Heavy Metal Accumulation in Kidney of *Microtus guentheri* (Danford and Alston 1880) From Korkuteli-Antalya, TURKEY

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Abstract

The objective of this study was to determine the concentrations of eighteen heavy metals (Fe, Al, Zn, Cu, Mn, Cr, Sr, Se, Mo, Ni, Sn, Pb, Ba, Co, V, As, Cd and Tl) in kidney from wild rodent Microtus guentheri from natural region which is near mine and stone quarry activities in Korkuteli-Antalya. This study is first record for heavy metal accumulation in kidney tissue for this species at this region. We worked with kidney samples of six voles specimens from one season (2016,in spring) collected by means of Sherman traps, in Korkuteli-Antalya. The concentrations of heavy metals were expressed for the kidney samples as milligrams per kilogram (ppm) for dry weight. The order of mean concentration of the heavy metals in samples was Fe>Al>Zn>Cu>Mn>Cr>Sr>Se>Mo>Ni>Sn>Pb>Ba>Co>V> As>Cd>Tl. The toxic heavy metal pollution is thought to be due to mine sources, like marble and stone quarries and maybe agricultural activities.

Keywords: Heavy metal accumulation, *Microtus guentheri*, kidney, ecotoxicology, biomonitor

1. Introduction

Anthropogenic activities can cause damage to the environment in order to meet the growing human population needs. Various chemicals and heavy metals are released to the environment due to industrial, agricultural and mining exploration activities (Marcheselli et al., 2010). Different pollutants can persist for a long time and affect living organisms. Heavy metal accumulation is an important environmental problem. Wild animals living in polluted areas are exposed to various pollutants (Kargar et al., 2012; Diviš et al., 2012). Sentinel organisms are suitable tools for biomonitoring. Small rodent species inhabiting near mine tailings are very important biomonitor organisms for revealing the effects of heavy metal exposure (Tovar-Sánchez et al., 2012; Yavuz & Aktaş, 2017). According to the literature, heavy metal accumulations were observed in the different organs and tissues of small rodents living in polluted areas (Martiniaková, 2010; Blagojević ve ark., 2012; Zarrintab and Mirzaei, 2017; Yavuz & Aktaş, 2017). It's well known that spesific metals mainly accumulates in particular organs [for example, cadmium (Cd) accumulates in kidney]. In this current study, *Microtus guentheri*, which is inhabited in the Korkuteli-Antalya near mine and stone quarry regions was used as biomonitor species for heavy metal accumulation in kidney tissues. Our findings are presented with the aim to determine the pollution levels in Korkuteli with a bimonitor rodent namely Levant Vole.

2. Materials and methods

Six (6) alive vole speciemen were captured from various locations in Korkuteli-Antalya, Turkey in 2016 spring season.

2.1. Field studies

Levant Voles were caught in different habitats in six different sites in which trapping were carried out (Fig. 1).

