Monitoring of some heavy metal residues in cattle slaughtered in Ismailia and Al-Wadi Al-Gadid Governorates

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Abstract

A total of 60 samples, ten from each of muscles, livers and kidneys were collected from cow calves at the age of (18-30 month) slaughtered at Ismailia and Al-Wadi Al-Gadid (El-Dakhla City) abattoirs in Egypt. Samples were analyzed for the following heavy metals residues; lead, cadmium, iron ,copper and zinc by using A.A. spectrometer. The results revealed that non of the examined samples exceeded the recommended limits of iron, copper and zinc, while cadmium and lead levels in muscle samples of Al-Wadi Al-Gadid and Ismailia as well as in Ismailia liver samples and lead levels of Ismailia kidney samples exceeded the permissible limit. Cadmium and lead concentration exhibited a significant increase in muscle and kidney samples of Ismailia. Cadmium and copper concentration revealed a significant increase , while zinc levels revealed a significant decrease in Ismailia liver samples Iron showed a significant decrease in Ismailia kidney samples compared to Al-Wadi Al-Gadid. Analysis of variance revealed significant difference of lead and copper concentrations between the different organs in Ismailia governorate and exhibited a significant differences in iron and zinc levels between the different organs of both governorates. The highest levels of cadmium and lead were detected in kidney samples followed by liver samples and the least levels recorded in muscle. Highest levels of cadmium detected in kidney and liver may be due to long term exposure. Copper and iron were highest in the liver while, the highest level of zinc detected in muscle samples followed by liver samples and the least level recorded in kidney.

Key words: *cow calves, lead, cadmium, copper .*

Introduction

Toxic metals are natural components of the environment, but human activities, notably industrial and mining processes, have been responsible for the wider diffusion of these elements. Toxic metals are accumulated in soils and plants, and animals fed with these plants will tend to accumulate toxic metals themselves. Cattle are the most susceptible livestock, with calves the most likely victims **(Siddiqui and Rajurkar, 2008)**. Animals in the process may be exposed to high levels of contaminants in the environment **(Nwude *et al*., 2010).** These metals bio-accumulate in organs and other tissues of animals. When these animals are slaughtered for human consumption, lead may bio-accumulate in human tissues and organs **(Miranda *et al*., 2009).** Ismailia Canal is considered as one of the most important irrigation and drinking water resources. During drought period the water level decreased and the concentrations of the most trace metals such as (Fe, Zn. Cu, Pb, Cd) were increased in water and superficial sediment of Ismailia Canal during drought period **(Abdo El -Nasharty, 2010).** Heavy metals (Cd, Cu, Pb, and Zn) were recorded in Ismailia at elevated concentrations in the soil, which a moderate degree of pollution reflected compared to the concentrations in normal and non-polluted soils in Egypt. Physio-chemical analysis of water showed that irrigation water contained different amount of heavy metals **(El-Sharabasy and Ibrahim, 2010)**. Although contamination of animal feed by toxic metals cannot be entirely avoided given the prevalence of these pollutants in the environment, there is a clear need for such contamination to be minimized, with the aim of reducing both direct effects on animal health and indirect effects on human health **(SCAN, 2003).** Toxic elements such as cadmium and lead are harmful, even at low concentrations, when ingested over a long time **(Akin and Unlu, 2007 and Storelli, 2009)** they accumulate in the kidney, bound to metalothionein and has biological half-life of over 10 years. Excessive long term cadmium exposure may produce irreversible adverse renal effects as reported by **(WHO, 1977, 1989, 1992).**

The aim of this study was to detect the environmental pollution with lead, cadmium, copper, iron and zinc in cattle muscle, liver and kidney of Ismailia and Al-Wadi Al-Gadid and to suggest a protocol for prevention of this pollution to protect animals against hazard of these metals.

