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RESEARCH ARTICLE

Investigating the influence of emitted arsenic from crude oil combustion on glutathione level in workers at Al- Qudis power plant, in Baghdad, Iraq

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Abstract

Al-Qudis power plant was chosen as one of the power stations of Baghdad, to investigate the effects of transition heavy metal (arsenic) that emitted from combustion of crude oil in that power plant on the glutathione (GSH) level of the workers. Air samples were taken seasonally during August 2011- July 2012 from four sites at Al- Qudis power plant which are oil treatment unit 1(site 1), oil treatment 2 (site2), pre –chimney 1(site 3) and pre-chimney 2 (site 4), to measure levels of arsenic (As) under study**.** Blood samples were collected from the workers to estimate As. Air arsenic highest mean value (1.103±0.01 µg/m^3) was recorded at site 2 during summer, while the lowest mean value (0.47 ± 0.07 µg/m^3) was verified at site 3 during autumn. The highest mean value was exceeded the WHO limits which is less than 1 µg/m^3. The results of current study showed that the mean value of arsenic in the blood of occupational samples was 0.877 ± 0.133 µg/l, the environmental samples of arsenic mean value was 0.569 ± 0.127 µg/l, while arsenic mean value of control sample was 0.0049 ± 0.0027µg/l. For reduced Glutathione (GSH) concentration, the current study results showed the highest value 5.4 ± 0.52 µmol/l in respect to control sample, while the lowest data 2.2595 ± 0.412 µmol/l and 2.6625 ± 0.475 µmol/l have been found in environmental and occupational samples, respectively. These results indicate that arsenic influence GSH level of Al-Qudis's workers.

Introduction

Air is the most essential to keep life continuous, and without air human will die within five minutes (Environmental Protection Agency, 2010).

In the last 200 years, or so, the growth in the world population, industrial revolution and increasing human activity has resulted in an increased demand for energy (Odat, 2009), this energy demanding led to significant increase in atmospheric pollutants and change air quality which may have an impact on human health (Atash, 2007; Fahimeh and Azadeh, 2012).

Air pollution is a major environmental problem and it comes in a variety of forms, from visible particles of soot or smoke to invisible gases such as sulfur dioxide and carbon monoxide, and it can be created indoors and outdoors (Gurjar et al., 2010; Moldoveanu, 2011).There are many sources of air pollution like naturel sources (volcanos, fires and sea spray) and anthropogenic sources (municipal incinerators, personal generators emissions, highway vehicle, metal smelters and power plants emissions (fuel combustion)) (EPA, 2010). Power plants emissions are a mixture of hundreds of constituents in either gas or particle form or semi-volatile matter (Wichmann, 2006; Lewtas, 2007).

The generation of electric power plant is one important source of pollutants such as mercury, sulfur dioxide, nitrogen oxides and toxic heavy metals associated with fine particulate matter (Alias et al. 2007; O'Connor and Roy 2008).

Although there is no clear definition of what a heavy metal is, density is in most cases taken to be the defining factor. **Heavy metals** are commonly defined as those having a specific density of more than 5 g/cm^3 (Jarup, 2003; Duruibeet al., 2007)**.**

In ambient air, concentrations of several toxic metal and metalloids and their compounds have been largely increased as a result of human activities, however, these are mainly encountered as part of particulate matter (EC, 2000; Mudgalet al., 2010; EH and E, 2011).Most heavy metals are dangerous because they tend to bio-accumulate in the human body (Jarup, 2003). The biotoxic effects of heavy metals refer to the harmful effects of heavy metals to the body when consumed above the bio-recommended limits (Duruibeet al., 2007, Inoue, 2013). The nature of effects could be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic.

The poisoning effects of heavy metals are due to their interference with the normal body biochemistry in the normal metabolic processes (Duruibeet al., 2007).