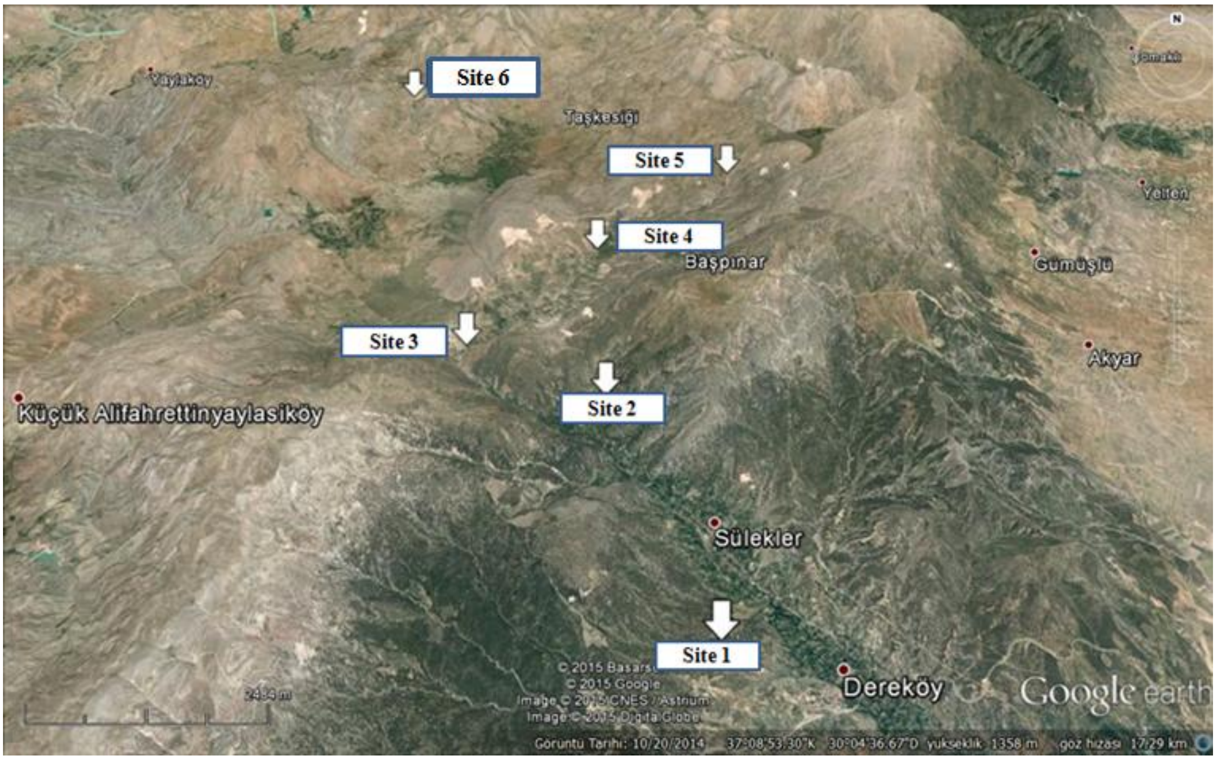

Fig. 1. Map showing the geographical location of the samples collected from Korkuteli-Antalya, Turkey.

Kidney samples of six voles specimens were evaluated from one season (2016, spring) collected via Sherman live traps in each site, in Korkuteli-Antalya. The bait used in the traps comprise of roasted peanuts mixed with some chewed bread. Captured *M. guentheri* samples were killed by cervical dislocation and kidneys were immediately removed, weighed and frozen at -40 °C prior to chemical analyses in polystyrene tubes. Kidney samples were removed from deep freeze and then allowed to dissolve for a period of time at room temperature. Kidney samples were set at 80-105 °C until completely dry and fixed weight. Also, microwave method was applied for the digestion produce of samples. Samples homogenized by milling prior to analyses. Acid microwave digestion was carried out in a Berghof speedwave MWS-2 microwave. From each tissue, 0.5 g homogenates were placed in a teflon digestion vessel with mix: 8 mL 65% nitric acid (HNO_3) and 2 mL 30% hydrogen peroxide (H_2O_2). After digestion the samples were cooled to room temperature and diluted with ultra-pure water. Then, samples were analysed by Inductively Coupled Plasma-Mass Spectometer (ICP-MS). The same procedures were conducted for a blind sample on the same conditions for control. The concentrations of heavy metals were demonstrated for the kidney samples as milligrams per kilogram (ppm) for dry weight. In this study, the results were given on dry weight (dry wt.) basis. In accordance with this objective for comparative purposes (with the results of other studies), the 29.3% ratio in kidney is used to convert wet weight to dry weight, as (Millán et al., 2008).

2.2. Statistical analysis

Descriptive statistical characteristics were calculated (mean, standard error) for kidney tissues of *M. Guentheri* in this study.

