlu spirometre ile yapılmıştır. İş yerinden toz örnekleri yaka dozimetresi ile alınıp, gravimetrik olarak analiz edilmiştir.

Bulgular: Bu çalışmada işçilerin kontrole göre WBC, PLT, AST, ALT, CR, As ve Hg düzeyleri yüksek bulunurken HGB ve HCT düzeyleri düşük bulunmuştur. 38 işçi silikozis tanısı almış, 9 işçide silikozis şüphesi olduğu saptanmışken 52 işçinin sağlıklı olduğu bulunmuştur. % zorlu soluk vermenin 1.saniyesinde atılan hacim/zorlu vital kapasite değeri işçiler için 81.430±5.314 (Ortalama ± SS) kontrol grubunda bu değer 1.31±5.22 (Ortalama ± SS) olarak bulunmuştur. Solunabilir toz konsantrasyonu ortalama değeri 3.58 mg/m^3'dür.

Sonuç: Seramik işçileri çalışma şartları nedeniyle karaciğer, akciğer ve hematopoetik sistem gibi birçok organ ve sistemin etkileneceği riskli kişiler olarak düşünülmelidir.

Anahtar Kelimeler: Seramik işçileri; silika; hematopoetik sistem; karaciğer; böbrek

INTRODUCTION

Silica (SiO_2) is a mineral compound made up of one silicon (Si) atom and two oxygen (O) atoms. It is an abundant mineral in rock, sand and soil. Quartz is a term often used to refer to crystalline silica (1). The International Agency for Research on Cancer (IARC) classified

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crystalline silica as a known human carcinogen (2). Ceramic workers are potentially exposed to chemical mixture including beryllium, inorganic lead, lime, aluminum and mainly crystalline silica, that can be associated with an increased risk of several cancers, pulmonary tuberculosis, asthma, chronic bronchitis, emphysema, renal and autoimmune diseases and also silicosis (3,4,5). Although health risks of occupational silica-containing dust exposure have been evaluated in coal miners, foundry, pottery, granite foundry and cement plant workers, sandblasters and stone crushers, occupational exposure to silica dust in workers is still considered to be an important health problem especially in developing countries. Occupational Safety and Health Administration (OSHA) has estimated that more than 2 million workers are exposed to crystalline silica dust in the general, maritime and construction industries (6). There were an estimated 3600-7300 newly recognized silicosis cases per year in the United States from 1987 to 1996 (7). In Turkey, 115 silicosis and silicotuberculosis cases have been recorded in 2014 according to the recent Statistical Yearbook of Ministry of Labour and Security of Turkey. These records comprised only the workers covered by the social security system (8).

Arsenic (As) is a naturally occurring element widely distributed in the earth's crust. As appears in Group 5 (V) of the periodic table and it is classified chemically as a metalloid, having both properties of a metal and a nonmetal. Occupational sources of As to human workers include vineyards, ceramics, glass making, smelting and refining of metallic ores, during production and use of As containing agricultural products like pesticides and herbicides. IARC has conducted that there is sufficient evidence that inorganic As compounds are skin and lung carcinogens in humans (9). Mercury (Hg) and its compounds are recognized as potentially hazardous materials and are rated as top category of environmental pollutants. Methylmercury compounds are classified as possible human carcinogen by IARC (10).

Ceramic industry, an important industry in Turkey, has a history of ceramic production reaching back thousands of years, from the primitive sculpture of prehistoric Anatolia to the ornaments and crockery of the Hitites and the ornate hand-painted tiles of Iznik. Turkey is ranked as one of the top five ceramic tile and ceramic sanitary ware exporters of the world (11). The aim of this study was to evaluation of health status of Turkish ceramic workers. For this purpose leukocyte (WBC), hemoglobin (HGB), haematocrit (HCT), thrombocyte (PLT), alanine aminotransferase (ALT), aspartate aminotransferase (AST), creatinin (CR), As and Hg levels were investigated in workers (n=99) and their controls (n=81). Besides, the measurements related to workplace respirable total dust levels, chest X-ray films and spirometry tests of the subjects were evaluated.