The most toxic forms of these metals in their ionic species are the most stable oxidation states (Duruibeet al., 2007). Most heavy metals produce reactive oxygen species, resulting in an increased lipid peroxidation (LPO), depletion of sulfhydryls, altered calcium homeostasis, and finally DNA damage (Arun, 2008; Stephen, 2013). Beside major pollutants, fossil fuel combustion generates emissions of potentially toxic heavy metals (Kamp and Castanas, 2008). California Air Resources Board (1998), Reddy, et al. (2005), Kampa and Castanas (2008), Wang et al.(2010) and Mudgal (2010) listed arsenic as one of toxic heavy metals emitted from anthropogenic activities like power plant emissions.

Arsenic (atomic number, 33; relative atomic mass, 74.92) has chemical and physical properties intermediate between a metal and a nonmetal, and is often referred to as a metalloid or semi-metal, the most predominant oxidation state were +3, +5 (Arsenite^{III,} and Arsenate$^{v)}$(IARC, 2012).

In the environment, arsenic was found in three major groups (Hughes, et al. 2011):
Inorganic arsenic compounds, Organic arsenic compounds and Arsine gas.

Inorganic arsenic (iAs) is a class I human carcinogen (IARC.2012).Mining, smelting of non-ferrous metals and burning of fossil fuels are the major anthropogenic sources of arsenic contamination of air, water, and soil (primarily in the form of arsenic trioxide) (IARC, 2012).

The pathogenic mechanisms of inorganic arsenic related to development of these pathologies are very complex and likely multifactorial (Flora, 2011).

One of principal mechanisms of arsenic toxicity and carcinogenicity is the induction of a strong oxidative stress with production of free radicals in cells; indeed, there is increasing evidence that the induction of reactive oxygen species (ROS) plays a crucial role in arsenic toxicity (Faitaet al., 2013).Glutathion is an important water-soluble antioxidant, synthesized from the amino acids glycine, glutamate, and cysteine (Abdalla, 2011). It has an importance for cellular function. Reduced glutathione (GSH) is the most abundant thiol in cell which acts as an important antioxidant for cellular defense (Ganesaratnamet al., 2004; Kadam and Abhang, 2013).GSH is produced by the liver and is able to detoxify the lungs, RBCs, liver and the intestinal tract; it also removes a wide range of toxins, including those produced by heavy metals, cigarette smoke, alcohol, radiation and cancer chemotherapy (Abdalla, M., 2011).The aim of this study was the interaction between arsenic and glutathione level in blood of Al-Qudis power plant workers.

Material and Methods

Sample collection

1.Air sampling Al-Qudis power plant was chosen for this study, as one of the power stations of Baghdad, to investigate the effects of heavy metals (arsenic) that emitted from combustion of crude oil in that power plant. Al-Qudis power plant was located in north-east of Bagdad. Four sites were chosen as air sampling at the plant which is: Old oil treatment, new oil treatment and chimney unit 1, chimney unit 2. The samples were collected seasonally from August 2011 till August 2012 for measuring the levels of heavy metal. Units' emission particulate samples were collected for one hour by using rotary vane air sampling pump, which fixed on 1.5 m height level (breathing level); on cellulose ester membrane filters at an accurately known flow rate 16 L/min. The particles of units emissions were precipitated on filters then heavy metal (arsenic) concentration estimated according to National Institute for Occupational Safety and Health (NIOSH, 2003).

2. Blood collection Ten milliliters of peripheral blood samples were collected from each of 90 male workers of the power plant's, which were divided into two groups, Oil treatment unit's workers which are occupationally exposed to exhaust and workers from other units which are environmentally exposed and from 20 persons not work at power station and far away from the power plant as control samples. The protocol of NOISH (1994) used to estimate blood arsenic concentration of workers.

Standards and samples were analyzed by using flameless atomic absorption. Standard was also analyzed once every ten samples.

3. Glutathione (GSH) estimation: GSH level estimated according to (Khan et al., 2012). 2.3 ml buffer was added to 0.2ml of the sample (serum) followed by addition of 0.5ml of DTNB.

The mixture was then analyzed by spectrophotometer. The reference cell contained buffer. Blank consist of 2.5ml of buffer and0.5ml of DTNB and measured against a reference cell containing 3ml of buffer. All the measurements were carried out at 412 nm after five minutes. UV/visible spectrophotometer of model 1601(Shimadzu) was used for absorbance readings.

