Bioaccumulative Effect of Cadmium Chloride on the Organs of Albino Rats

Lana S. Salih* **Khabat A. Ali**** **Nashmeel S. Khudhur*****

*Department of Biology, College of Science, University of Salahaddin- Erbil
** Department of Biology, College of Education, University of Salahaddin- Erbil
*** Department of Environmental Science, College of Science, University of Salahaddin- Erbil

Abstract

Cadmium is trace metal which accumulates in the body and is extremely toxic in living organisms. This study aimed to determine the accumulation of heavy metal Cadmium (Cd) in different organs and tissues of female albino rats. The experimental animals were exposed to Cd at sublethal concentration. Tissue Cd concentration was measured by using PYE UNICAm SP9-Philips atomic absorption spectrophotometeric method and the results were given as mg. kg^{-1} dry wt. The highest concentration of Cd was found in bone ($p < 0.05$) and the lowest concentration was in brain, and Cd was not detected in spleen, intestine and ovary. The order of heavy metal accumulation in the tissues was bone > liver > kidney > lung ≥ brain. The accumulation of cadmium was significantly high in the studied tissues.

Keywords: Bioaccumulation, Cadmium Chloride, Albino Rats.

Introduction

Cadmium (Cd) is known as a highly toxic substance and an environmental contaminant (Teranishi *et al.,* 2002). It is a transitional metal that exists in different states and it occurs in rock erosion and abrasion and volcanic eruptions, fossil fuels and particularly non-ferrous mining and metal industries (Obianime and Roberts, 2009). Cadmium is a non-essential element and is generally present in the environment at low levels which enters human and animal bodies via different industrial products, environmental pollution and different contaminated foods, active and passive inhalation of tobacco smoke and inhalation by workers in the non-ferrous metal industry (WHO, 2010 and Kara *et al.,* 2005). It is considered as being one of the most ecotoxic metals that exhibits adverse effects on all biological processes of humans, animals, and plants. This metal reveals its great adverse potential to affects the environment and the quality of food (Pendias and Mukherjee,

2007). Cadmium interacts with the metabolism of three essential metals: calcium, zinc and iron and it is toxic to several tissues, most notably causing hepatotoxicity upon acute administration, as well as nephrotoxicity upon chronic exposure (Ersan *et al.,* 2008). Cadmium exerts toxic effects on the kidney, the skeletal system and the respiratory system and is classified as a human carcinogen. It is readily accumulates in many organisms, notably mollusks and crustaceans (WHO, 2010), as well as in different organs particularly the liver and kidneys and has a long biological half-life of 17-30 years in humans and its toxicity is depend on dose, duration and route of exposure (Obianime and Roberts, 2009). Lower concentrations are found in vegetables, cereals and starchy roots. According to WHO statement, national, regional and global actions are needed to decrease global environmental cadmium releases and reduce occupational and environmental exposure (WHO, 2010). Thus we found an importance to give more information about the accumulative capacity of cadmium in the organs of female albino rats.

Materials and methods

Thirty albino female rats (240-290 g) 10-12 weeks old were used. The rats were housed under temperature controlled (22-25 °C) conditions with a 12:12 light:dark cycle, and they fed with pellet rat diet and water were given. The rats were initially divided into 2 equal groups; the first was control group and the second was study group and administered $CdCl_2$ (150 $mg.l^{-1}$ via drinking water). After eight weeks of treatment, the sacrificed animals were anesthetized by chloroform and the body organs were harvested by dissection, washed by saline solution 0.9% NaCl and weighted. All tissues were kept at -20 ºC until analysis day. Samples for each organ (liver, kidney, lungs, spleen, intestine, bone, brain and ovary) from each group was taken using clean equipments and put separately in prewashed labeled petri dishes and transferred into oven to dry at 105 °C for 12 hours to obtain small pieces of coal. The dried tissues were placed in Muffle Furnace at 480 °C for 4-5 hours. The dry-ashed samples were cooled at room temperature then digested in 5 ml of nitric acid and left for 12 hours. Then, the samples were heated to obtain dry sediment and each one was introduced with 1 ml of perchloric acid and 5 ml of nitric acid (Petukhova, 2013) and the volume completed to 50 ml with distilled de-ionized water and the solutions were filtered. The resulting solutions of digested organs were analyzed by Flame Atomic Absorption Spectrophotometer (PYE UNICAm SP9-Philips) for detection of Cd concentrations (Dalaly and Al-Hakim, 1987) in milligrams per kilogram of dry body weight of rats ($mg.kg^{-1}$ dry wt.). The obtained data were expressed as Mean ± Standard errors and Student's *t*-test was used to compares both groups and P value < 0.05 was considered as statistically significant according to (Townend, 2002). SPSS program version 11.5 was applied to find out statistical differences between the two studied groups. The percentage of cadmium accumulation was finding out by this equation:

$$\text{Cd \% accumulation} = \frac{\text{Concentration of Cd in the studied organ}}{\text{Total concentration Cd}} \times 100$$

Results

Tissue concentrations of accumulated cadmium in different organs of female albino rat are presented by mean ± SE in Table (1) and Figures (1-10). The highest cadmium concentration 1.705±0.0026 $mg.kg^{-1}$ dry wt. was observed in bone tissues after 8 weeks of treatment with cadmium chloride via drinking water. The concentrations of cadmium in the other organs including liver, kidney, lung and brain were: 1.023±0.0066, 0.795±0.0000, 0.114±0.0000 and 0.114±0.0000 $mg.kg^{-1}$ dry wt. respectively. Statistical analysis showed significant differences ($p<0.05$) in the organs: liver, kidney, lung, bone and brain by *t* values of 2.38, 31.50, 4.50, 5.30 and 4.50 respectively. The order of cadmium accumulation was: bone (46%) > liver (27%) > kidney (21%) > lung (3%) ≥ brain (3%) (Figure 2) and this indicate that bone seem to be the target organ of cadmium accumulation in female albino rats. Whereas, cadmium was not detected in spleen, intestine and ovary after treatment.

Discussion

Guideline values recommended for cadmium in drinking water is 0.005 $mg.l^{-1}$ and the lethal dose LD50 is 665 $mg.kg^{-1}$ body weights upon oral uptake (WHO, 2004). In this experiment the exposure of rats to cadmium involved much higher doses of this metal but below concentration which is thought to be chronically toxic to rats (Bowen, 1979). The observed cadmium concentration in liver and kidneys by the present investigation was slightly lower than those obtained by (Josthna *et al.,* 2012) who acclimatized the rats to laboratory conditions for a week then starved them for 24 hours, and this may refer to the effect of starvation which resulted in consumption of more amounts of water and feed. On the other hand, the observation of (Rani *et al.,* 2010) seem to be similar to the present findings, who observed a significant Cd accumulation in liver and kidney among the selected tissues included small intestine and testis of male albino rats.

Conclusion

This study showed that cadmium has accumulative capability when administered to female albino rates via drinking water in a sub-chronic toxicity testing.

References

Bowen, H.J.M. (1979). Environmental Chemistry of the Elements. Academic Press, New Yurok.

Dalaly, B.K. and Al-Hakim, S.H. (1987). Food Analysis. The book house for press and publication. Univ. Mosul. Iraq.

Ersan, Y.; Smail, A. and Evren, K. (2008). Effects of cadmium compounds (cadmium para hydroxybenzoate and cadmium chloride) on the liver of mature mice. Turk J Zool. 32: 115-119.

Josthna P.; Geetharathan T.; Sujatha P. and Deepika G. (2012). Accumulation of lead and cadmium in the organs and tissues of albino rat. International Journal of Pharmacy & Life Sciences. 3(12): 2186-2189.

Kara, H.; Karatas, F. and Canatan, H. (2005). Effect of single dose cadmium chloride administration on oxidative stress in female and female rats. Turk J Vet Anim Sci. 29: 37-42.

Obianime, A.W. and Roberts, I.I. (2009). Antioxidants, cadmium-induced toxicity, serum biochemical and the histological abnormalities of the kidney and testes of the female wistar rats. Nigerian J of Physiological Sciences. 24 (2): 177-185.

Pendias, A.K. and Mukherjee, A.B. (2007). Trace Elements from Soil to Human. Springer-Verlag Berlin Heidelberg.