Materials and Methods

Samples collection:

Portions of muscle tissue, liver and kidney from sixty cow calves at slaughter were collected from Ismailia and Al-Wadi Al-Gadid (El -Dakhla City) abattoirs, ten from each. The age of the slaughtered calves was (18-30 month). Gross fat, connective tissue and major blood vessels were removed **(Lopez Alonso *et al.*, 2000).**

Samples analysis:

Each tissue sample was ground & homogenized according to **(Al-Baggou', 2002)**. One gram from each homogenized sample was digested in a Pyrex beaker with 7 ml of a mixture of ultra pure concentrated nitric acid: perchloric acid (HNO_3: $HCLO_4$) at a ratio of (6:1) and diluted with 5 ml of deionized water. The solution was analyzed for lead, cadmium, iron, copper and zinc by using Unicam 969AA spectrometer England according to (**Iwegbue, 2008**).

Statistical analysis:

Student t-test was used to compare the differences in the mean concentrations of the same heavy metal between Ismailia and Al-Wadi Al-Gadid in the tissue of the same organ. On the other hand, the differences in the mean concentrations for each heavy metal between muscle, liver and kidney tissues were compared by one -way analysis of variance. **(Petrie and Watson, 2003).**

Results and Discussion

Table (1). Cadmium levels in tissue samples of Al-Wadi Al-Gadid and Ismailia governorates relatives to (EC) No.466/2001

Concentration of Cadmium in mg/ kg (ppm)			MPL
Tissues samples	Al-Wadi Al-Gadid	Ismailia	(EC, 2001)
Muscle	0.10 ± 0.04	0.84 ± 0.10***	0.05 ppm
Liver	0.13 ± 0.02	0.89 ± 0.11***	0.5 ppm
Kidney	0.18 ± 0.03	0.94 ± 0.23 **	1 ppm
F	1.95	0.12	

Data are represented as means of 10 samples ± S.E. ** highly significant (P < 0.01).
*** Very highly significant (P < 0.001) F-values: between different organs.

Cadmium is highly toxic non-essential heavy metal and it does not have a role in biological processes in living organisms. Thus even at low concentration, cadmium could be harmful to living organisms**.** The toxicity of cadmium and lead is due to their ability to cause, oxidative damage to living tissues. Damage includes enhanced lipid peroxidation, DNA damage, enzyme inactivation and the oxidation of protein sulfydryl groups**(Taiz and Zeiger, 1998).**

Animals exposed to cadmium accumulate it in their livers and kidneys as their free protein-thiol group content leads to a strong fixation of heavy metals. Despite the excretory mechanism for such metals, which is based on low molecular compounds with SH groups **(Pompe -Gotal and Crnic, 2002).**

The data obtained in Table (1) revealed that cadmium level was significantly higher (P<0.001) in Ismailia muscle and liver samples

(0.84±0.10) and (0.89±0.11) respectively and at (P<0.01) for kidney (0.94±0.23) compared to Al-Wadi Al-Gadid (0.10 ±0.04),(0.13±0.02) and (0.18±0.03) respectively. The examined muscle samples of both Governorates and liver samples from Ismailia exceeded the permissible limit of cadmium (0.05 ppm) in muscle and (0.5ppm) in liver as recommended by the **(EC, 2001)** and exceeded the limit (0.5 ppm) in muscle, liver and kidney in all samples of Ismailia as prescribed by **(EOS, 1993)** and **(FAO / WHO, 2000)**, similar findings were detected by **(Aranha *et al*, 1994; Roga-Franc *et al*, 1996 and Akan *et al*., 2010)** who found that cadmium concentration was above the (0.5 ppm) in liver and kidney of cattle. Dissimilar results detected by **(Khalafalla *et al*., 2011),** where cadmium level not exceeded the recommended levels in muscle,liver and kidney of cattle. Cadmium levels (0.331mg/kg) in muscle samples were recorded by **(Koréneková *et al*., 2002).** Analysis of variance in Table (1) showed non significant difference in cadmium concentrations between the different organs in both Governorate, but the highest level was detected in kidney samples followed by liver samples and the least level recorded in muscle. In this respect, **Hiba (2011)** recorded higher cadmium levels in bovine kidney (1.48 mg/kg) and lowest levels in muscle. In this study, higher cadmium levels observed in Ismailia examined samples compared to Al-Wadi Al-Gadid revealed that animals may be exposed to high levels of contaminants in their environment because a variety of industries discharging their treated and untreated waste water into the Ismailia canal which was the source of water used for irrigation purposes **(El-Sharabasy and Ibrahim, 2010)**, as well as the phosphate fertilizer which is considered the main source of cadmium in the environment and application of sewage sludge on agricultural land **(Dimari *et al*., 2008)**. Also, our results revealed higher cadmium levels in kidney followed by liver, which means that animals may be exposed to cadmium for long time. Cadmium is not only at a higher concentration level in all parts, but could also be said to have considerably accumulated in the liver and kidney perhaps due to long term exposure **(Lenntech, 2009)**. Cadmium is toxic to virtually every system in the animal body. It is almost absent in the human body at birth, however accumulates with age. Cadmium accumulated in the kidney and liver over long time **(McLaughlin *et al*., 1999)**.

