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Effect of Cement Pollution on some Biochemical Parameters in the Blood Serum of Hamam AL-Alil Cement Factory Workers

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ABSTRACT

Long time exposure to cement industry pollution leads to several health problems. This study was designed to investigate the effects on 55 workers which were divided into groups according to the departments of Hamam AL-Alil Cement Factory-Iraq. The biochemical parameters included in the study are: calcium, zinc, lactate dehydrogenase, alkaline phosphatase, acid phosphatase, glutathione and malonaldehyde.

The results showed that there was a significant increase in calcium, lactate dehydrogenase, alkaline phosphatase, acid phosphatase and malonaldehyde in workers serum which increased with increasing exposure time. The results also showed a significant decrease in glutathione and zinc in workers serum which increased with increasing exposure time in all factory department.

Key word: Cement Pollution, Ions, Enzymes, Glutathione, Malonaldehyde, Serum.

تأثير ملوثات الأسمنت على بعض المتغيرات الكيموحيوية في دم عمال معمل سمنت حمام العليل

الملخص

إن التعرض المستمر لملوثات صناعة الاسمنت يؤدي إلى العديد من المشاكل الصحية. لذلك صممت الدراسة للبحث في تأثير هذه الملوثات على 55 عامل والذين تم توزيعهم إلى مجاميع حسب مواقع عملهم في معمل سمنت حمام العليل- العراق. تناولت الدراسة قياس عدد من المتغيرات الكيموحيوية مثل الكالسيوم، الزنك، اللاكتيت ديهايدروجينيز الفوسفاتيز القاعدي، الفوسفاتيز الحامضي، الكلوتاثيون والمالونالديهايد.

أظهرت النتائج بأن هناك زيادة معنوية في كل من مستوى ايونات الكالسيوم وأنزيمات اللاكتيت ديهايدروجينيز والفوسفاتيز القاعدي والفوسفاتيز الحامضي والمالونالديهايد مع انخفاض معنوي في مستوى الكلوتاثيون وايونات الزنك في مصل دم العاملين مع ازدياد فترة التعرض.

INTRODUCTION

The major pollution problem in Portland cement factories is cement dust emission into the environment from various points of the production process such as Crusher, Kiln, Mills, Storage soils and Packing section (ILO, 1999). This resulted in the exposure of factory workers to cement dust leading to the impairment of respiratory function and a prevalence of respiratory diseases symptoms among workers (Mwaiselage *et al.,* 2006).

Portland cement is composed of four major component: CaO, SiO_2, Al_2O_3 and Fe_2O_3 also trace elements: Cr, Zn, F, Mn, P, Sr, Na, Ti, K, Mg, and S. (Keith-Kirby and Kanare, 1988). Therefore, many of these elements are spread into the environment through air and affect human subsequently. The effect depends on time of exposure, type of work, location of work, residence and weather condition (AL-Omer, 2000).

Most of the trace elements are found in the human body in very minute quantities and any increase in some of them may have a toxic effect (AL-Sa'ady *et al.,* 2000). These may be part of the chemical structure of the enzymatic systems or act as catalysts in the enzyme activity (AL-Omer, 2000).

Any variation in the enzyme activity is an indication of the effect of the pollution. Fewer studies have examined the effect on other systems. Therefore, the present study examined calcium and zinc levels, lactate dehydrogenase, alkaline phosphatase and acid phosphatase enzymes activity, also glutathione and malonaldehyde as a sample of non-enzymatic antioxidant and lipid peroxidation.

MATERIALS AND METHODS

Specimen Collection and Serum Preparation

The blood specimen collected from 55 workers of different departments of Hamam AL-Alil Cement Factory and from students and employees of Mosul University as the control group. 4-5 ml of the drawn blood were put in plain tube, left to complete clot formation, the serum was then separated from the clotted blood by centrifugation at 3000 rpm for 15 min., then decanted into clean and sterile plain tubes and stored at (-20) C^o.

Estimation of Calcium and Zinc levels in Serum

Atomic absorption spectroscopy (AAS) technique was used to determine Ca and Zn levels using the standard curve to convert the optical density into concentration (Zhang and Zhang, 2003).

Estimation of Enzymes Activity in Serum

Lactate dehydrogenase (LDH):

The LDH activity was determined using a BIOLABO-Reagent/France kit (Tietz, 1999).

Alkaline phosphatase (ALP):

The ALP activity was determined using a BIOMERIEUX Company/France kit (Kind and King, 1954).