Results and Discussion

1. Arsenic in air:

For air arsenic levels, during summer season the current study recorded that mean of arsenic levels were 1.035±0.04 µg/m^3, 1.103±0.01 µg/m^3, 1.058±0.06 µg/m^3 and 1.036±0.04 µg/m^{3}in site 1, site 2, site 3 and site 4, respectively (Fig. 1), while during autumn the records were 0.507±0.04 µg/m^3, 0.578±0.09 µg/m^3, 0.47±0.07 µg/m^3 and 0.487±0.07 µg/m^3 at site 1, site 2, site 3 and site (4), respectively (Fig. 2).The records of winter were 0.525±0.05 µg/m^3, 0.532±0.110 µg/m^3, 0.487±0.16 µg/m^3 and 0.506±0.12 µg/m^3 in site 1, site 2, site 3 and site 4, respectively (Fig. 3). Spring findings were 0.54±0.11µg/m^3, 0.586±0.08 µg/m^3, 0.538±0.11 µg/m^3 and 0.572 ± 0.05 µg/m^3, in site 1, site 2, site 3 and site 4, respectively (Fig. 4). The present study found that the highest mean value of arsenic levels was recorded during summer, while the lowest value was recorded at autumn. The summer level of arsenic was unacceptable by WHO standards which is less than 1 µg/m^3. For occupational exposure, Inhalation of arsenic-containing particulates is the primary route. Hazardous air pollutants, such as arsenic are integral components of fine particulate matter emitted directly from fossil fuel power plants. Barakat (2013) found that arsenic level emitted from personal generators was highest during summer and this is consistent with current study, while Fang et al. (2009) and Wang et al. (2010) found that the highest values was recorded during spring due to dust storm which always occur during dry spring time. The highest value of arsenic might be due to composition of oil-fuel, incomplete combustion of fuel (increasing in TSP), and increased demand for electrical energy.

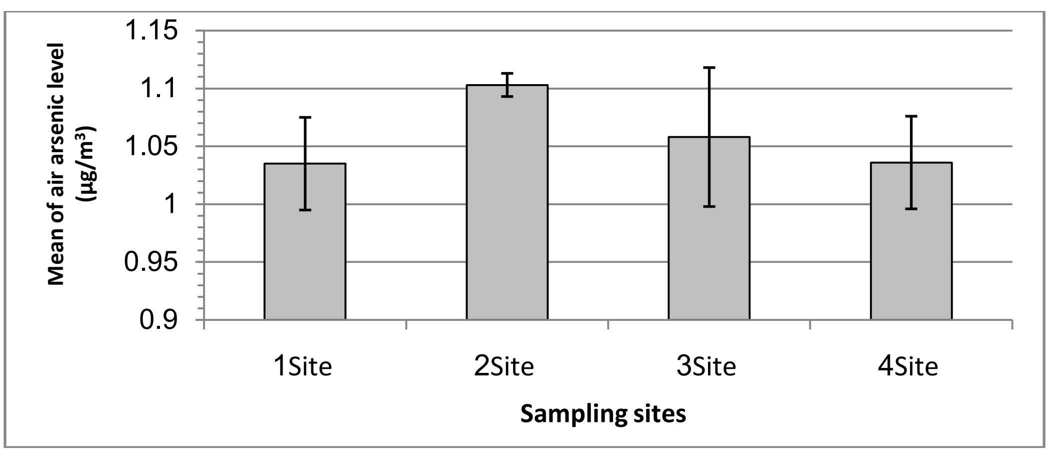

Figure 1: Mean of air arsenic level (µg/m^3) during summer at Al-Qudis power plant.