Table (2). Lead levels in tissue samples of Al-Wadi Al-Gadid and Ismailia governorates relative to (EOS, 1993).

Concentration of Lead in mg/ kg (ppm)			MPL (EOS, 1993)
Tissues samples	Al-Wadi Al-Gadid	Ismailia	
Muscle	0.30 ± 0.12	0.68 ± 0.12 *	0.1 ppm
Liver	0.46 ± 0.13	0.83 ± 0.14	0.5 ppm
Kidney	0.49 ± 0.12	1.37± 0.02***	0.5 ppm
F	1.11	13.43##	

Data are represented as means of 10 samples ± S.E. * significant (P < 0.05)
*** Very highly significant (P < 0.001) F-values: between different organs.# #Significant at (P<0.001).

Lead concentrations in Table (2) showed a significant increase (P<0.05) in Ismailia muscle samples (0.68±0.12) than (0.30 ±0.12) of Al-Wadi Al-Gadid, higher value of lead concentration in Ismailia liver samples (0.83±0.14) than (0.46±0.13) of Al-Wadi Al-Gadid with non significant difference. Lead level revealed a very high significant increase (P<0.001) in Ismailia kidney samples (1.37±0.02) than (0.49±0.12) of Al-Wadi Al-Gadid. All the examined samples from Ismailia and muscle samples from Al-Wadi Al-Gadid exceeded the permissible limit of lead set by the **(EOS, 1993)** which stipulates that the permissible limit of lead should not exceed (0.1ppm) in beef muscles and (0.5ppm in liver and kidney). These results were higher than that of **(Khalafalla *et al*, 2011)** in muscle, liver and kidney from cattle slaughtered in Beni-Suef. At the same time his results agreed with the results of liver and kidney samples from Al-Wadi Al-Gadid. The lead levels of liver and kidney samples observed in Al-Wadi Al-Gadid were nearly close to permissible limit may be due to increase of lead level in well water and plant of Al-Wadi Al-Gadid which exceeding the permissible limits as reported by **(Sahar and Samira, 2011)**.

Analysis of variance revealed in Table (2) non significant differences in lead levels between the different organs of Al-Wadi Al-Gadid, while showed a significant variation (P<0.001) between different organs from Ismailia. The highest concentrations of lead in all samples were observed in kidney followed by liver, while the lowest one was observed in muscle which mean that kidney is considered to be the target organ for lead accumulation. Similar results were detected by **(Khalafalla**,***et al*, 2011)**.Also, **(Mariam *et al*.,2004**, in Lahore, **Akan *et al*., 2010** and **Bala *et al*., 2012,** in Nigeria**)** who reported that the high levels of lead were observed in liver and kidney samples of cattle. The higher concentration of cadmium and lead in the kidney tissue reported in this study may be due to the detoxification function of the organ where these metals are accumulated **(Aranha,1994 and Stoyke *et al*.,1995)**. Ismailia has been exposed to municipal and different industrial wastes **(Tarek and Ali, 2007)** that may explain higher lead levels observed in Ismailia examined samples compared to Al-

Table (3). Copper levels in tissue samples of Al-Wadi Al-Gadid and Ismailia governorates relative to **(ANZFA, 2001)** MPL.