Acid phosphatase (ACP):

The ACP activity was determined using a BIOLABO-Reagent/France kit (Fishman and Lerner, 1953).

Estimation of Glutathione and Malonaldehyde levels in Serum

Glutathione (GSH):

Glutathione level was determine by the modified Tietz (1999) method (AL-Zamely *et al.,* 2001).

Malonaldehyde (MDA):

Malonaldehyde level was determine by the modified Gudie and Shah (1989) method Muslih *et al.,* 2002).

Statistical Analysis

The statistical program (SPSS) was used to analyze the data (Indrayan and Sarkaddam, 2001).

RESULTES AND DISCUSSION

Ca and Zn levels:

The result showed that there was a significant increase in calcium ion level in the serum of cement workers especially at Mills and Kiln departments (Table 1). The result also indicated that there was a significant increase in calcium ion with increasing exposure time to cement pollution (Table 2).

The increase might be due to the fact that calcium compounds are the major components of Portland cement (Mwaiselage *et al.,* 2005). Also heavy metals increase the acidity of the blood. The body draws calcium from the bones to help restore the proper blood pH, further, toxic metals set up condition that lead to inflammation in arteries and tissues causing more calcium to be drawn to the area as a buffer (Pouls, 1999).

The calcium increase in the Kiln might be due to the large amount of fine materials produced during the Portland cement making process, these materials are carried out by the flow of hot gasses generated inside the kiln and not incorporated into the clinker (Maslehuddin *et al.,* 2008).

These results agree with (Fatima *et al.,* 1997) who found a significant increase in total protein and calcium level in the serum specimen of workers exposed to cement dust of Hyderabad Cement Factory-India. These parameters were increased with exposure time.

The results also showed a significant decrease in zinc ion level in workers serum of all departments of the factory especially in Cement Mill and Kiln departments (Table 1). A significant decrease with increasing exposure time was also observed (Table 2). The decrease could be caused by the dermatitis and eczema (Yanagisawa, 2004) which have resulted from dust exposure as 60% of the workers were found to suffer from dermatitis and eczema, or the zinc decreased with increasing calcium is observed by (Gill and Walton, 1979) who established that protein kinase activity is sensitive to inhibition by calcium ion which might be present in tissue extracts that causes many cell activities resulting in decreasing zinc level.

Table 1: Ca and Zn levels in serum of cement workers depending on departments.

Departments	Ca (mg/100 ml) Mean ± SE	% Increase	Zn (µg/100 ml) Mean ± SE	% Decrease
Control	10.8 ± 0.40 [a]	-	111.4 ± 3.58 [b]	-
Maintenance	11.3 ± 0.70 [a]	4.6	94.0 ± 4.00 [a]	15.6
Crusher	11.6 ± 0.46 [a]	7.4	92.0 ± 1.00 [a]	17.4
Raw mill	12.2 ± 0.50 [ab]	13.0	90.5 ± 3.77 [a]	18.7
Cement mill	12.4 ± 0.47 [ab]	14.8	84.8 ± 4.54 [a]	23.8
Kiln	13.3 ± 0.47 [b]	23.1	80.2 ± 6.19 [a]	28.0
Packing	11.1 ± 0.29 [a]	2.7	96.2 ± 5.24 [ab]	13.6

* Different letter vertically refers to presence of significant differences between treatment at $P \leq 0.05$, according to Duncan - test.

Table 2: Ca and Zn levels in serum of cement workers depending on exposure time.

Variables / Exposure time	Ca (mg/100 ml) Mean ± SE	% Increase	Zn (µg/100 ml) Mean ± SE	% Decrease
Control	10.8 ± 0.40 [a]	-	111.4 ± 3.58 [b]	-
1 – 4	11.6 ± 0.73 [ab]	7.4	89.7 ± 4.00 [a]	19.5
5 – 8	12.0 ± 0.35 [ab]	11.1	88.9 ± 0.00 [a]	20.1
9 – 12	12.6 ± 0.88 [ab]	11.7	86.0 ± 3.77 [a]	22.8
13 >	13.2 ± 0.46 [b]	22.2	84.0 ± 4.54 [a]	24.6

* Different letter vertically refers to presence of significant differences between treatment at $P \leq 0.05$, according to Duncan - test.

Enzymes Activity:

LDH

The result indicated that there was a significant increase in the activity of LDH in the serum of cement factory workers, the highest activity was in the Cement mill, Maintenance and Packing departments (Table 3). The enzyme activity also increased with increasing exposure time (Table 4).

