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# CADMIUM LEVELS IN SOIL AND ITS CONTENT IN SOME VEGETABLES GROWN IN THE CENTRAL REGION OF SAUDI ARABIA

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## ABSTRACT

The information regarding the status of cadmium (Cd) in the soils of the central region in Saudi Arabia is lacking. The lack of these informations will make the evaluation of Cd status in these soils and the grown plants in this region a difficult task. Therefore, the present study was initiated to investigate the levels of Cd naturally present in soils of Al-Kharj, Riyadh and Qasseem provinces and in the vegetables growing in these soils.

Data revealed that there were significant differences between the average values of total Cd content in the surface layer of the cultivated soils. The average values were 0.24; 0.23 and 0.18 mg $kg^{-1}$ for Al-Kharj, Riyadh and Qasseem provinces, respectively. On the other hand, these values in the uncultivated areas were 0.10; 0.21 and 0.17 mg $kg^{-1}$ for the same provinces, respectively.

As for the Cd content of the various vegetables grown in soils of the three provinces, the results indicated significant differences among the three provinces. Data showed a positive significant correlation between the Cd content in these soils and the vegetables growing in them (r= 0.67).

The total Cd content in the studied soils and the concentration of Cd in various vegetables plants sampled from these soils were well within the range of those reported for uncontaminated areas of the world.

**Keywords**: Cadmium, vegetables, soils.

## INTRODUCTION

Increased interest about the contamination of soil and water resources with heavy metals has occurred in recent years. Adverse health effect consequent upon consumption of contaminated feed has also received much attention. Cadmium (Cd) among these heavy metals is considered to be the most hazardious due to its high phytoavailability and the ease of its transfer to the food chain. Cadmium naturally occurs in all soils in minute quantities, but can accumulate in agricultural soils from various sources, such as organic and inorganic fertilizers and atmospheric deposition(Alloway,1995 and McLaughlin and Singh,1999).

The agricultural land in the central region of Saudi Arabia is wittnessing remarkable development and intensification of agricultural production, this is coupled by intensive use of chemical fertilizers which is considered as one of the main sources of addition of Cd to agricultural soils. Thus, the data of the present status of Cd in these soils are essential for assessment of any possible future accumulation of this element(Modaihsh *et al.*, 2001).

The information regarding the status of cadmium in the soils of the central region in Saudi Arabia is lacking. The lack of these information will make the evaluation of the status of Cd in the soil and plants of this region a difficult task.

It is therefore thought important to investigate the levels of cadmium naturally present in the soils and vegetable plants growing in this region. Such information is vital for monitoring changes and development of pollution control strategies for various background conditions.

The present study was initiated to study the cadmium levels of vegetables and of soils in the central region of Saudi Arabia (AL-Kharj, Riyadh and Qasseem).This study also aims to establish background about the concentrations of cadmium in these soils and in some of the important vegetables plants grown in soils of these regions.

## MATERIALS AND METHODS

Three important agricultural districts in the Kingdom of Saudi Arabia,were chosen as the site of the current study, the first one is Al-Kharj province. It is situated 75 km south of Riyadh and lies on latitude 24؛ 11´ North and Longitude 47؛ 15´ East. The second is Riyadh which lies on latitude 24؛ 11´ and Longitude 46؛ 45´ and the third one is Qasseem region which lies on latitude 25؛ 30´ and Longitude 45؛ 42´. Some physical and chemical characteristices of the studied soils are shown in Table (1).

**Plant Samples**:

Plant samples (vegetable crops) were chosen from the three districts as following: 1-Lettuce ( Lactuca sativa), 2- Potato ( Solanum tuberosum), 3-Tomato (Lycoperiscon esculentum) and 4- Cucumber ( Cucumis sativus) plants.

Plant samples were dried in an oven at 50-60 $^0$C and ground to be available for analysis. The dried samples were wet digested with $HClO_4$ – $HNO_3$ mixture and the cadmium was determined in the digestion product with atomic absorption ( Page,1986).

