

THE CONTENTS OF Pb, Cd, Ni and Cr IN SOILS AND TOBACCO IN VARIOUS REGIONS OF R. MACEDONIA

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ABSTRACT

Tobacco is one of the most important crops grown in the Republic of Macedonia. This crop can easily accumulate certain metals in its leaves. High concentration of these metals affects the quality of tobacco products and can have a harmful effect on consumers' health. The soil study was conducted on family farms in different parts of Macedonia. Analyses were made on pH, humus, total content of Pb, Cd, Ni and Cr in soils, as well as concentrations of these elements in the three primings of tobacco. Correlation coefficients between the total metal concentration in investigated parameters in tobacco and soils indicated the existence of strong relationship between the lower, middle and upper primings for each metal.

Statistically significant dependence was found between Pb contents of the plant material (all three primings) and humus, clay and Cd, Cu, Zn and Ni content in the soil. All other obtained results showed that the Pb, Cd, Ni and Cr contents in soil had no influence upon their accumulation in tobacco leaves. Metal concentrations in tobacco plants and respective soils were below the permissible limits.

Key Words: soil, heavy metals, tobacco

СОДРЖИНА НА Pb, Cd, Ni И Cr ВО ПОЧВАТА И ТУТУНОТ ВО НЕКОИ РЕГИОНИ ВО Р. МАКЕДОНИЈА

Тутунот е еден од најважните култури што се одгледува во Република Македонија. Познато е дека тутунот е култура која има способност да акумулира поголема количина на одредени метали во своите вегетативни органи. Високата концентрација на овие метали може да има штетно влијание врз квалитетот на тутунската суровина, а со тоа и врз здравствената состојба на консуматорите. Тргувајќи од суштината на изнесеното ги поставивме целите на оваа студија. Истражувањата беа спроведени на почви од семејни земјоделски стопанства од повеќе позначајни локации низ републиката. Беа спроведени анализи на рН, хумус, вкупната содржина на Pb, Cd, Ni и Cr во почвата, како и концентрацијата на овие елементи во три бербени појаси на тутунскиот страк. Корелационите коефициенти меѓу вкупната концентрација на испитуваните метали во тутунот и почвите покажуваат дека постои силна врска меѓу концентрациите на бербениот појас (прв, втор и трет) со секој испитуван метал. Статистички значајна зависност беше пронајдена помеѓу содржината на Pb во растителниот материјал (во трите берби) и хумус, глина, како и содржина на кадмиум, цинк, никел и бакар во почвата. Сите други резултати покажуваат дека содржината на Pb, Cd, Ni и Cr во почвата немаат влијание врз нивната акумулација во тутунските листови.

Добиените концентрации на испитуваните метали се во согласност со стандардите и се под дозволените граници.

Клучни зборови: почва, Pb, Cd, Ni, Cr, тутун

INTRODUCTION

During the past decades, there has been a growing concern for environmental pollution. This is due to the high concentrations of heavy metals in the environment, since they can be easily absorbed from the soil. The specific climatic conditions and soil properties contribute to high quality production of Oriental tobacco in Macedonia. About 90% of the total tobacco production is exported and this culture is a strategic product viewed from economic, trading, fiscal, social and demographic aspects. Heavy metals from soil can be easily absorbed by the plants and humans have the greatest influence upon the levels of these elements. The heavy metals content in plants depends on several factors: bio-ecological characteristics of plant species, concentration, chemical form of these elements in the soil and eco-pedological conditions which determine their mobility and

availability (Knezević, 2006).

Because of the wide use of tobacco in cigarette industry, the monitoring of heavy metals accumulation in tobacco is of crucial importance for human health (Adamu et al., 1989; Bell et al., 1992).

The group of potentially toxic elements investigated in this paper includes Pb, Cd, Ni and Cr. Tobacco is well-known accumulator of heavy metals and is characterized as a high-leaf, high-root Cd accumulator (Matsi, 2002). The aim of this work was to analyze the heavy metal contents (Cd, Cr, Ni and Pb) in agricultural soils and in Oriental tobaccos collected from different locations in Macedonia. These results will provide an insight into possible heavy metal contamination that may be occurring in the study area.

