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Investigation on some heavy metals' accumulation (Cd, Zn, Cr, Vn) in the muscle and hepatic tissues of the Persian Jird and Mole vole

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Abstract

Rodents are a group of mammals that have always been considered as bio-indicators for ecosystems' health. This study has been designed to do so and to investigate the changing way of element absorption measurements like Cadmium, Vanadium, Chromium, and Zinc in the muscle and liver of *Meriones persicus* and *Ellobius lutesence* in the vicinity of the oil refinery and petrochemistry of Shazand. Totally 18 individuals from *M. persicus* and 15 individuals belong to the *E. lutesence* have been sampled, and target tissues have been taken and analyzed in the corresponding lab. Our results showed that Cadmium, Vanadium, and Chromium were highly accumulated in Persian jirds' muscle tissue and showed a tapering trend in those areas where are far from the refinery factory. Zinc has been detected in a high amount in the liver of jirds as well. Based on the distance from the oil refinery factory, Cd and Zn were detected in the muscle tissue of Mole voles and comparatively in a lower amount in the hepatic tissues.

Keywords:

Biomagnification, Environmental pollution, Rodents, Shazand oil refinery factory, Markazi Province

Introduction

Most of the previous investigations have been shown that animals' internal organs, especially kidneys and liver, are target organs, which usually accumulate some pollutant materials like some of the heavy metals (Etemadi Deilami *et al*. 2013). The existence of such materials in animal bodies can produce harmful side effects and increases the mortality rate. Most of these elements are

inorganic solvent in water and would be dissolved by entering the water. Hg and Cd are some of the best-known metals (Naderi *et al*. 2012). Heavy metal accumulation has been transformed into one of the significant concerns regarding their harmful effects on human and environmental health (Saboohi *et al*. 2014). Some of the most important metals which may be accumulated in rodents tissues are Cadmium, Copper, Nickel, Lead, Mercury, and Arsenic (Michael and Hughes 2002). Refineries establishment is a kind of activity that disperse some heavy metal to the soil. Moreover, the soil may be contaminated by Petroleum hydrocarbon through oil refinement and transfer. These compounds carry some negative environmental effects as organic pollutants. The kidneys are the most important organs which may absorb heavy metals (Erfanmanesh *et al*. 2011). This study aimed to investigate some heavy metals accumulation (Copper, Zinc, Vanadium, and Cadmium) in the bodies of Persian jirds and Mole voles around the Shazand petrochemistry and oil refinery.

Material and methods

Study area

Shazand county is located in West-South of Markazi province. The area is about 2827 square kilometers and is surrounded by Arak from North and North-East, Boroujerd from South and West-South. Malayer from West and Khomeyn from East. The mean altitude is 1920-2050 m above sea levels. Shazand is a mountainous area with cold winters and moderate summers.