**Soil Samples:**

Surface soil samples (0-30 cm) were taken from the same sites of the vegetable plants samples. Also, uncultivated soil samples were collected to compare with the cultivated soill samples. All the collected soil samples were air dried, ground and sieved through a 2 mm sieve and kept for analysis.

Mechanical analysis was carried out according to the international pipette method using sodium hexametaphosphate as a dispersing agent (Richards,1954). Organic matter (OM) content was determined according to Walkley-Black method (Jackson,1965). Total carbonate percentage as $CaCO_3$ was volumetrically measured by Collins،s calcimeter (Wright,1959). pH and EC values were measured in the soil paste and soil paste extract, respectively (Richards,1954). Cadmium content in the studied soil samples was determined according to Page(1986) with atomic absorption.

Data obtained were subjected to statistical analysis using Statistical Analysis System-Analysis of Variance(SAS,1989).

**Table (1 ). Some physical and chemical properties of the studied soils**

| Site | Farm No. | Particle size distribution Clay % | Silt % | Sand % | Texture * | EC $Dsm^{-1}$ | pH | O.M. % | $CaCO_3$ % |
|---|---|---|---|---|---|---|---|---|---|
| AL-Kharj | F1 | 7.4 | 6.1 | 86.5 | S | 1.58 | 7.33 | 0.28 | 42 |
| AL-Kharj | F2 | 7.1 | 3.8 | 89.1 | S | 0.68 | 7.67 | 0.21 | 19.8 |
| AL-Kharj | F3 | 13 | 4 | 83 | S.L | 1.88 | 7.05 | 0.09 | 39 |
| AL-Kharj | F4 | 8.1 | 4.8 | 87.1 | S | 0.32 | 7.52 | 0.2 | 28.7 |
| AL-Kharj | F5 | 16.5 | 24.4 | 59.1 | S.L | 2.9 | 7.69 | 0.17 | 23.9 |
| AL-Kharj | F6 | 8.5 | 9 | 82.5 | L .S | 1.92 | 7.11 | 0.1 | 23 |
| AL-Kharj | F7 | 37 | 7.4 | 55.6 | S.C | 2.08 | 7.45 | 0.6 | 27 |
| AL-Kharj | F8 | 46.5 | 5.5 | 48 | S.C | 2.12 | 7.8 | 0.35 | 33 |
| Qassem | F1 | 4.1 | 10.5 | 85.4 | L .S | 1.11 | 6.6 | 0.2 | 6 |
| Qassem | F2 | 13.1 | 6.4 | 80.5 | L .S | 1.6 | 7.45 | 0.4 | 7.4 |
| Qassem | F3 | 2.4 | 4.2 | 91.4 | L .S | 0.96 | 7.13 | 0.13 | 7 |
| Qassem | F4 | 5.4 | 10 | 84.6 | L .S | 3.32 | 6.8 | 0.2 | 7.2 |
| Qassem | F5 | 22.3 | 7.3 | 70.4 | S.L.C | 0.21 | 7.35 | 0.15 | 3.4 |
| Qassem | F6 | 47.5 | 8.5 | 44 | S.C | 2.1 | 7.7 | 0.4 | 7.8 |
| Qassem | F7 | 9.1 | 0.2 | 90.7 | S | 1.4 | 7.15 | 0.1 | 8.5 |
| Qassem | F8 | 6 | 18.6 | 75.4 | L .S | 1.6 | 7.5 | 0.15 | 9.5 |
| Riyadh | F1 | 30.3 | 23.7 | 46 | S.C.L | 2.55 | 7.6 | 0.5 | 32 |
| Riyadh | F2 | 20.9 | 35.1 | 44 | L | 4.4 | 8.2 | 0.25 | 35 |
| Riyadh | F3 | 25 | 26.8 | 48.2 | S.C.L | 2.85 | 7.35 | 0.44 | 22 |
| Riyadh | F4 | 27.5 | 22 | 50.5 | S.C.L | 2.2 | 7.2 | 0.48 | 21 |
| Riyadh | F5 | 14.4 | 29 | 56.6 | S.L | 1.55 | 7.6 | 0.22 | 15 |
| Riyadh | F6 | 24.6 | 23.4 | 52 | S.C.L | 2.6 | 7.77 | 0.3 | 19 |
| Riyadh | F7 | 38.8 | 18.6 | 42.6 | C.L | 4.6 | 7.9 | 0.36 | 27 |
| Riyadh | F8 | 34 | 21.2 | 44.8 | C.L | 3.95 | 7.82 | 0.4 | 22 |