MATERIALS AND METHODS

50 composite soil samples were collected from pedological profiles at fixed depths of 0 - 10 cm, 10 - 20 and 20-30 cm. Two samples from each locality were taken during November, 2010. In addition to soil samples, two dry tobacco samples were taken each from the lower, middle and upper primings. The lower primings included sand and bottom leaves, the middle primings - the first, second and third middle leaves and the upper primings - lower top and top leaves. The samples were collected from family farms in the well-known tobacco growing regions in the central part of Macedonia (Prilep, Krivogashtani, Mogila, Novaci, Bitola, Demir Hisar, Krushevo, Dolneni, Veles, Cashka, Studenicani), as well as some regions in Eastern Macedonia (Strumica, Vasilevo, Bosilevo, Novo Selo, Radovish and Konce). Soil samples were provided in accordance with ISO 11464:2006. First, they were air-dried and after that crushed and sieved through a 2-mm sieve. Determination was made of their physical properties, such as: clay content (Korunović & S.V. Stojanović, 1989), pH

(10390:2005), Total nitrogen (modified Kjeldahl method-ISO 11361:1995), humus (Standard method developed by I.V. Tjurin, modified by Simakov), potassium and phosphorus (Al-method, validated at the Scientific Tobacco Institute - Prilep, Macedonia, 2009). The total concentration of metals was determined using the Aqua Regia (HCl-HNO₃, 3:1) extraction method (ISO 11047:1998) after digestion at 180°C for 2 h. All reagents were of analytical grade (Merck, Germany). Appropriate blanks were included in all extractions. The data were statistically analyzed using correlation analysis (Pearson correlation, two-tailed). Results from two replicates were averaged prior to statistical analyses. Statistical analyses were performed using SPSS 9.0 software. Correlation analysis was used to establish relationships between physical and chemical characteristics of the soil samples and between these characteristics and the heavy metal content of Oriental tobacco leaf samples from three positions of the plant.

RESULTS AND DISCUSSION

Descriptive statistics for heavy metal content in soils and tobacco leaves from the study area are shown in Table 1. In Oriental tobacco leaves, the mean concentrations of Cd and Pb (as presented in Table 1) had higher values in the first primings and the lowest values in the third primings. Ni had higher concentrations in the second primings, whereas Cr in the third

primings. The leaves of the lower primings seemed to accumulate high amounts of metals, but in all cases the concentrations were lower than those reported by other investigators (Murty et al., 1986; Clarke and Brennan, 1989; Bell et al., 1992; Gondola and Kadar, 1994; Ruso et al., 2001; McNeill et al., 2006).

Table 1. Content of Cd, Pb, Cr and Ni in tobacco and soil (n=50)

Elements	Statistical index	Lower primings	Middle primings	Upper primings	Depth (cm)		
					0-10	10-20	20-30
Cd mg/kg	Mean	0.6	0.5	0.4	0.3	0.3	0.3
	Minimum	0.20	0.10	0.05	0.10	0.07	0.13
	Maximum	2.1	1.6	1.2	0.5	0.6	0.6
	CV, %	67.6	66.0	65.5	29.8	30.2	30.5
Pb mg/kg	Mean	1.3	1.3	1.3	8.65	9.34	8.64
	Minimum	0.7	0.7	0.2	0.00	1.00	1.5
	Maximum	2.2	2.3	2.4	31.0	41.00	30.5
	CV, %	31.3	30.8	37.1	85.6	87.5	81.4
Cr mg/kg	Mean	2.9	2.9	3.3	57.6	57.1	55.9
	Minimum	1.0	1.1	1.3	3.2	12.8	5.5
	Maximum	4.9	5.0	8.2	222.7	240.9	125.5
	CV, %	35.6	35.9	42.3	58.4	59.1	46.2
Ni mg/kg	Mean	4.9	5.2	5.1	42.7	47.4	43.9
	Minimum	2.3	2.0	1.8	15.6	15.3	14.1
	Maximum	9.0	11.0	9.7	104.0	126.4	91.5
	CV, %	37.4	36.9	37.6	43.7	50.2	40.7