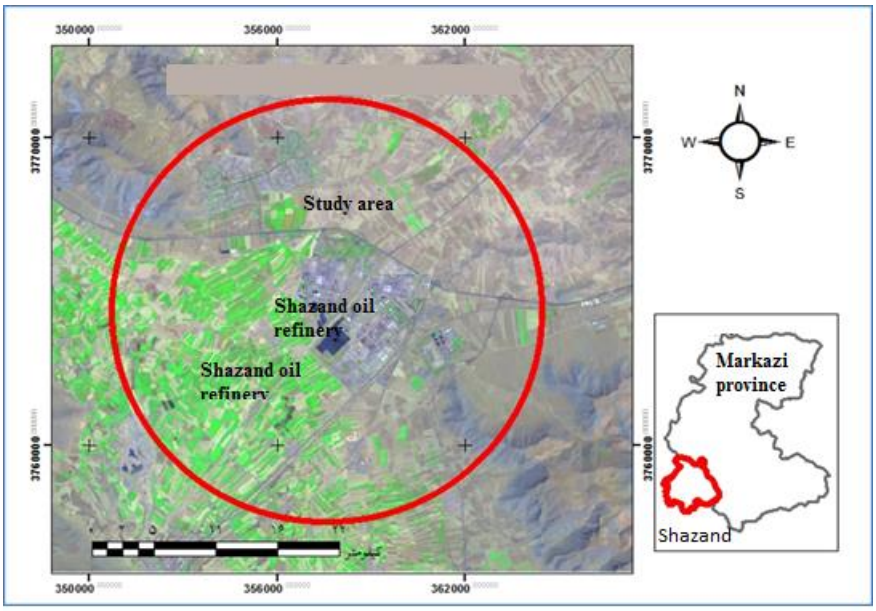

Figure 1. The red circle shows the study area around the oil refinery factory

Research methodology

This study has been done in the vicinity of petrochemistry and oil refinery factory within a radius of at least nine kilometers. We sampled target species in each 3 kilometers circles from the center. Invasive sampling has been adopted using kill traps based on the license issued by the Iran Department of Environment (95/25457, 27 Aug. 2016). The exact trapping location had been assigned to the trapped species (*Meriones persicus and Ellobius lutesence*), and tissue samples from muscles and livers have been taken in the field and stored in a standard manner. In a systematic random sampling design with predefined distances from the oil refinery factory, totally

we sampled 33 individuals from both species. The radius distance from the oil refinery factory was set in each three km from the center. The determination of the metal concentration in the experimental solution was based on the calibration curve. In plotting the calibration curves lead, Cadmium, and chromium stock solutions of 1000 ppm were prepared by dissolving 1.6 g of Pb(NO3)2, 2.74 g Cd(NO3) 2.4H2O, and 2.83 g K2Cr2O7in de-ionized water, respectively. Blank solutions were prepared for the methods and, for the standard working solutions, to prepare 100 ppm, 10 mL of the standard Pb(NO3)2, Cd(NO3) 2.4H2O, and K2Cr2O7 stock solution were pipetted and added into 100 mL calibrated flasks finally diluted with de-ionized water, and the solution was mixed thoroughly. Next, to prepare 50 ppm standard solution of each metal, 50 mL of each of 100 ppm stock solution was pipetted into 100 mL volumetric flasks and diluted with de-ionized water. Finally to prepare 0.0, 0.5, 1.0, 2.0, 4.0, 6.0 ppm aliquots of this standard working solution 0.0, 0.5, 1.0, 2.0, 4.0, 6.0 mL was pipetted from 50 ppm standard solution into 50 mL calibrated flasks and made up to volume with De-ionized water. One-way ANOVA and T-student tests were used to compare the means among the groups. The K-S test was used to test the data distribution normality (P>0.05).

Results and Discussion

One-way analysis of variance showed that Cadmium is the most different metal among the others with regard to its accumulation behavior in both muscle and hepatic tissues (ANOVA: F2,15=5.366, P<0.05) (Tables 1 and 2).

Table 1. Results of one-way analysis of variance in mean comparisons from Persian Jird

M. persicus		**F**	**df**	**Mean of squares**	**P-value**
Cd	Muscle	5.36	2,15	0.030 0.006	0.017
	liver	-	-	- -	-
Cr	Muscle	0.632	2,15	0.015 0.024	0.545
	liver	-	-	- -	-
Zn	Muscle	0.327	2,15	0.236 0.722	0.726
	liver	3.397	2,15	2.302 0.678	0.061
Vn	Muscle	0.792	2,15	0.169 0.213	0.470
	liver	0.361	2, 15	0.093 0.256	0.703

Table 2. Results of one-way analysis of variance in mean comparisons from Mole voles