Concentration of Copper in mg/ kg (ppm)			MPL **(ANZFA, 2001)**
Tissues samples	Al-Wadi Al-Gadid	Ismailia	
Muscle	5 ±0.4	2.21 ± 0.57	200 ppm
Liver	3.67±0.59	5.99 ± 0.10***	200 ppm
Kidney	3.60±0.61	2.41± 0.50	200 ppm
F	1.33	8.54##	

Data are represented as means of 10 samples ± S.E.
*** Very highly significant (P < 0.001).
F-values: between different organs. ##Highly significant at (P<0.001).

Copper is essential for good health, but very high intake can cause health problems such as liver and kidney damage **(ATSDR, 2004)**.Copper concentrations in Table (3) showed non significant decrease in Ismailia muscle and kidney samples (2.21±0.57)and (2.41±0.50) compared to (2.59 ±0.45) and (3,60±0.61) of Al-Wadi Al-Gadid respectively, while significant increase (P < 0.001) in Ismailia liver samples (5.99±0.10) than (3.67 ± 0.59) of Al-Wadi Al-Gadid .

None of the examined samples exceeded copper permissible limit (200 ppm) of **(ANZFA, 2001)** or the maximum residue level (20ppm) prescribed by (**MFPO**,**1973)** in meat products. Similar results reported by **Ihedioha and Okoye (2012)** who assessed increased concentration of copper in liver of Nigerian raised cow, their results were below the (**FAO/WHO, 2000)** permissible limit for copper, except for 83% of liver samples. Analysis of variance revealed significant (P<0.001) differences between organs of Ismailia, while no significant differences were observed in Al-Wadi Al-Gadid, The highest level of copper detected in liver samples followed by kidney samples and the least level recorded in muscle. It can be noticed that the highest bioaccumulation were

observed in the organs mainly implicated in metals metabolism. Higher copper level in Al-Wadi Al-Gadid samples may related to lower cadmium and lead levels in these tissues, since, Cadmium interacts with a number of minerals mainly zinc, iron and copper due to chemical similarities and competition for binding stage (**McLaughlin *et al*.,1999)**..Similar to our result **(Jarup *et al*., 1998;Vukašinović *et al*., 2007** and **Okoye and Ugwu, 2010)** reported that copper was highest in the liver. Higher copper level in liver samples of Ismailia may indicate the presence of other substances, which are capable of accumulating copper or crucial role of this element in the metabolism **(El-Sharabasy and Ibrahim, 2010)**.
Iron is an essential metal and is required for normal metabolic activity in both plants and animals **(Iwegbue, 2008**). Living organisms require trace amounts of some heavy metals, including copper, iron, manganese and zinc, since high levels of these metals in their muscles represent a potential human health hazard **(Kime, 1995)**.

Table (4). Iron levels in tissue samples of Al-Wadi Al-Gadid and Ismailia governorates relative to **(GRSAFS, 1972).**

Concentration of Iron in mg/ kg (ppm)			MPL (GRSAFS, 1972).
Tissues samples	Al-Wadi Al-Gadid	Ismailia	
Muscle	27.59 ± 2.27	23.83 ±1.17	30 ppm
Liver	29.90 ± 2.61	25.78±1.48	30 ppm
Kidney	21.06 ± 0.16	20.56±0.10 *	30 ppm
F	5.81#	6.48#	

Data are represented as means of 10 samples ± S.E. *Significant ($P < 0.05$).
F-values: between different organs # Significant at ($P < 0.01$) .

As shown in Table (4), Iron exhibited lower levels in all examined samples of Ismailia compared to Al-Wadi Al-Gadid, with significant decrease ($P< 0.05$) of Ismailia kidney samples (20.56±0.10) compared to(21.06 ± 0.16) of Al-Wadi Al-Gadid None of the examined samples in both governorates exceeded the recommended limits (30 ppm) of iron set by (**GRSAFS, 1972)**.