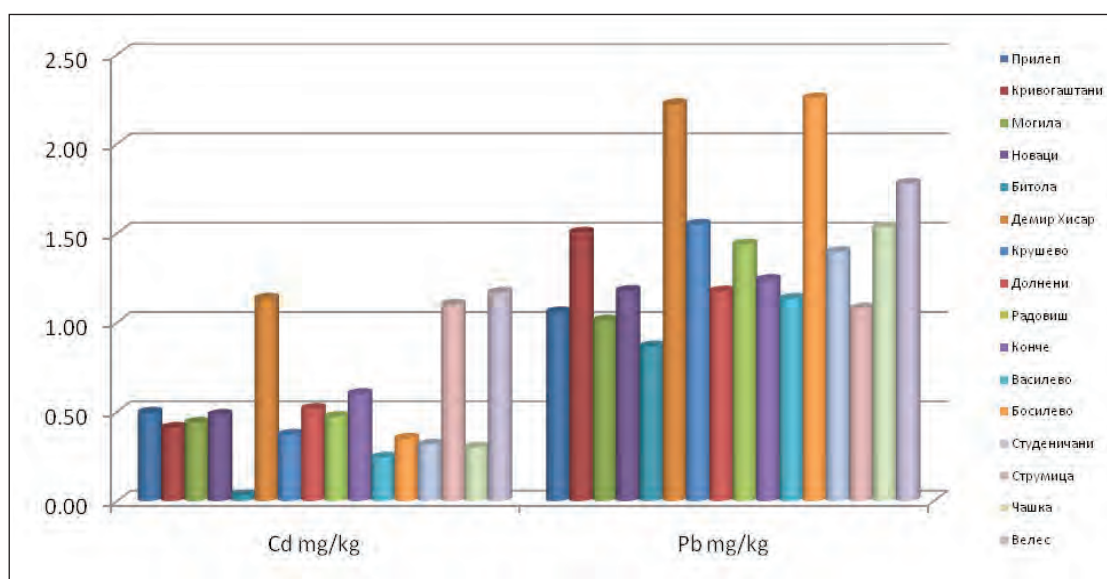


Figure 1. Cd and Pb average concentrations in tobacco samples

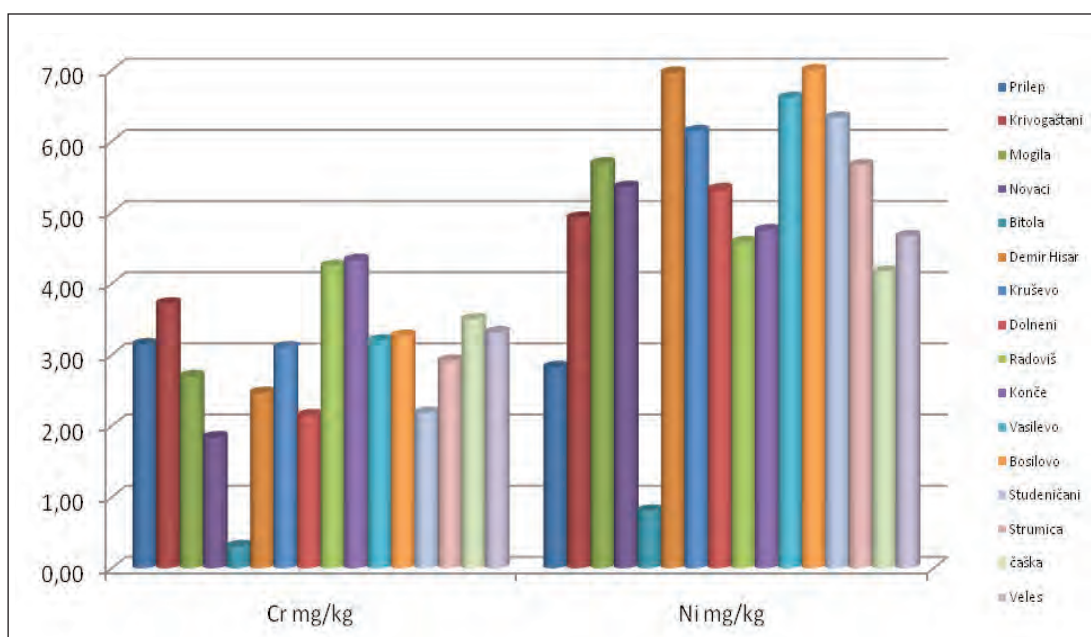


Figure 2. Cr and Ni average concentrations in tobacco samples

Figure 1 presents concentration of Cd and Pb in the tobacco samples from different sampling spots. Highest average Cd concentrations were detected in Demir Hisar, Strumica and Veles, with 1.1 mg/kg, 1.1 mg/kg and 1.2 mg/kg respectively. Pb concentrations varied from 0.2 to 2.4 mg/kg. Highest average values for Pb were recorded in Demir Hisar, while lowest in Bitola with an average of 0.2 mg/kg. Cr и Ni concentrations are given in Figure 2. The lowest Cr concentrations were measured in Radoviš and Konče, and the lowest Ni concentrations were recorded in the areas of Demir Hisar and Bosilevo.

Mean soil concentrations in the soil for Cd, Pb, Ni and Cr were: 0.3 mg/kg; 1.3 mg/kg; 43 mg/kg and 56 mg/kg respectively (Table 1).