The increase might be due to the fact that LDH is especially concentrated in the heart, liver, red blood cells, kidney, muscles, brain and lungs, thus the damage of any of these organs could elevate LDH levels in serum. It was illustrated by (Drent *et al.,* 1997) that lung-related disorders as a possible source of serum LDH abnormalities. Many researchers demonstrated that cement workers are susceptible to respiratory diseases (Noor *et al.,* 2000 ; Laraqui *et al.,* 2002 ; Fell *et al.,* 2003).

The results agree with publication of (Cobben *et al.,* 1997) who found that cell damage is increased in several pulmonary disorders and high level of LDH activity were found in rats exposed to silica, also (Gulumian *et al.,* 2006) found that the increase in LDH activity and the membrane-bond enzyme ALP activity could be used as indicators of cell damage by crystalline silica.

ALP

The result demonstrated that there was a significant increase in ALP activity in cement workers serum, the highest activity in the Mills and Packing departments (Table 3). Also the results showed that the enzyme activity increased in a proportional way with exposure time to cement pollution (Table 4). Increasing ALP activity might be due to exposure to heavy metals either by direct inhalation of suspended dust particles in air, dermal contact or indirect ingestion. Some of them are toxic and might interfere with enzymes system and metabolism of the body (Arogunjo, 2007).

The results are in agreement with (Mojiminiyi *et al.,* 2007) who stated that the ALP activity increased proportionally with exposure time to cement dust in Sokoto Cement Factory-Nigeria and the highest activity was the Crusher, Cranes and Mills departments, also agree with other investigators (Struzak-Wysokinska *et al.,* 1990) where the activity of ALP in workers exposed to cement dust was very high.

ACP

The result showed that there was a significant increase in ACP activity, maximum activity was at the Packing, Cement mill and Crusher departments (Table 3). Also the activity increased with increasing exposure time (Table 4). The increase might be due to that ACP is a hydrolytic lysosomal enzyme released during stress induced by tissue or cell damage (Jayakumar *et al.,* 2008). Also the increasing in the activity of ACP in serum used as indicator of metal toxicity (Versteeg *et al.,* 1988 ; Bull *et al.,* 2002).

The results agree with the reported values of (Struzak-Wysokinska *et al.,* 1990) where the activity of ACP increased with increasing intensity of pathological changes and increasing exposure to cement dust.

Table 3: Effect of cement pollution on LDH, ALP and ACP in serum of cement workers depending on departments.

Departments	LDH (IU/L)	% Increase	ALP (U/L)	% Increase	ACP (U/L)	% Increase
	Mean ± SE		Mean ± SE		Mean ± SE	
Control	140.1 ± 9.38 [a]	-	47.5 ± 5.58 [a]	-	2.65 ± 0.36 [a]	-
Maintenance	259.0 ± 37.5 [bc]	84.8	51.0 ± 4.58 [a]	7.3	2.66 ± 0.43 [a]	-
Crusher	154.0 ± 16.0 [ab]	10.0	52.0 ± 5.57 [a]	9.4	6.10 ± 1.23 [b]	130.1
Raw mill	179.6 ± 36.6 [abc]	28.1	81.6 ± 12.2 [ab]	71.7	2.70 ± 0.64 [a]	1.8
Cement mill	251.0 ± 28.1 [abc]	79.1	85.6 ± 15.2 [ab]	80.2	5.17 ± 1.10 [ab]	95.0
Kiln	167.0 ± 19.7 [ab]	19.2	58.6 ± 8.33 [ab]	23.3	3.71 ± 0.90 [ab]	40.0
Packing	286.3 ± 40.4 [c]	104	97.5 ± 15.3 [b]	105.2	3.80 ± 0.52 [ab]	43.3

- Different letter vertically refers to presence of significant differences between treatment at $P \leq 0.05$, according to Duncan - test.

Table 4: Effect of cement pollution on LDH, ALP and ACP in serum of cement workers depending on exposure time.

Variables / Exposure time	LDH (IU/L) Mean ± SE	% Increase	ALP (U/L) Mean ± SE	% Increase	ACP (U/L) Mean ± SE	% Increase
Control	140.1 ± 9.38 ^{a}	-	47.5 ± 5.58 ^{a}	-	2.65 ± 0.36 ^{a}	-
1 – 4	173.5 ± 42.0 ^{ab}	23.8	60.5 ± 7.17 ^{a}	27.3	3.04 ± 0.48 ^{ab}	14.7
5 – 8	227.1 ± 19.1 ^{ab}	62.0	67.8 ± 7.72 ^{a}	42.7	3.95 ± 0.71 ^{ab}	49.0
9 – 12	189.5 ± 3.50 ^{ab}	35.2	71.6 ± 15.8 ^{a}	50.7	4.15 ± 1.15 ^{ab}	56.6
13 >	272.0 ± 41.3 ^{b}	94.1	75.4 ± 7.21 ^{a}	58.7	5.80 ± 0.91 ^{b}	118.8

* Different letter vertically refers to presence of significant differences between treatment at $P \leq 0.05$, according to Duncan - test.