EXPERIMENTAL

This study was approved by XX University Clinical Research Ethical Committee (Date and Number: 20/11/2014, KA-14038).

Subject selection

The study group consisted of 99 male workers from a Turkish Sanitary Ceramic Plant exposed to crystalline silica-containing dust. Male office workers (n=81) without dust exposure comparable for age and smoking habits to the workers were selected as the control group. In order to mitigate the influences of environmental factors, all male participants were selected from same geographical region. Each participant completed a detailed questionnaire which included questions regarding working conditions, possible confounding factors such as smoking, alcohol consumption and nutritional habits. Written informed consent was obtained from the donors.

Radiological examination and spirometry test

Posteroanterior chest (PA) radiographs of workers were taken in the radiology clinic of XX Hospital. A short exposure time with high voltage technique was used (Trophy UFXRAY, 500 mA, TM). The radiographs were read by a specialist according to the International Labour Office classifications (12).

Standard spirometry measurements of workers and controls were done with a dry-seal – spirometry (Zan 100, nSpire Health Inc., Oberthulba, Germany). Pulmonary function tests were interpreted in accordance with the American Thoracic Society standards (13).

Exposure measurements

Collection and measurement of the dust samples were performed by a nationally accredited laboratory. Dust samples were collected from the level of respiration on the daily shift (8 h) of workers with badge dosimeter (Buck, Libra Plus-5). The pore size of cellulose membrane filters was 0.8 μm. Respirable total dust concentrations in mg/m^3 were measured by the gravimetric analyses according to the Health and Safety Executive method MDHS 14/3.

Urine As and Hg Measurement

As and Hg levels of workers and controls were determined in the morning spot urine samples using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) (Agilent 7700 series, Tokyo, Japan). Urine samples were collected in sterile plastic pots and then diluted 1:10 with 5 % pure nitric acid solution. Standard solutions of As and Hg were prepared by the dilution of certified standard solutions (High Purity Standards, Charleston, SC, USA). Two levels quality control materials were used (Seronorm, Billingstad, Norway). The calibration curve ranged from 0 to 100 μg/L.

Biochemical and Hematological Parameters

AST, ALT and CR levels of workers and controls were analyzed by Konelab Prime 60i auto-analyzer (Thermo Scientific, Wilmington, DE, USA). Hb, PLT, WBC numbers and HCT percentages were determined by Coulter LH780 (Brea, CA, USA).

Statistical analysis:

Analysis of data was performed using the computer program SPSS 20.0 for Windows (IBM Analytics, New York, USA). The distribution of

the data was checked for normality using the Kolmogorov Smirnov test. The homogeneity of the variance was verified by the Levene test. Data are expressed as mean ± standard deviation for continuous variables and the number of cases per cent (%) for categorical variables. The differences among the groups with normal distribution were evaluated by Student's t test. The differences among the groups without normal distribution were evaluated by Mann Whitney U. The magnitude of linear relationship was calculated by Pearson correlation analysis. Values of $p<0.05$ were considered as statistically significant.

RESULTS

General characterization of the study subjects

The general characteristics of the study subjects are shown in Table 1. Gender was not a confounding factor for our study since the study population consisted of men only. Age, smoking and alcohol habits were comparable between subjects. The safety equipments were claimed to be used by most of the workers. 69.7 %, 61.6 % and 34.3 % of the workers used masks, gloves and safety goggles, respectively. However it was observed that the necessary equipments were not suitable for a better protection as masks were made from permeable fabrics. The average cigarette consumption of smoking workers and controls was nearly 20 cigarettes per day (Table 1).