The average metal concentrations recorded in soil samples are as follows: Cd – 0.3 mg/kg; Pb - 8.9 mg/kg, Ni - 43 mg/kg and Cr - 56 mg/kg (Table 1). Figure 3 represents the average Cd and Pb concentrations in soils. The highest average concentrations were measured in Prilep, with an average of 16.2 mg/kg, while the lowest concentrations were measured in Bitola. Figure 4 represents Cr and Ni in soils in all sampling locations. Highest concentration of 122 mg/kg for Cr was measured in Novaci, Ni average concentrations varied from 15 to 48 mg/kg. The total Pb had the highest coefficient of variance. The mean values of all metals were similar in the three soil depths.

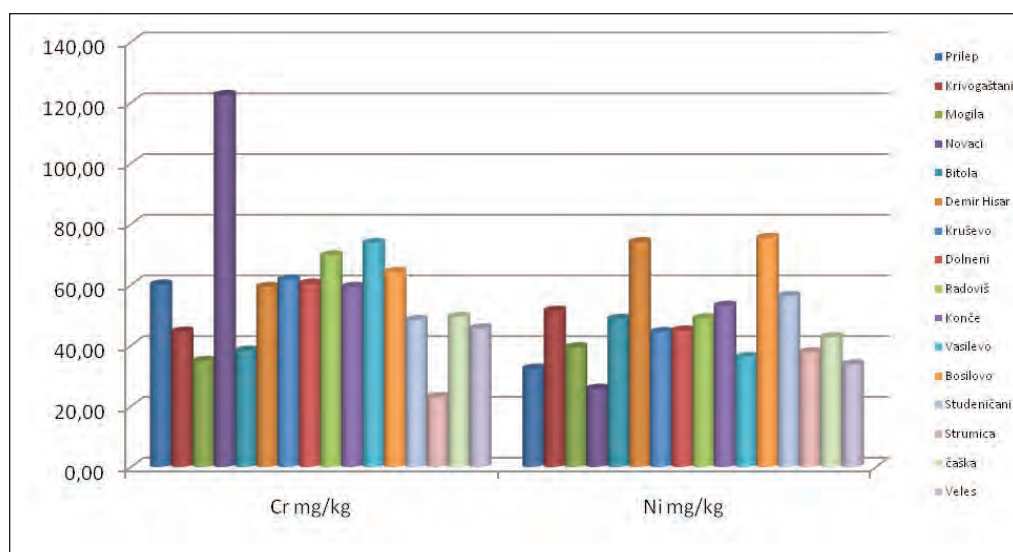


Figure 3. Cr and Ni average concentrations in soils in some tobacco-growing regions in R. Macedonia

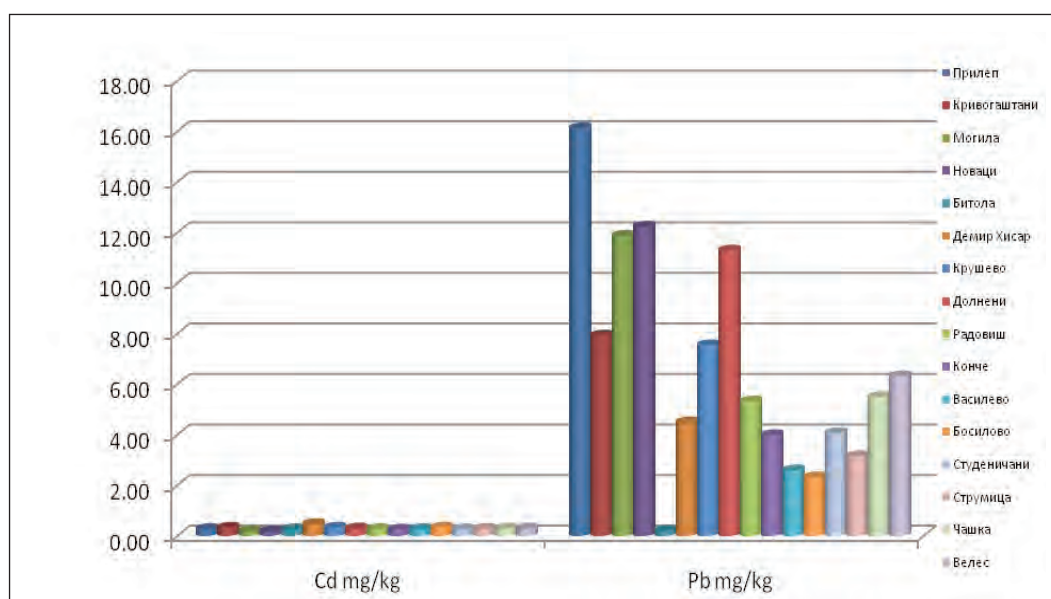


Figure 4. Average Cd and Pb concentrations in soils in some tobacco-growing regions in R. Macedonia