*** S = Sandy  L= Loamy  C = Clayey**

## RESULTS AND DISSCUSION

Data in Table (2) revealed that the total Cd content in the surface layer (0-30 cm) of Al-Kharj area ranged from (0.09-0.94 $mgkg^{-1}$ soil) with an average of 0.24 $mgkg^{-1}$ for the cultivated soils and between 0.03 to 0.16 $mgkg^{-1}$ soil with an average of 0.10 for the uncultivated ones. The results also revealed that there were significant differences between Cd concentrations in the cultivated farms (0.24 $mgkg^{-1}$) and in the adjacent uncultivated soils(0.10 $mgkg^{-1}$). It is worthy to note that there is no relation between total Cd in the studied soils and the different studied soil characteristics. This may be due to the different agricultural prosses applied in these farms. This result is in agreement with those reported by Pezzarossa *et al.*(1991) and Singh (1991).

Data in Table (2) showed a significant difference in Cd concentrations in the vegetable plants grown in this area, it ranged from 0.08 to 1.3 $mgkg^{-1}$ with an average of 0.58 $mgkg^{-1}$. The highest value of Cd in the vegetables was found in the soil contains the highest value of total Cd content. Also, the data showed that there were a positive significant correlations between soils and plants Cd content (r = 0.67).

**Table (2): Cadmium content in the studied soils and in some vegetable plants grown in Al-Kharj area**

| Farm No.* | Cd in soil ($mgkg^{-1}$) | | Cd in Plant ($mgkg^{-1}$) |
|---|---|---|---|
| | Cd Out** | Cd In** | |
| F1 | 0.14 | 0.16 | 0.50 |
| F2 | 0.11 | 0.09 | 0.08 |
| F3 | 0.09 | 0.06 | 1.08 |
| F4 | 0.14 | 0.09 | 0.44 |
| F5 | 0.09 | 0.03 | 0.96 |
| F6 | 0.94 | 0.09 | 1.30 |
| F7 | 0.16 | 0.15 | 0.14 |
| F8 | 0.25 | 0.16 | 0.13 |
| LSD (0.05) | 0.07 | 0.04 | 0.31 |
| | 0.24 a | 0.10 b | 0.58 |

*** F1 & F2 = Potato farms F3 & F4 = Tomato farms**
**F5 & F6 = Cucumber farms F7 & F8 = Lettuce farms**
**** Cd In = Cadmium content inside farms**
**** Cd Out = Cadmium content outside farms**

In Qasseem area the data in Table (3) showed that the total Cd content in the studied soils (0-30 cm) ranged from 0.06 to 0.32 $mgkg^{-1}$ with an average of 0.18 $mgkg^{-1}$for the cultivated soils while it ranged from 0.12 to 0.26 $mgkg^{-1}$ with an average of 0.17 $mgkg^{-1}$ for the uncultivated soils. It was found significant differences between the total Cd content in the different farms, also outside the farms.

The data in Table (3) showed significant differences between the concentration of Cd in the vegetable plants cultivated in the different farms in Qasseem area, it ranged from 0.05 to 0.38 $mgkg^{-1}$ with an average of 0.19 $mgkg^{-1}$. These differences may be due to the $Cl^-$ content of soil which plays a rule on Cd uptake by plants (John *et al.* 1972; Bingham *et al.*1983 and Hirsch *et al.*1989) or $SO_4^=$ ions (Bingham *et al.*1986) or $Na^+$ ions (Zachara and Smith, 1994). McLaughlin *et al.*($1994_a$) did not find any difference in Cd concentration in different varieties of potato and also reported that Cd concentration in potato tubers was affected by $Cl^-$ cocentration in the soil.