Analysis of variance revealed significant difference ($P<0.01$) of iron concentration between organs in both Governorates. The highest level of iron detected in liver samples followed by muscle samples and the least level recorded in kidney in both Governorates. Similar to our results **(Iwegbue, 2008**; **Akan *et al*., 2010** and **Ihedioha and Okoye, 2012)** who recorded that the concentration of iron in the liver is significantly higher than that of kidneys. Cadmium and lead interact with a number of minerals mainly zinc, iron and copper due to chemical similarities and competition for binding stage **McLaughlin *et al*. (1999)**, so the decreased iron level is correlated with increased cadmium adsorption and body burden **(Akesson *et al*., 2002)**. Cadmium has been shown to interact with iron metabolism **(Puls,1994; Goyer, 1997)**. Thus, the decreased level of iron concentration in all Ismailia samples may attributed to increased concentration of cadmium and lead in these samples.

Table (5). Zinc levels in tissue samples of Al-Wadi Al-Gadid and Ismailia governorates relative to **ANZFA (2001)**.

Concentration of Zinc in mg/ kg (ppm)			MPL **ANZFA (2001)**
Tissues samples	Al-Wadi Al-Gadid	Ismailia	
Muscle	14.49± 1.49	14.08 ± 1.89	150 ppm
Liver	9.94 ± 0.33	7.36 ± 0.52***	150 ppm
Kidney	7.38 ± 0.52	6.73±0.51	150 ppm
F	16.69##	24.95##	

Data are represented as means of 10 samples ±S.E.
*** Very highly significant(P<0.001) F-values: between different organs .
Significant at (P < 0.001)

Essential elements such as zinc may produce toxic effects when intake is excessively high **(Storelli, 2009).** Zinc levels in Table (5) revealed lower concentration in all samples from Ismailia compared to Al-Wadi Al-Gadid, with a significant decrease (P<0.001) in Ismailia liver samples. All the examined samples were within the permissible limit (150 ppm) set by **(ANZFA, 2001)** in both Governorates.

Analysis of variance exhibited a significant difference (P<0.001) of zinc levels between organs of both governorates, the highest level of zinc detected in muscle samples followed by liver samples and the least level recorded in kidney. In accordance to our results **(Jarup *et al*., 1998 ; Lopez-Alonso *et al*., 2000 and Vukašinović *et al*., 2007)** who stated that zinc is deposited in the muscular tissue the most. Cadmium causes reductions in both intestinal zinc absorption and hepatic zinc reserves in cattle **(Smith *et al*., 1991),** as a result of competition for the cation-binding sites of metallothionein (MT) **(Goyer. 1997**; **Okoye and Ugwu,2010)**. Lead competes with essential elements such as zinc leads to stimulation of urinary excretion of zinc **(Amal *et al*., 2008).** Thus, the lower zinc concentration of Ismailia samples recorded in this study may be attributed to higher cadmium and lead accumulation in these organs.

Conclusion and Recommendations

Our result indicated higher levels of cadmium and lead were observed in Ismailia samples compared to Al-Wadi Al-Gadid. These elements exceeded the maximum permissible limit in Al-Wadi Al-Gadid muscles samples and all Ismailia samples except cadmium level in kidney samples. Essential metals showed lower levels in Ismailia samples than Al-Wadi Al-Gadid, that may be attributed to toxic and essential metals interactions. Since, the accumulation of cadmium and lead in tissues interact with the absorption of copper, iron and zinc due to chemical similarities and competition for binding stage. Higher copper levels in liver samples of Ismailia may indicate the presence of other substances, which are capable of accumulating copper or crucial role of this element in the metabolism. However, the concentrations of copper,iron and zinc were within the tolerance limits in both Governorates. Livers and kidneys were found to have the highest significant levels of metals, that may be due to the detoxification function of these organs. The highest zinc residues were recorded in all muscle samples while most of elements recorded the lowest concentrations in muscle samples. Thus, muscle is one of the important tissues for zinc accumulation and possesses zinc concentrations higher than the liver. The obtained higher levels of cadmium and lead in all samples from Ismailia may reflects a moderate degree of pollution in its environment that may be due to exposure of soil or drinking water to municipal and different industrial wastes, since a variety of industries discharging their treated and untreated waste water into the Ismailia Canal which is considered as one of the most important irrigation and drinking water resources, as well as the phosphate fertilizer which is considered the main source of cadmium in the environment and application of sewage sludge on agricultural lands. Cadmium is not only at a higher concentration level in all Ismailia samples, but could also be said to have the highest accumulation in the kidney and liver perhaps due to long term exposure. These metals induce health hazard, since their bioaccumulation were observed in organs mainly implicated in metals metabolism and excess concentration of these metals cause damage to these organs.