Table 1. Demographic characteristics of the study population

Factors	Controls (n=81)	Workers (n=99)
Age (years)*	44.7 ± 9.6	35.5 ± 5.8
18-29	11 (13.6%)	16 (16.1%)
30-42	12 (14.8%)	75 (75.8%)
>42	58 (71.6%)	8 (8.1%)
Smokers	48 (59.3%)	33 (33.3%)
Non-smokers	33 (40.7%)	66 (66.7%)
Alcohol consumption		
No	81 (100%)	83 (83.8%)
Yes	0 (0%)	16 (16.2%)
Duration of Exposure (years)		
0-5		21 (21.2%)
6-10		46 (46.5%)
11-15		19 (19.2%)
16-20		13 (13.1%)
Using Protective Equipment		
Gloves		
No		17 (17.2%)
Sometimes		21 (21.2%)
Yes		61 (61.6%)
Mask		
No		30 (30.3%)
Yes		69 (69.7%)
Safety goggles		
No		57 (57.6%)
Sometimes		8 (8.1%)
Yes		34 (34.3%)

* Expressed as Mean ± SD, SD: standard deviation

Radiological examination and spirometry test

38 workers were diagnosed with silicosis, 9 workers were suspected to be silicosis whereas 52 workers were normal. According to the ILO classification, PA chest radiographs of 32, 4 and 2 silicotic workers were found to be category 1, 2 and 3, respectively.

In the spirometric evaluation to assess lung functions of ceramic workers and their controls forced expression volume in 1 second (FEV1), forced vital capacity (FVC) and FEV1/FVC ratios were measured. An obstructive pattern was defined as an FEV1/FVC ratio < 75 % (14). When workers FEV1/FVC ratios were evaluated, 13 % displayed FEV1/FVC ratios less than 75 %. Average value of FEV1/FVC ratios was found to be 81.430±5.314 (Mean ± SD) for workers and 81.31±5.22 (Mean ± SD) for controls. There were no statistically significant differences between workers and controls regarding to FEV1/FVC ratios.

Exposure measurements

The respirable total dust measurement varied according to the different parts of the plant and range from 0.89-4.12 mg/m^3 Glazing was the unit where dust concentrations were highest. The mean concentration of respirable total dust in ceramic workers was 3.58 mg/m^3.

Urine As and Hg Levels, Biochemical and Hematological Parameters

WBC, PLT, AST, ALT, CR, As and Hg levels of workers higher while HGB and HCT leves lower than the controls. There were a statistically significant difference in HGB, HCT, CR, ALT and Hg levels between workers and controls (Table 2). Difference in AST, WBC, PLT and As levels between workers and controls were not statistically significant (Table 2).

Table 2. Urine As and Hg Levels, Biochemical and Hematological Parameters of the study population

Parameters*	Controls (n=81)	Workers (n=99)
WBC (cell/mm^3)	7.5 ± 2.3	7.7 ± 1.7
HGB (g/dl)	16.1 ± 1.1	15.5 ± 1.0[a]
HCT (%)	47.5 ± 2.9	46.1 ± 3.1[a]
PLT (10^3/µL)	219.3 ± 52.5	225.5 ± 45.9
AST (U/L)	20.8 ± 7.6	21.0 ± 4.7
ALT (U/L)	25.6 ± 17.	33.1 ± 15.0[a]
CR (mg/dl)	0.7 ± 0.1	0.9 ± 0.1[a]
As	15.4 ± 11.4	16.0 ± 9.1
Hg	0.4 ± 1.1	1.0 ± 1.4[a]

* Expressed as Mean ± SD, SD: standard deviation, [a];$p<0.05$ compared to controls.

WBC; leukocyte, HGB; hemoglobin, HCT; haematocrit, PLT; thrombocyte, ALT; alanine aminotransferase, AST; aspartate aminotransferase, CR; creatinine, As; arsenic, Hg; mercury.

Investigation of correlations

There were important correlation between WBC and HGB, HCT, PLT levels; HGB and HCT, CR levels; HCT and CR levels; AST and ALT levels, CR and Hg levels (Table 3).