Petukhova, T.V. (2013). Content of heavy metals in the muscle tissue of cattle. E3S Web of Conferences, 1, 15002 (2013). http://www.e3s-conferences.org or http://dx.doi.org/10.1051/e3sconf/20130115002

Rani, A.U.; Babu, D.K. and Obaiah, J. (2010). Effect of combinations of four trace elements on cadmium bioaccumulation in a few tissues of male albino rats. Journal of Applied and Natural Science. 2(1): 66-69.

Teranishi, H.; Takagawa, K.; Arai, Y.; Wakaki, K.; Sumi, Y. and Takaya, K. (2002). Histological staining of cadmium with 2-(8-quinolylazo)-4, 5-diphenylimidazole (QAI) in the kidneys of rats periorally exposed to cadmium. J Occup Health. 44: 60-62.

Townend, J. (2002). Practical Statistics for Environmental and Biological Science. John Wiley & Sons, Ltd. England. 276pp.

WHO: World Health Organization, (2004). Guideline for Drinking Water Quality. Third edition. Vol.1, Geneva.

WHO: World Health Organization, (2010). Exposure to Cadmium: A Major Public Health Concern. Public Health and Environment World Health Organization 20 Avenue Appia, 1211 Geneva 27, Switzerland.

Table 1: concentrations of cadmium mg.kg^{-1} dry wt. (mean±S.E.) with their *t*-test data, after 8 weeks of treatment of female albino rates.

Organs		$CdCl_2$ treated	Control	*t* value
1	Liver	1.023±0.0066*	0.568±0.0009	15.588
2	Kidney	0.795±0.0000*	0.000±0.0009	12.124
3	Lungs	0.114±0.0000*	0.000±0.0009	1.732
4	Spleen	0.000±0.0000	0.000±0.0000	*N.S.*
5	Intestine	0.000±0.0000	0.000±0.0000	*N.S.*
6	Bone	1.705±0.0026*	1.136±0.0026	8.660
7	Brain	0.114±0.0000*	0.000±0.0009	1.732
8	Ovary	0.000±0.0000	0.000±0.0000	*N.S.*

N.S. means non significant differences.

*Values statistically significant from control (P < 0.05)

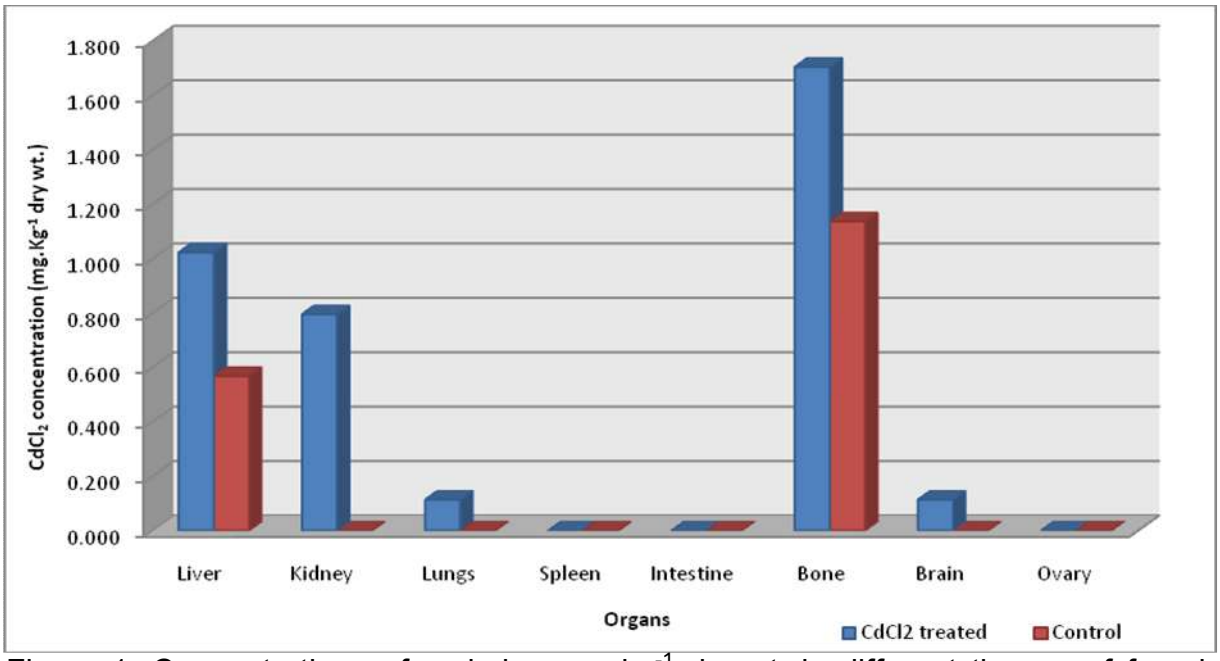

Figure 1: Concentrations of cadmium mg.kg^{-1} dry wt. in different tissues of female albino rates after 8 weeks of treatment.