3. RESULTS

The mean concentrations of the metals accumulated in kidney samples of *M. guentheri* as follows (M±Se, n=6): Fe: 579.92±46.50, Al: 247.93±68.96, Zn: 101.41±7.12, Cu: 22.24±1.22, Mn: 12.16±1.49, Cr: 8.61±1.88, Sr: 4.08±1.13, Se: 3.60±0.32, Mo: 2.16±0.22, Ni: 1.19±0.21, Sn: 0.79±0.18, Pb: 0.79±0.13, Ba: 0.67±0.20, Co: 0.55±0.06, V: 0.49±0.05, As: 0.29±0.04, Cd: 0.22±0.05, Tl: 0.03±0.005 ppm. The order of mean concentration of the heavy metals in samples was Fe>Al>Zn>Cu>Mn>Cr>Sr>Se>Mo>Ni>Sn>Pb>Ba>Co>V>As>Cd>Tl. According to this data; The toxic heavy metal pollution began at the vicinity of Korkuteli. Case, is thought to be due to mine sources, like marble and stone quarries and maybe agricultural activities.

4. DISCUSSION

Renal tissue is the primary target of bioaccumulation of heavy metals such as Cd (Chmielnicka et al., 1989; Prozialeck et al., 2009). The bioaccumulation of Pb, Cd and other important metals and metalloids in the liver and kidneys of small mammals in polluted areas has been reported in literatures (Damek-Poprawa and Sawicka-Kapusta, 2003; Martiniková et al., 2010; Milton et al., 2003; Mohallal & Younes, 2015; Okati & Rezaee, 2013; Pereira et al., 2006; Torres et al., 2006; Sánchez-Chardi and Nadal, 2007; Sánchez-Chardi et al., 2007; Swiergosz-Kowalewska et al., 2005; Zarrintab & Mirzaei, 2017).

The current study revealed that some heavy metal accumulation levels which are in the kidney samples of the *M. guentheri* collected from polluted areas in Korkuteli higher than the literature mean values. For instance, the value obtained for Fe, the accumulation concentration value ($\overline{X}$=579.92±46.50 ppm) is significantly higher than the literature values except two studies in terms of kidney tissue. For kidney tissue the values are; 275.7 ppm, 362.3 ppm, 110.2 ppm, 382.8 ppm from

Apodemus flavicollis were collected near steelworks and zinc smelters in Poland respectively, Warsaw, Krakow, Bukowno and Miasteczko (Damek-Poprawa and Sawicka-Kapusta, 2003), 506.90 ppm from *Apodemus flavicollis* and 394.73 ppm from *Myodes glareolus* samples collected from polluted site in Slovakia (Martiniková et al., 2010), 527.4 ppm from *Acomys cahirinus* samples collected from contaminated area with automobile, coal, iron, steel, cement industry activities and red brick factories (Mohallal & Younes, 2015). The higher exceptional values are 589.11 ppm from *Apodemus slyvaticus* (Sánchez-Chardi et al., 2007) and 755 ppm from *Crocidura russula* collected from landfill site (Sánchez-Chardi & Nadal, 2007).