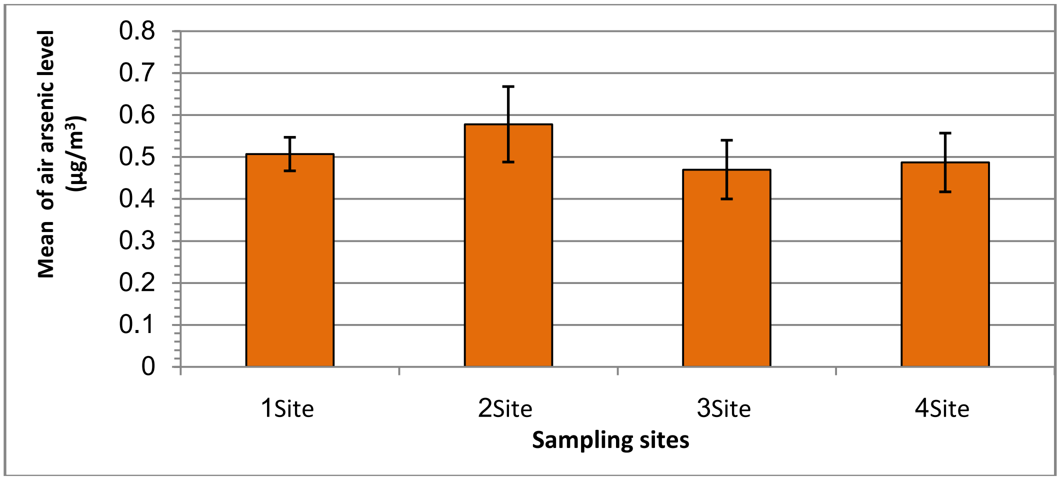

Figure 2: Mean of air arsenic level (µg/m^3) during autumn at Al-Qudis power plant.

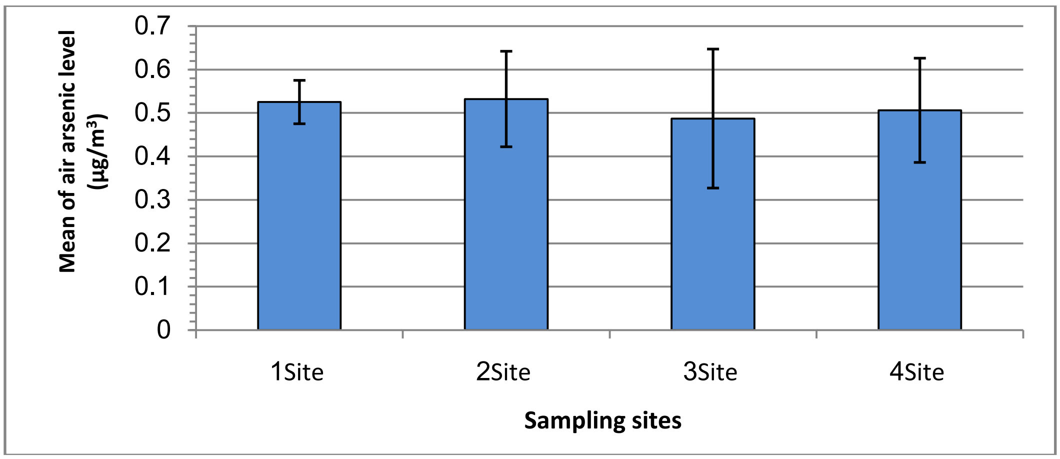

Figure 3: Mean air arsenic level (µg/m^3) during winter at Al-Qudis power plant.