Table 3. Correlations of Parameters

Correlations		Pearson correlations
WBC	HGB	0.231*
	HCT	0.243*
	PLT	0.207*
HGB	HCT	0.964*
	CR	0.205*
HCT	CR	0.175*
AST	ALT	0.841*
CR	Hg	0.164*

*p< 0.05.

WBC; leukocyte, HGB; hemoglobin, HCT; haematocrit, PLT; thrombocyte, ALT; alanine aminotransferase, AST; aspartate aminotransferase, CR; creatinine, As; arsenic, Hg; mercury.

DISCUSSION

Ceramic workers have elevated risk of chronic silicosis, cancer, renal and autoimmune diseases (15). There is a need for a reliable biomarkers to predict the likelihood of these diseases (16). The human hematopoietic system is extremely sensitive to some environmental influences because of rapid synthesis and destruction of cells with consequent heavy metabolic demand (17). The present work was conducted to evaluate clinical, biochemical, toxicological and hematological parameters in a Turkish ceramic plant. Our results showed that ceramic workers had higher urine Hg and As levels compared to the controls. Also, workers had significamtly higher ALT and CR levels while significantly lower HGB and HCT levels when comparing to the controls. These results indicate that ceramic workers are exposed to As and Hg during ceramic processing. Higher CR levels in workers indicate that ceramic workers have impaired renal function. Differences in the levels of WBC, HGB, HCT and PLT in ceramic workers showed that hematologic abnormalities. Increases in ALT and AST levels of ceramic workers compared to the controls demonstrate the liver function abnormalities.

In studies that evaluate the relationship between occupational exposure to airborne particulates and pulmonary diseases, early radiographical categories including 0/1 and 1/0 are considered as early stages of pneumoconiosis (18). In this study, nearly 50 % of workers were diagnosed as silicosis with 84 % found to display silicosis in profusion category 1, 10 % silicosis in profusion category 2 and 6 % silicosis in profusion category 3 whereas all the controls had normal chest radiographs. These results showed that majority of workers displayed the onset of silicosis. In Turkey, silicosis ratios were found to be 36 %, 12 %, 7 % in the studies of sandblasters, quartz processing workers and ceramic workers, respectively (19-21). When evaluating the pulmonary function, there were no statistically significant differences between FEV1/FVC ratios of workers and controls. Aziz et al. (15) revealed that all the respiratory tract symptoms (cough, sputum production, dyspnea and wheezes) were more frequent among the Egyptian ceramic workers than the control group. But similar to our result, there were no statistical significant differences between two groups as regarding to FEV1/FVC %. Also they found that, free silica and radon levels were higher than the Egyptian permissible levels. In our study, although total respirable mean dust levels in the plant were below the accepted limit value (5 mg/m^3) of the occupational health authorities of our country, the incidence of silicosis is found to be quite high. It seems that exposure measurement in the plant was not done properly. No data are available about the levels of crystalline silica and other metal content of dust which is the limitation of the study, because only respirable dust measurements are obligatory in Turkey.

In relation to silica exposure, only few studies exist in which biochemical and hemotological parameters has been determined. Most of the studies on the ceramic workers has been tended to focus on the respiratory system. The respiratory abnormalities like pneumoconiosis, pulmonary tuberculosis, bronchiectasis, chronic bronchitis can increase some basic hematological parameters which may reflect a secondary response to some disease process (22). Similar to our study, it was shown that Nigerian cement factory workers exposed to silica had higher AST and ALT levels (23). In the study of Egyptian ceramic workers, AST levels was found to be significantly elevated while there was no significant change in the ALT levels compared to the controls (2). But study population was quite smaller (n=40) compared to this study. Increased levels of transaminase enzymes which was observed this study may be due to prolonged duration of exposure to silica containing dust. Pollutants may accumulate in liver and exert its toxic effect via per oxidative damage to hepatic cell membranes causing transaminase to liberate into the blood. Higher ALT and AST levels probably suggest that workers are more susceptible to hepatic damage (24).