According to literature, it is reported that the crucial toxic levels of Zn concentration were to be 465 and 274 µg/g dry weight, respectively in the kidney and liver of mammals (Swiergosz-Kowalewska et al., 2005). Accumulation concentrations of Zn ($\overline{X}$=101.41±7.12 ppm) in kidney tissue in our study is compatible with literature data which were founded by investigators from 57.51 to 401 ppm. The values are; 57.51 ppm (new road area), 61.22 ppm (industrial road), 65.29 ppm (steel smelting area) from *Rombomys opimus* and 75.38 ppm (Beheshtieh farming area), 113.14 ppm (Majid Abad farming area) from *Rattus norvegicus* (Zarrintab & Mirzaei, 2017), 72 ppm from *Clethrionomys glareolus* collected from near an old lead mine in UK (Milton et al., 2003), 81.5 ppm, 72.6 ppm, 73.3 ppm, 89.6 ppm from *Apodemus flavicollis* were collected near steelworks and zinc smelters sites in Poland respectively, Warsaw, Krakow, Bukowno and Miasteczko (Damek-Poprawa and Sawicka-Kapusta, 2003), 81.64 ppm from *Apodemus flavicollis* and 80.28 ppm from *Myodes glareolus* samples collected from polluted site in Slovakia (Martiniková et al., 2010), 226.4 ppm from *Acomys cahirinus* samples collected from contaminated area with automobile, coal, iron, steel, cement industry activities and red brick factories (Mohallal & Younes, 2015), 135.88 ppm from *Apodemus slyvaticus* (Sánchez-Chardi et al., 2007) and 194.65 ppm from *Crocidura russula* collected from landfill site collected (Sánchez-Chardi & Nadal, 2007), 84 ppm from *Microtus agrestis*, 152 ppm from *Sorex araneus* and 401 ppm from *Apodemus sylvaticus* collected from contaminated grassland established on flourspar tailings (Cooke & Andrew, 1990), 62.97 ppm for *Meriones persicus* collected from polluted by agricultural activities (Okati & Rezaee, 2013). In the view of literature, it can be seen that our result ($\overline{X}$=101.41±7.12 ppm) is compatible with the other data obtained from different polluted sites in world except a few studies. These exceptional cases may be due to species differences and variation of pollution sources. Similarly, Cu concentration ($\overline{X}$=22.24±1.22 ppm) in kidney tissue in the current study compatible with literature data. The values are; 5.38 ppm from *Apodemus flavicollis* and 3.05 ppm from *Myodes glareolus* samples collected from polluted site in Slovakia (Martiniková et al., 2010), 14.03 ppm (new road area), 14.57 ppm (industrial road), 16.6 ppm (steel smelting area) from *Rombomys opimus* and 19.67 ppm (Beheshtieh farming area), 16.35 ppm (Majid Abad farming area) from *Rattus norvegicus* (Zarrintab & Mirzaei, 2017), 22.104 ppm from *Rattus rattus L.* and 47.781 ppm from *Mus spretus* samples collected from abandoned mining area in Portugal (Pereira et al., 2006), 23.45 ppm from *Apodemus slyvaticus* (Sánchez-Chardi et al., 2007) and 49.47 ppm from *Crocidura russula* collected from landfill site collected (Sánchez-Chardi & Nadal, 2007), 35 ppm from *Acomys cahirinus* samples collected from contaminated area with automobile, coal, iron, steel, cement industry activities and red brick factories (Mohallal & Younes, 2015), 155.13 ppm for *Meriones persicus* collected from polluted by agricultural activities (Okati & Rezaee, 2013),

There is a limited number of study in the literature in terms of Mn accumulation in kidney tissue of wild small mammals. Also, this situation can be seen in literature for Cr accumulation in kidney tissue of wild small mammals. According to our results, accumulation concentration of Mn ($\overline{X}$=12.16±1.49 ppm) in kidney tissue higher than results of *Apodemus slyvaticus* ($\overline{X}$=6.59 ppm), but lower than *Crocidura russula* ($\bar{X}$=16.44 ppm), collected from the same landfill site (Sánchez-Chardi et al., 2007; Sánchez-Chardi & Nadal, 2007).

Our results show that, accumulation concentration of Cr ($\bar{X}$=8.61±1.88 ppm) in kidney tissue higher than literature except with one study. The values of related studies in the literature are; 0.072 ppm from *Rattus rattus L.* and 0.985 ppm from *Mus spretus* samples collected from abandoned mining area in Portugal (Pereira et al., 2006), 3.61 ppm from *Apodemus slyvaticus* (Sánchez-Chardi et al., 2007) and 5.40 ppm from *Crocidura russula* collected from landfill site collected (Sánchez-Chardi & Nadal, 2007). But, according to another study carried out in Osaka-Japan show that high concentration of Cr in kidney tissue of wild rodent collected from different polluted sites. The values of this study are; 29,72 ppm, 45,06 ppm, 38.04 ppm, 36.24 ppm from wild rodents inhabiting near four different localities polluted by small factories, 33.74 ppm from wild rodents inhabiting near residential area and 31.33 ppm from wild rodents inhabiting near residential area beside a railroad (Minami et al., 2008).