**Table (3): Cadmium content in the studied soils and in some vegetable plants grown in Qasseem area.**

| Farm No. | Cd in soil ($mgkg^{-1}$) | | Cd in Plant ($mgkg^{-1}$) |
|---|---|---|---|
| | Cd In | Cd Out | |
| F1 | 0.18 | 0.15 | 0.19 |
| F2 | 0.19 | 0.13 | 0.22 |
| F3 | 0.32 | 0.25 | 0.18 |
| F4 | 0.06 | 0.12 | 0.05 |
| F5 | 0.23 | 0.25 | 0.38 |
| F6 | 0.16 | 0.12 | 0.20 |
| F7 | 0.18 | 0.12 | 0.14 |
| F8 | 0.21 | 0.26 | 0.14 |
| LSD (0.05) | 0.07 | 0.03 | 0.12 |
| Mean | 0.18 a | 0.17 a | 0.19 |

In Riyadh area, the value of total Cd ranged between 0.18 to 0.25 $mgkg^{-1}$ with an average of 0.23 $mgkg^{-1}$ in the cultivated soils as shown in Table(4). On the other hand, total Cd ranged from 0.16 to 0.27 $mgkg^{-1}$ with an average of 0.21 $mgkg^{-1}$ in the adjacent uncultivated soils.

The results showed that there are no significant differences between the Cd content in the different soils in Riyadh area, while there are significant differences between Cd content in the cultivated and uncultivated soils. Modaihsh *et al.*(2001) reported that Cd which found in the phosphatic fertilizers as impurities may increase the Cd content in the cultivated soils.

The data in Table (4) indicated a significant difference in the Cd concentration in the vegetable plants grown in Riyadh area, it ranged from 0.09 to 0.31 $mgkg^{-1}$ with an average of 0.18 $mgkg^{-1}$. This difference may be related to high $Cl^-$ concentration in the irrigation water used in this area. McLaughlin *et al.* ($1994_b$) stated that the addition of $Cl^-$ ions to the irrigation water increased significantly Cd content in potato tubers.

**Table (4): Cadmium content in the studied soils and in some vegetable plants grown in Riyadh area**

| Farm No. | Cd in soil ($mgkg^{-1}$) | | Cd in Plant ($mgkg^{-1}$) |
|---|---|---|---|
| | Cd In | Cd Out | |
| F1 | 0.18 | 0.16 | 0.21 |
| F2 | 0.24 | 0.27 | 0.11 |
| F3 | 0.24 | 0.26 | 0.18 |
| F4 | 0.25 | 0.24 | 0.20 |
| F5 | 0.23 | 0.17 | 0.23 |
| F6 | 0.23 | 0.19 | 0.31 |
| F7 | 0.22 | 0.19 | 0.09 |
| F8 | 0.24 | 0.21 | 0.09 |
| LSD (0.05) | 0.07 | 0.03 | 0.07 |
| Mean | 0.23 a | 0.21 b | 0.18 |

The results of Table (5) demonstrated that there were significant differences between average soil Cd contents in the three provinces: Al-Kharj, Qasseem and Riyadh..Al- Kharj area registered the highest level (0.24 $mgkg^{-1}$) followed by Riyadh area (0.23 $mgkg^{-1}$) with no significant difference. The average Cd content in Qasseem area declined sharply and reach 0.18 $mgkg^{-1}$. The data also showed that the average Cd content inside the farms in the studied areas was 0.22 $mgkg^{-1}$ whereas the average Cd content outside the cultivated farms in the three areas was significantly low (0.16 $mgkg^{-1}$) ( Tables 2,3,4).

Concerning Cd content of the various vegetable crops grown in the three provinces, the results of Table (5) indicated significant differences between the three provinces. Vegetables crops grown in Al-Kharj province registered the highest Cd content (0.58 $mgkg^{-1}$) which was significantly higher than the other two provinces. Crops grown in Qasseem province were little higher in their Cd content than those grown in Riyadh, however, the difference is not significant.