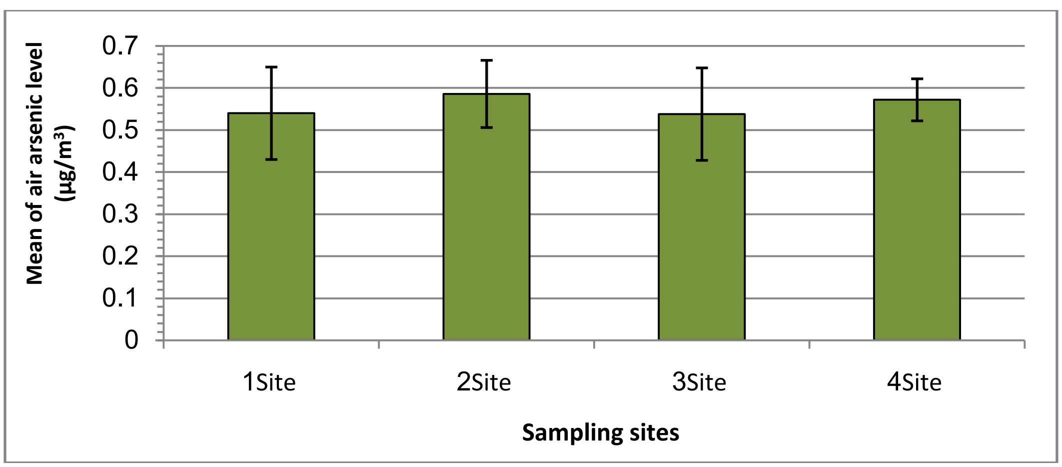

Figure 4: Mean of air arsenic level (µg/m^3) during spring at Al-Qudis power plant.

2. Arsenic in blood

It seems clearly that occupational sample had the highest mean of blood arsenic content (0.877 ± 0.133 µg/l) than those of both environmental and control samples which had mean blood content of 0.569 ± 0.127 µg/l and 0.0049 ±0.0027 µg/l, respectively (Fig.5).

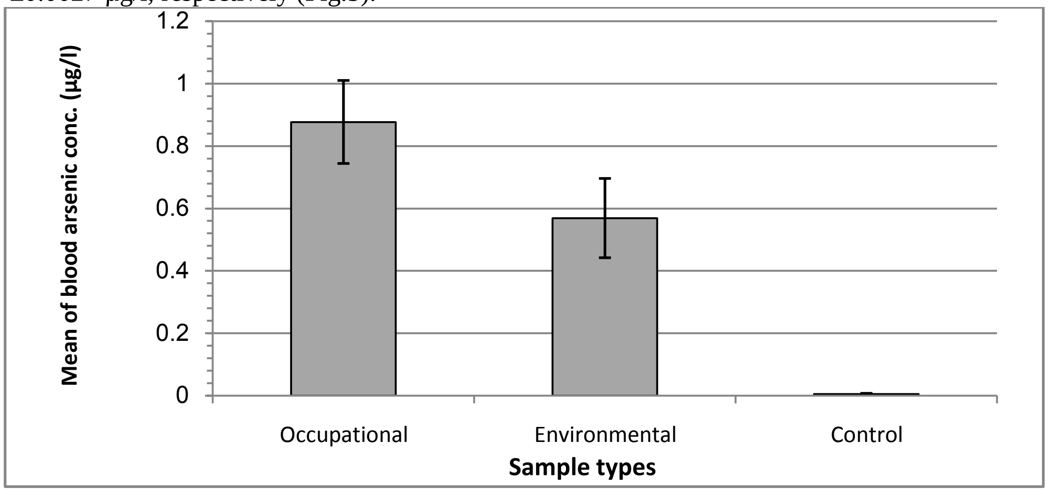

Figure 5: Mean of blood arsenic concentration (µg/l) of workers at Al-Qudis power plant.

In present study the highest value was recorded in occupational sample which is 0.877±0.133 µg/l. However, all results for occupational, environmental and control values were at acceptable level which is less than 1 µg/L in blood (ATDSR, 2007). But it is at upper of acceptable limits and should be monitored.

The significant differences between samples of blood arsenic level which is 0.05 between occupational and environmental samples, and environmental and control samples, and highly significant ($P \leq 0.001$) for occupational and control samples revealed envision that the site of work has an effect on blood arsenic levels for worker, in addition to environmental factors like nature of fuel used and incomplete combustion.

3. Glutathione (GSH)

As shown in figure (6), the highest values (5.4 ± 0.52 µmol/l) of glutathione concentration (GSH) was recorded for control sample, while the lowest values (2.2595 ± 0.412 µmol/l) and (2.6625 ± 0.475 µmol/l) have been found in environmental and occupational samples, respectively.

However, current results show that control sample had significantly ($P\leq0.001$) higher GSH concentration than those of both occupational and environmental samples due to LSD values which were 1.456 µmol/l and 1.372µmol/l respectively but the differences between mean GSH of occupational and environmental samples were insignificant ($P>0.05$) and the LSD value was 1.273µmol/l.