Accumulation concentration of Ni ($\bar{X}$=1.19±0.21 ppm) in kidney tissue in our study is compatible with literature data which were founded by investigators from 0.065 to 136.96 ppm. The values are; 0.065 ppm from *Rattus rattus L.* and 2.175 ppm from *Mus spretus* samples collected from abandoned mining area in Portugal (Pereira et al., 2006), 0.44 ppm (new road area), 0.48 ppm (industrial road), 0.41 ppm (steel smelting area) from *Rombomys opimus* and 1.10 ppm (Beheshtieh farming area), 1.61 ppm (Majid Abad farming area) from *Rattus norvegicus* (Zarrintab & Mirzaei, 2017), 12.3 ppm from *Acomys cahirinus* samples collected from contaminated area with automobile, coal, iron, steel, cement industry activities and red brick factories (Mohallal & Younes, 2015), 136.96 ppm for *Meriones persicus* collected from polluted by agricultural activities (Okati & Rezaee, 2013).

The accumulation concentration of Pb 0.79±0.13 ppm was found in kidney tissue in our study. Although our Pb value is consistent with some studies, it is observed that the our result is lower than the more literature. The values are; 0,33 ppm, 0.21 ppm, 0.34 ppm, 0.74 ppm from wild rodents inhabiting near four different localities polluted by small factories, 0.31 ppm from wild rodents inhabiting near residential area and 0.38 ppm from wild rodents inhabiting near residential area beside a railroad (Minami et al., 2008), 1.1 ppm from *Apodemus slyvaticus* (Sánchez-Chardi et al., 2007 and 16.36 ppm from *Crocidura russula* collected from landfill site (Sánchez-Chardi & Nadal, 2007), 4.3 ppm from *Acomys cahirinus* samples collected from contaminated area with automobile, coal, iron, steel, cement industry activities and red brick factories (Mohallal & Younes, 2015), 3.29 ppm (new road area), 3.12 ppm (industrial road), 2.7 ppm (steel smelting area) from *Rombomys opimus* and 6.34 ppm (Beheshtieh farming area), 7.73 ppm (Majid Abad farming area) from *Rattus norvegicus* (Zarrintab & Mirzaei, 2017), 16.1 ppm from *Clethrionomys glareolus* collected from near an old lead mine in UK (Milton et al., 2003), 3.34 ppm from *Rattus rattus L.* and 19.56 ppm from *Mus spretus* samples collected from abandoned mining area in Portugal (Pereira et al., 2006), 0.44 ppm, 1.43 ppm, 93.21 ppm, 2.51 ppm from *Apodemus flavicollis* were collected near steelworks and zinc smelters sites in Poland respectively, Warsaw, Krakow, Bukowno and Miasteczko (Damek-Poprawa and Sawicka-Kapusta, 2003), 22.2 ppm from *Microtus agrestis*, 22.5 ppm from *Apodemus sylvaticus* and 81 ppm from *Sorex araneus* collected from contaminated grassland established on flourspar tailings (Cooke & Andrew, 1990).