Compatible with our results, higher CR levels were found in cement and ceramic workers (2, 23, 25). Besides, Rapiti et al. (26) and Steenland et al. (27) provided further evidence that exposure to silica dust among ceramic workers is associated with nephrotoxic effects. This might indicate an association between exposure to toxic chemicals and nephrotoxicity.

We found that ceramic workers higher WBC levels compared to the controls but difference was not statistically significant. This is agrees with the results of Abdelaty et al.(2) which revealed increase in the mean WBC count of the exposed subjects over the control. But this is variance with the results of Tajudeen et al. (28) that reported significant reduction in total WBC count in rats living around in Portland cement factory. This difference might be occur due to the difference of study species. WBC count is often seen as a marker for inflammatory response. Changes in the number of circulating leukocytes can represent a primary disorder of leukocyte production or may reflect a secondary response to some disease process (29). We also found that HGB levels of workers were significantly lower than the controls. Similar findings were reported by Mandal and Suva (30) and Jude et al (31). A significant decrease in HGB levels might be due to decrease in synthesis HGB in bone marrow or decrease concentration of HGB within the cell. Also in our study, significantly lower HCT and HGB levels in ceramic workers indicative of anemia (32).

CONCLUSION

This study showed that ceramic workers must be considered as risky persons as their working conditions may affect many organs and systems in their body like liver, kidney, hematopoetic system and it may lead to organ damage. Also, they exposed to not only silica but also other toxic chemicals such as As and Hg. In view of these experimental results it can be concluded that workers in the ceramic industry should be checked periodically and even any minor changes in the levels of biochemical, clinical and hematological parameters should be considered seriously. Thus, we recommend that ceramic workers should regularly use suitable protective equipments in their workplace, gets a periodic medical checkup which might help detect the possible diseases in initial stage.

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REFERENCES

[1] Yassin A, Yebesi F, Tingle R. Occupational exposure to crystalline silica dust in the United States, 1988-2003. Environ. Health Perspect 2005; 113: 255-60.

[2] International Agency for Research on Cancer (IARC). IARC monographs on the evaluation of carcinogenic risks to humans. Silica, some silicates, coal dust and para-aramid fibrils. Lyon: IARC; 1997.

[3] Abdelatty M, Ebeid M, Salem T. Epidemiological Study on the Effect of Ceramic Dust on Egyptian Worker Health. Med. J. Cairo Univ 2014; 82: 169-75.

[4] Association Advancing Occupational and Environmental Health (ACGIH). Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinati: Signature Publication; 1995.

[5] National Institute for Occupational Safety and Health (NIOSH). Health Effects of Occupational Exposure to Respirable Crystalline Silica. Cincinati; 2002.

[6] Occupational Safety and Health Administration (OSHA). Occupational Exposure to Respirable Crystalline Silica–Review of Health Effects Literature and Preliminary Quantitative Risk Assessment. 2013.

[7] Rosenman KD, Reilly MJ, Henneberger PK. Estimating the total number of newly-recognized silicosis cases in the United States. Am J Ind Med 2003; 44: 141-7.

[8] 2014 Statistical Yearbook of Ministry of Labour and Security of Turkey.

[9] International Agency for Research on Cancer (IARC). IARC monographs on the evaluation of carcinogenic risks to humans. Arsenic, Metals, Fibres and Dust, Lyon; IARC; 2012.

[10] International Agency for Research on Cancer (IARC). IARC monographs on the evaluation of carcinogenic risks to humans. Mercury and Mercury Compounds.

[11] turkishceramics.com [Internet] [cited 2017 July 10]. Available from: http://www.turkishceramics.com/About.

[12] International Classification of Radiographs of Pneumoconioses (ILO). Classification of Radiographs of Pneumoconiosis. Genova: 2000.

[13] Miller M, Hankinson, J., Brusasco, V., Burgos, F., Casaburi, R.,. Standardization of spirometry-2005 update. Eur Respir J Supplement 2005; 26: 319-38.