It is worthy to note that Cd content in the vegetable plants and in the soils of the three provinces near to the same values registered in different areas in the world (Kabata-Pendias and Pendias,1992).

Data showed a positive significant correlation between Cd in soil and plants in the three provinces (r= 0.67). Nevertheless, this relation was positive and significant only in Al-Kharj province.

**Table (5): Cadmium content in the studied soils and in some vegetable plants grown in Al-Kharj, Qasseem and Riyadh areas**

| | Cd in soil ($mgkg^{-1}$) | | | Cd in Plant ($mgkg^{-1}$) | | |
|---|---|---|---|---|---|---|
| **Farm** | **AL-Kharj** | **Qasseem** | **Riyadh** | **AL-Kharj** | **Qasseem** | **Riyadh** |
| F1 | 0.14 | 0.18 | 0.18 | 0.5 | 0.19 | 0.21 |
| F2 | 0.11 | 0.19 | 0.24 | 0.08 | 0.22 | 0.11 |
| F3 | 0.09 | 0.32 | 0.24 | 1.08 | 0.18 | 0.18 |
| F4 | 0.14 | 0.06 | 0.25 | 0.44 | 0.05 | 0.2 |
| F5 | 0.09 | 0.23 | 0.23 | 0.96 | 0.38 | 0.23 |
| F6 | 0.94 | 0.16 | 0.23 | 1.3 | 0.2 | 0.31 |
| F7 | 0.16 | 0.18 | 0.22 | 0.14 | 0.14 | 0.09 |
| F8 | 0.25 | 0.21 | 0.24 | 0.13 | 0.14 | 0.09 |
| Mean | 0.24 a | 0.18b | 0.23a | 0.58a | 0.19b | 0.18b |

It can be concluded that the concentrations of Cd in the editable part of various vegetable plants sampled from the three studied provinces were well within the range of those found in uncontaminated areas of the world (McLaughlin, *et al.*1996 and DePieri,*et al.*1997). Also,the range of total Cd found in soil of the current survey was also well within the range reported for uncontaminated world soils (Kabata-Pendias and Pendias,1992). The only exception was for Cd content in plants sampled in one of Al-Kharj fields.

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## مستويات الكادميوم فى التربة وفى بعض الخضروات النامية فى المنطقة الوسطى بالمملكة العربية السعودية

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تعتبر المعلومات المتوفرة عن تركيز عنصر الكادميوم في بعض ترب المنطقة الوسطى بالمملكة العربية السعودية قليلة وغير كاملة وهذا يجعل من الصعوبة بمكان رصد وتقييم التغيرات التي قد تحدث في تركيز هذا العنصر تحت ظروف تكثيف وتنويع الإنتاج الزراعي الذي تشهده هذه المنطقة .لهذا فإن الهدف من هذه الدراسة هو معرفة تركيز عنصر الكادميوم في بعض ترب المنطقة الوسطى) الخرج، الرياض، القصيم ( وفي الخضروات النامية فيها.

وقد أظهرت النتائج أن قيم متوسطات تركيز الكادميوم داخل المزارع كانت0.23 ، 0.24و 0.18 ملجم/كجم فى مناطق الخرج والرياض والقصيم على الترتيب وكانت الفروق بين هذه القيم معنوية ,بينما كانت قيم هذه المتوسطات فى المناطق الغير مزروعة 0.10 ،0.21 و0.17 ملجم/كجم على الترتيب لنفس المناطق الثلاث.

بالنسبة لمحتوى النباتات المختلفة من الكادميوم والنامية في ترب المناطف الثلاث فقد أوضحت النتائج وجود إختلافات معنوية بين متوسط محتوى النباتات المختلفة من الكادميوم فى مناطق البحث الثلاث، وأظهرت النتائج وجود علاقة إرتباط معنوية.(r=0.67)

كان تركيز الكادميوم فى ترب المناطق الثلاث وفى الخضر المختلفة النامية فيها فى حدود القيم المسجلة فى كثير من مناطق العالم.