E. lutescens		**F**	**df**	**Mean of squares**	**P-value**
Cd	**Muscle**	4.898	2, 12	0.002 0	0.028
	liver	0	2, 12	- -	0
Cr	**Muscle**	0.711	2, 12	0.042 0.059	0.511

	liver	3.171	2, 12	0.003 0.001	0.078
	Muscle	1.831	2, 12	10.526 5.745	0.202
Zn	**liver**	1.663	2, 12	1.107 0.666	0.230
Vn	**Muscle**	0.955	2, 12	1.214 1.272	0.412
	liver	1.822	2, 12	2.246 0.135	0.204

Tukey test as one of the most practical post hoc tests showed that most of the groups (especially group one in comparison with others) are different in terms of Cd amount. But both second and third groups were not significantly different. The paired t-test result of mean difference between Vn and Zn has been shown in table 3.

Table 3. Paired t-test results to compare Vn and Zn in both target tissues muscle

M. persicus	**F**	**df**	**P-value**
Zn	0.140	34	0.710
Vn	1.654	34	0.207
E. lutescens			
Cd	49.641	۲۸	0
Cr	4.622	۲۸	0.040
Zn	10.227	۲۸	0.003

The independent t-test showed Vn and Cd absorption shows different behaviours between liver and muscle of Persian jirds. Vanadium absorption was totally different in liver and muscle tissues. ($t=2.75$, $df=34$, $p<0.01$) while it showed a significant difference in Zinc element in terms of absorption in the liver and muscle tissue of *M. persicus*. The analysis showed that target metals were accumulated differently in the liver and muscle of *E. lutesence* as well. There was a relationship between sampling location distance from petro-chemistry and oil refinery factory and accumulated metals in the target tissues. Mean comparison tests such as paired t-test indicated that there was a significant difference between Cadmium and Chrome as well regarding their accumulation rate in different tissues of mole voles as well. At the same time, Vn and Zinc didn't show any significant differences (Tables 4 and 5).

Table 4. Results of the paired T-test in the study area

E. lutescens (N=30)	Mean	SD
Cd	0.0094	0.020
Cr	0.10	0.17
Zn	1.70	2.16
Vn	1.35	0.88
Cr	0.10	0.17
Vn	1.35	0.88
Cd	0.0094	0.02
Zn	1.70	2.25

Table 5. Independent T-test results of mean difference between two target tissues

E. lutescens	F	T	df
Cd	64.49	72.2	28
Cr	62.4	32.1	28
Zn	22.10	61.3	28
Vn	61.1	8.20	28

The study shows that Cd, Vn, and Cr were accumulated more in the muscle tissue of *M. persicus* than hepatic tissues. Regarding the sampling distance from the Shazand refinery factory we found a tapering trend in the metals values in different tissues as they were diminished in far areas from the factory. Such kind of trends was already reported by Naderi et al. (2016) in studying Fat dormouse in the Hyrcanian forests of northern Iran. Our results also showed that different metals show different accumulation behaviors in the target tissues. For example, Zinc was accumulated in hepatic tissues of the Persian jirds while Cd and Zinc showed higher amounts in the muscle tissue of *E. lutescent*. Cr and Vn were classified among those metals accumulated mostly in the liver tissues (Carral *et al*. 1995, Damek-Poprawa and Kapusta, 2004).

Mousavi *et al.* (2006) measured the amount of Zinc, Copper, Lead, and Cadmium in different tissues of rats in northern Iran and showed that the amount of the deposited Pb and Cd in the Norwegian rats bones are more than the global standard. It's worth mentioning that the acceptable amount of Zinc in human Food is less than 0.5 ppm and Cadmium is less than 0.003 ppm based on WHO standards in 1987. The Chrome amount also shouldn't exceed one ppm (Naderi *et al*. 2016).

Based on this study in Shazand, rodents that were trapped from the vicinity of the oil refinery factory had a higher amount of metals in comparison with the rodents that were sampled from longer radiuses. This probably refers to higher heavy metal pollution near the Shazand oil refinery factory, which should be considered by local authorities as a threat to humans as well.

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