GSH and MDA levels:

The result in (Table 5) showed that there was a significant decrease in GSH level in cement workers serum in some factory departments, the decrease was proportional to exposure time (Table 6). The decrease might be due to the leaching profile of cement-stabilized heavy metal ions, namely Pb, Cd, As and Cr besides the other pollutants (Halim *et al.,* 2004). These compounds might enter in the bodies of cement workers through different ways and cause different internal effects (Aydin *et al.,* 2004). Also the reduction in GSH level might be due to deficiency of the raw materials that are necessary to glutathione synthesis at oxidative stress like NADPH that resulting from pentoses pathway. This would stimulate glutathione reeducates enzyme to transform the active GSH from the inactive form-disulpher (Dickinson *et al.,* 2003).

These results agree with others (Aydin *et al.,* 2004 ; Orman *et al.,* 2005 ; Al-Helaly, 2006 ; Ali, 2007) where they found that there was a significant decrease in antioxidant glutathione, superoxid dismutase, vitamin C and vitamin E in workers exposed to cement and silica pollution.

Results also showed that there were significant increase in lipid peroxidation MDA in workers serum of all cement factory departments (Table 5), the highest in Mills. Also the increase was proportional with exposure time (Table 6). The increase might be caused by the products resulting from lipid peroxidation. The most widely used index of peroxidation is MDA formation, it is also one of the principle products of the endoperoxidase (break down) in various disease (Dezewart *et al.,* 1999 ; Valdimirov, 2004).

These results agree with others (Orman *et al.,* 2005 ; Al-Helaly, 2006 ; Ali, 2007) where MDA level in workers exposed to silica and cement pollution were significantly higher and the direct measure of MDA and GSH could be accepted as an indicator of oxidative injury. Also the results agree with (Aydin *et al.,* 2004) that some biochemical parameters were increased significantly like MDA level to 175%, ALT 61% and AST 39% in cement workers serum.

Table 5: Effect of cement pollution on GSH and MDA levels (µmol/L) in serum of cement workers depending on departments.

Departments	GSH	% Decrease	MDA	% Increase
	Mean ± SE		Mean ± SE	
Control	9.40 ± 0.74 b	-	4.32 ± 0.74 a	-
Maintenance	5.55 ± 1.21 a	41.0	11.37 ± 2.76 c	163.1
Crusher	6.30 ± 1.45 a	33.0	6.87 ± 0.31 b	59.00
Raw mill	9.48 ± 2.34 b	-	23.1 ± 4.65 e	434.0
Cement mill	6.33 ± 1.39 a	32.6	15.2 ± 3.99 d	251.0
Kiln	9.30 ± 0.91 b	1.00	5.40 ± 0.85 a	25.00
Packing	6.15 ± 1.28 a	34.5	4.98 ± 1.55 a	15.20

* Different letter vertically refers to presence of significant differences between treatment at $P \leq 0.05$, according to Duncan - test.

Table 6: Effect of cement pollution on GSH and MDA levels (µmol/L) in serum of cement workers depending on exposure time.

Variables / Exposure time	GSH	% Decrease	MDA	% Increase
	Mean ± SE		Mean ± SE	
Control	9.40 ± 0.74 b	-	4.32 ± 0.74 a	-
1 – 4	8.34 ± 1.63 ab	11.2	10.0 ± 2.53 b	131.4
5 – 8	8.31 ± 0.92 ab	11.6	12.7 ± 4.50 bc	194.0
9 – 12	8.25 ± 1.65 ab	12.2	20.2 ± 3.99 d	367.0
13 >	7.41 ± 2.69 b	21.1	15.1 ± 2.95 c	249.0

* Different letter vertically refers to presence of significant differences between treatment at $P \leq 0.05$, according to Duncan - test.

CONCLUSION

Some biochemical analysis and antioxidant parameter seemed to be reliable and sensitive methods for detecting the damaged cells and fulfill the requirements of a biological marker of cement pollution exposure. Also these techniques might be considered as promising tools in biomonitoring studies on workers exposed to occupational hazards.

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