It is recommended that government should prohibit the industrial companies to discharge their effluents unless effective hygienic treatment and/or safe disposal of hazard waste is applied, control the use of phosphate fertilizer, application of sewage sludge on agricultural lands and continuous monitoring for metals is necessary. The discharge of untreated or inadequately treated domestic or industrial wastes are presently one of the main deterioration of ecosystem environment, can also cause deterioration effects to human health (**Jordao *et al*, 2002).**

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تقصى متبقيات بعض العناصر الثقيلة فى الماشية المذبوحة بمحافظتى الاسماعيلية و الوادى الجديد

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الملخص العربى

تم تجميع ستين عينه من عضلات وأكباد وكلى الماشية المذبوحة فى مجازر محافظتى الوادى الجديد و الإسماعيلية. عمر الحيوانات المذبوحة كان اقل من ثلاث سنوات (ثمانية عشر- ثلاثون) شهر.وقد تم هضم العينات و تحليلها لتقدير مستوى الكادميوم والرصاص والنحاس والحديد والزنك بواسطة جهاز الإمتصاص الذرى وقد اشارت النتائج زيادة معنوية فى مستوى الكادميوم فى كل العينات المأخوذة من الاسماعيلية مقارنة مع مثيلاتها من الوادى الجديد, وكانت نسبة الكادميوم فى عينات الكبد المأخوذة من الإسماعيلية واجمالى عينات العضلات المفحوصة قد تخطت الحدود المسموح بها, بينما عينات الوادى فى الكبد والكلى وعينات الاسماعيلية من الكلى لم تتخطى الحدود المسموح بها و رغم زيادة نسبة الكادميوم فى عينات الكلى والكبد والعضلات على التوالى الا ان تحليل التباين قد اظهرعدم حدوث اختلاف معنوى فى نسبة الكادميوم بين عينات الأعضاء المختلفة فى كلتا المحا فظتين. اعلى تركيز للكادميوم فى الكلى والكبد ربما يشير الى التعرض للكادميوم لمدة طويلة, وقد اشارت النتائج الي حدوث زيادة معنوية فى نسبة الرصاص الموجودة فى عينات العضلات والكلى المأخوذة من الاسماعيلية مقارنة مع مثيلاتها من الوادى الجديد,و قد تخطت نسبة الرصاص الموجودة فى العضلات من كلتا المحافظتين والرصاص فى عينات كبد وكلى محافظة الإسماعيلية الحدود المسموح بها, و اظهر تحليل التباين اختلاف معنوى فى نسبة الرصاص بين عينات الأعضاء المختلفة فى الاسماعيلية فكان اعلى تركيزللرصاص فى عينات الكلى يلية الكبد ثم العضلات, وتبين من النتائج زيادة معنوية فى تركيز النحاس و نقص فى الزنك فى عينات الكبد ونقص فى الحديد فى عينات الكلي فى الاسماعيلية مقارنة مع مثيلاتها من الوادى الجديد,فى حين اى من اجمالى العينات المفحوصة لم يتخطى الحدود المسموح بها فى النحاس والحديد والزنك,وبتحليل التباين ظهر اختلاف معنوى فى نسبة النحاس بين عينات الأعضاء المختلفة فى الاسماعيلية, فى حين اظهرت نسبة الحديد والزنك اختلافا معنويا بين عينات الأعضاء المختلفة فى كلتا المحافظتين.وكانت اعلى نسبة تركيز للنحاس والحديد فى عينات الكبد بينما كانت عينات العضلات تحوى اعلى نسبة تركيز للزنك يلية الكبد واقل تركيز فى الكلى .