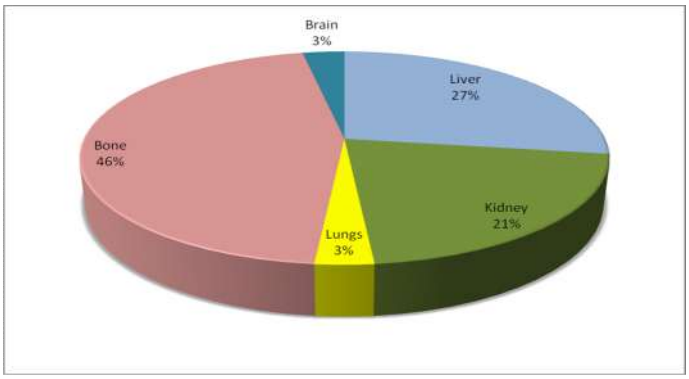

Figure 2: percentages of cadmium accumulation in different organs of female albino rates after 8 weeks of treatment.

کاریگەری زیندەکەڵەکەبوونی کلۆریدی کادمیۆم لە شانەکانی جورجی سپی

پوختە

کادمیۆم یەکێکە لە کەمە توخمەکان کە زیندەکەڵەکە دەبێت وژەهراویە بۆ لەشی زیندەوەران. ئەم تویژینەوەیە ئەنجام دراوە بۆ پێوانە کردنی خەستی توخم قورسی کادمیۆم لە شانە جیاجیاکانی جورجی سپی. جورجەکان خرانە بەر بڕی ژێر کوژەری کادمیۆم. خەستی کادمیۆم لە شانەکان بە ڕێگای شەبەنگی گەریلەی هەامژراو (PYE UNICAm SP9-Philips) پێوانە کرا وئەنجامەکان بە شێوەی مایکرۆگرام. گرام$^{-1}$ بۆ کێشی ووشك دەربڕا. بەرزترین خەستی کادمیۆم لە ئێسکەکان بەدی کرا وکەکترین خەستیش لە دەماخ بوو ($p < 0.05$) ولە سپڵ وڕیخۆڵە وهێلکەدانیش کادمیۆم بەدی نەکرا. زیندەکەڵەکە بوونی کادمیۆم لە شانەکان بەم شیوەیە بوو: ئێسك > جگەر > گورچیلە > سیەکان ≥ دەماخ. زیندەکەڵەکە بوونی کادمیۆم لە شانەکان بە شێوەیەکی واتایی بەرزبوو.

التأثير التراكمي لكلوريد الكادميوم على أعضاء الجرذان البيضاء

الخلاصة

الكادميوم عبارة عن عنصر ضئيل يتراكم في الجسم وذات سمية عالية في الكائنات الحية. أجريت هذه الدراسة بهدف تحديد تراكم العنصر الثقيل الكادميوم في مختلف أعضاء وأنسجة الجرذان البيضاء. تم تعريض الحيوانات المختبرية الى الجرعة تحت القاتلة للكادميوم. تم قياس تراكيز الكادميوم في الأنسجة باستخدام طريقة المطياف الذري الماص (PYE UNICAm SP9-Philips) وبينت النتائج بشكل مايكروغرام. غرام$^{-1}$ بالوزن الجاف. كانت أعلى تركيز الكادميوم العظام وأقل تركيز في الدماغ ($p < 0.05$)، ولم يتواجد الكادميوم في كل من الطحال والأمعاء والمبيض. كانت الترتيب التراكمي للكادميوم بالشكل الأتي: العظام > الكبد > الكلية > الرئتين ≥ الدماغ. كانت تراكم الكادميوم في الأنسجة عالية معنوياً.