There is a few study in the literature in terms of this As accumulation in kidney tissue of wild small mammals. The current study show that, As accumulation concentration is ($\bar{X}$=0.29±0.04 ppm) lower than literature data obtained from kidney tissue of small wild rodents inhabiting different polluted areas. The values are; 2 ppm from *Clethrionomys glareolus* 1.3 ppm from *Microtus agrestis*, 4.4 ppm from *Apodemus sylvaticus* ppm and 6.2 ppm *Sorex araneus* collected from near Arsenic refinery in UK (İsmail & Roberts 1992), 2.20 ppm from *Rattus rattus L.* and 3.89 ppm from *Mus spretus* samples collected from abandoned mining area in Portugal (Pereira et al., 2006). Similarly, Cd accumulation concentration in our study is ($\overline{X}$=0.22±0.05 ppm) lower than most of literature data obtained from kidney tissue of small wild rodents inhabiting different polluted areas. The Literature values are; 0.071 ppm from *Apodemus flavicollis* and 0.075 ppm from *Myodes glareolus* samples collected from polluted site in Slovakia (Martiniková et al., 2010), 0.10 ppm, 0.89 ppm, 0.89 ppm, 0.70 ppm from wild rodents inhabiting near four different localities polluted by small factories, 0.74 ppm from wild rodents inhabiting near residential area and 0.71 ppm from wild rodents inhabiting near residential area beside a railroad (Minami et al., 2008), 1.28 ppm from *Rattus rattus L.* and 1.12 ppm from *Mus spretus* samples collected from abandoned mining area in Portugal (Pereira et al., 2006). 1.44 ppm from *Apodemus slyvaticus* (Sánchez-Chardi et al., 2007) and *2*5.59 ppm from *Crocidura russula* collected from landfill site collected (Sánchez-Chardi & Nadal, 2007), 1.9 ppm from *Clethrionomys glareolus* collected from near an old lead mine in UK (Milton et al., 2003), 1.78 ppm from *Apodemus sylvaticus*, 5.27 ppm from *Microtus agrestis*, and 149 ppm from *Sorex araneus* collected from contaminated grassland established on flourspar tailings (Cooke & Andrew, 1990). 1.19 ppm, 1.16 ppm, 23.58 ppm, 6.59 ppm from *Apodemus flavicollis* were collected near steelworks and zinc smelters sites in Poland respectively, Warsaw, Krakow, Bukowno and Miasteczko (Damek-Poprawa and Sawicka-Kapusta, 2003), 1.16 ppm (new road area), 1.52 ppm (industrial road), 3.43 ppm (steel smelting area) from *Rombomys opimus* and 5.33 ppm (Beheshtieh farming area), 10.49 ppm (Majid Abad farming area) from *Rattus norvegicus* (Zarrintab & Mirzaei, 2017).

The current study show that, Mo accumulation concentration is ($\overline{X}$=2.16±0.22 ppm) in correlatation with literature data obtained from kidney tissue of small wild rodents inhabiting different polluted areas. The values are; 1.92 ppm from *Apodemus slyvaticus* (Sánchez-Chardi et al., 2007) and *2*.53 ppm from *Crocidura russula* collected from landfill site collected (Sánchez-Chardi & Nadal, 2007).

This is the first study for revealing the accumulation concenration of Al, Sr, Se, Sn, Ba, Co, V, Tl for kidney samples of *M. guentheri* in this area in Turkey, and there was no literature information for these heavy metals. For this reason, it is hoped that the current study can be crucial for eliminating lack of literature in this field and species. It is expected that the elements demonstrated above can be important for monitoring studies in future.

According to Cooke and Andrews (1990) the possible reasons for interspecific variations of bioaccumulation among the same polluted sites comprise of differences in dietary intake, digestion and assimilation efficiencies in other physiological, biochemical and behavioral factors. The aims of this study were to analyse the accumulation levels of heavy metals in kidney of *Microtus guentheri* inhabiting in polluted sites in Korkuteli-Antalya. Prior to this study there was no information available about the heavy metal levels of small mammals in this region. In this field, stone quarries and mines are located. For this reason, the primary objective of this study was to measure in the present levels of heavy metal accumulation that could be used to examine future environmental effects of bioaccumulation from the mines and marble quarries. Our results are the first study for this species living in this region. The results obtained from this study can be used as a reference in case bioaccumulation observations occur in the future. The species examined in this case can be used as a biomonitor for long-term and large-scale studies in the future.

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