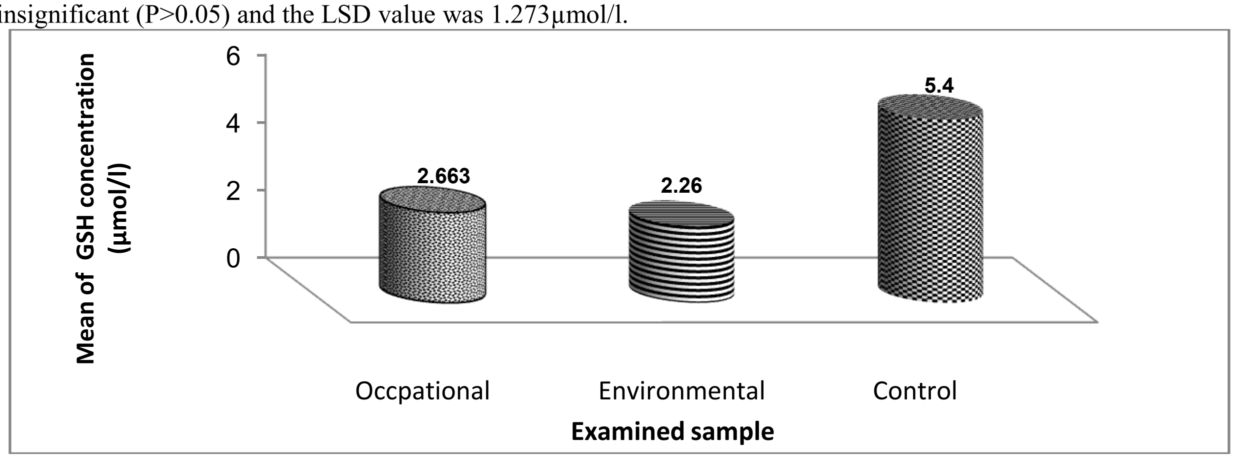

Figure 6: Mean of Glutathione (GSH) concentration (µmol/l) in occupational, environmental and control samples

This fact may be led to suppose that GSH concentration is effected by the air pollution (emissions of power plant). The reduction of GSH level was possibly due to its increased antioxidant activity and conjugation action with the xenobiotics present within fly ashes propelled by GST (Manjo and Padhy, 2013).A study by Khan et al. (2012) found aluminum caused depletion of GSH concentration in plasma and attributed this to the interaction of reduced glutathione and aluminum either from oxidized Glutathione (GSSG) or Al-SG complex (heavy metals-SG complex). Epidemiological studies had found that heavy metals, PAHs, and other particulate air pollution in urban environment could be associated with an increasing number of evidences demonstrated the involvement of reactive oxygen species (ROS) (Hung and Wang, 2001; Pope et al., 2002; Lai et al., 2003). This oxygen species might lead to the formation of oxidative DNA damage (Van Delf et al., 1998). According to Al-Helaly (2011) an increase exposure of different pollutants led to glutathione deficiency which contributes to oxidative stress in workers then decreased the antioxidant enzymes levels. This behaviour might give an indication for the oxidation that take place in exposed persons which plays a key role in aging and pathogenesis of many diseases, one of which is cancer (Abdalla, 2011; Manoj and Padhy, 2013).Hall et al. (2013) indicated that glutathione deficiency may be due to arsenic exposure. Cadmium could induce cancer through the induction of oxidative stress (Joseph, 2009). From above results the present study concluded GSH reduction in occupational and environmental samples may be associated to the interaction of reduced GSH and heavy metal to form oxidized Glutathione (GSSG) or metals-SG complex, the TSP concentrations in the emissions of Al- Qudis power plant and smoking influence.

Conclusion

From above results the present study concluded GSH reduction in occupational and environmental samples may be associated to the interaction of reduced GSH and heavy metal (arsenic) to form oxidized Glutathione (GSSG) or metals-SG complex, the TSP concentrations in the emissions of Al- Qudis power plant.

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