[14] Bateman ED, Hurd SS, Barnes PJ, Bousquet J, Drazen JM, FitzGerald M, et al. Global strategy for asthma management and prevention: GINA executive summary. Eur Respir J 2008; 31: 143-78.

[15] Aziz HM, Ahmed SB, Saleh IA. Respiratory hazards among egyptian ceramics workers. Researcher 2010; 2: 65-73.

[16] Toraason M, Albertini R, Bayard S, Bigbee W, Blair A, Boffetta P, et al. Applying new biotechnologies to the study of occupational cancer—a workshop summary. Environ. Health Perspect 2004; 112: 413-6.

[17] Jude AC, Sasikala K, Kumar RA, Sudha S, Raichel J. Haematological and cytogenetic studies in workers occupationally exposed to cement dust. Int J Hum Genet 2002; 2: 95-9.

[18] Kuempel ED, Attfield MD, Vallyathan V, Lapp NL, Hale JM, Smith RJ, et al. Pulmonary inflammation and crystalline silica in respirable coal mine dust: dose-response. J Biosci 2003; 28: 61-9.

[19] Sevinc C, Cimrin AH, Manisali M, Yalcin E, Alkan Y. Sandblasting under uncontrolled and primitive conditions in Turkey. J Occup Health 2003; 45: 66-9.

[20] Polatlı M, Türkan H, Akdilli A, Çildağ O. Kuvars İşçilerinde Silikozis Riski. Solunum Hastalıkları 2001;12: 90-5.

[21] Şakar A, Kaya E, Çelik P, Gencer N, Temel O, Yaman N, et al. Seramik fabrikası işçilerinde silikozis. Tüberküloz ve Toraks 2005; 53:148-55.

[22] Hofmann R, Benz E, Silberstein L, Heslop H, Weitz J, Anastasi J. Hematology: Basic Principles and Practice. 6th ed. Canada; Elsevier: 2013.

[23] Ogunbileje J, Akinosun O, Anetor J, Akinduti P, Ejilude O, Nwobi N, et al. Effects of different cement factory sections products on Immunoglobulin levels and some biochemical parameters in Nigeria cement factory workers. New York Sci J 2010; 3: 102-6.

[24] Dongre NN, Suryakar A, Patil AJ, Rathi D. Occupational lead exposure in automobile workers in North Karnataka (India): effect on liver and kidney functions. Al Ameen J Med Sci 2010; 3: 284-92.

[25] Ogunbileje J, Akinosun O. Biochemical and haematological profile in Nigerian cement factory workers. RJET 2011; 5: 133-40.

[26] Rapiti E, Sperati A, Miceli M, Forastiere F, Di Lallo D, Cavariani F, et al. End stage renal disease among ceramic workers exposed to silica. Int J Occup Environ Med 1999; 56: 559-61.

[27] Steenland K, Rosenman K, Socie E, Valiante D. Silicosis and end-stage renal disease. Scand. J. Work Environ 2002; 28: 439-42.

[28] Tajudeen Y, Okpuzor J, Fausat AT. Investigation of general effects of cement dust to clear the controversy surrounding its toxicity. Asian J Sci Res 2011; 4: 315-25.

[29] Schwartz J, Weiss ST. Host and environmental factors influencing the peripheral blood leukocyte count. Am J Epidemiol 1991; 134: 1402-9.

[30] Mandal A, Suva P. Haematological changes among construction workers exposed to cement dust in West Bengal, India. Prog Health Sci 2014; 4: 88-94.

[31] Jude AC, Sasikala K, Kumar RA, Sudha S, Raichel J. Haematological and cytogenetic studies in workers occupationally exposed to cement dust. Int J Hum Genet 2002; 2: 95-9.

[32] Kumar P, Gupta Y, Tiwari V, Tiwari S, Singh A. Haematological and biochemical abnormalities in Cirrhinus mrigala (Ham.) induced by lead. J. Ecophysiol. Occup. Health 2005; 5: 213-6.