Correlation coefficients (Table 2), showed a strong relationship between the concentrations of each tobacco priming (first, second and third) for almost every studied metal at 0.01 level. Comparing the obtained results of heavy metal analysis to those of plant material (tobacco leafs), no significant statistical correlation was determined between the soil parameters and Cd,

Ni and Cr content of the plants. That was not case with Pb content of all three priming of the oriental tobacco where: clay, humus as well as Cd, Cu, Zn and Ni content in the soil had significant coorelation. Significant coorelation was found and for Pb content of the soil and Ni concentration in second and third primings of tobacco plants.

Table 2. Correlation between soil parameters and concentration of metals in oriental tobacco leaves (n = 50)

Parameter	Cd 1 st	Cd 2 nd	Cd 3 ^d	Pb 1 st	Pb 2 nd	Pb 3 ^d	Cr 1 st	Cr 2 nd	Cr 3 ^d	Ni 1 st	Ni 2 nd
humus	0,024	0,072	0,090	0,399**	0,429**	0,190	-0,081	-0,116	-0,024	0,013	-0,068
pH	0,186	-0,113	-0,165	0,146	0,129	-0,028	0,091	0,118	0,014	-0,103	-0,088
Clay %	0,179	0,040	0,162	0,645**	0,603**	0,318*	0,244	0,102	0,308*	0,098	0,019
Cd soil	-0,031	0,076	0,008	0,399**	0,396**	0,292*	-0,138	0,003	-0,069	0,315*	0,306*
Pb soil	-0,015	0,146	0,243	-0,225	-0,217	-0,280*	0,050	-0,157	0,019	-0,457**	-0,489**
Mn soil	0,116	0,237	0,266	0,052	0,078	-0,068	-0,273	-0,140	-0,048	-0,062	0,102
Fe soil	-0,114	0,030	-0,046	0,184	0,223	0,027	0,392**	0,253	0,349*	-0,165	-0,152
Cu soil	-0,160	0,059	0,160	0,456**	0,389**	0,314*	0,195	0,111	0,434**	0,276	0,420**
Zn soil	0,038	-0,006	0,205	0,279*	0,287*	0,125	0,026	0,176	0,270	0,258	0,246
Cr soil	-0,238	-0,160	-0,164	-0,007	-0,013	0,047	-0,070	-0,104	0,059	-0,067	-0,032
Ni soil	0,145	0,075	0,161	0,641**	0,691**	0,458**	-0,042	0,106	0,256	0,213	0,320*
Cd 1 st		0,316*	0,317*	0,133	0,106	0,096	-0,067	0,041	-0,115	0,029	-0,031
Cd 2 nd			0,638**	0,295*	0,320*	0,183	-0,096	0,050	0,166	-0,069	0,028
Cd 3 ^d				0,307*	0,335*	0,247	0,023	0,029	0,056	-0,144	0,040
Pb 1 st					0,955**	0,701**	0,075	0,158	0,289*	0,312*	0,314*
Pb 2 nd						0,699**	0,009	0,136	0,259	0,237	0,247
Pb 3 ^d							0,107	0,294	0,180	0,287	0,263
Cr 1 st								0,580**	0,471**	-0,164	-0,230
Cr 2 nd									0,535**	-0,091	-0,075
Cr 3 ^d										-0,172	-0,134
Ni 1 st											0,716**
Ni 2 nd											

1st - Lower primings2nd - Middle primings3^d - Upper primings

*.Correlation is significant at the 0.05 level (2-tailed).

**.Correlation is significant at the 0.01 level (2-tailed)

CONCLUSION

Clay and pH had no influence on the concentrations of Cd, Cr and Ni in all three primings of the Oriental tobacco, as stated by Adamu et al., 1989; Golia et al. 2007. Clay, humus and Cd, Cu, Zn and Ni content of the soil had a significant correlation with the concentration of Pb in all three primings and Cr content in the upper primings of tobacco plants. According to the results, a conclusion can be drawn that most of the tested soils are ideal for producing a high

quality oriental tobacco. Considering the fact that heavy metal concentrations in investigated tobacco leaves and soils are below permissible limits, it can be stated that tobacco-growing regions of R. Macedonia are not contaminated with heavy metals. Comparing the results obtained in soil to those in tobacco leaf, it can be concluded that metal content in soil has a negligible or no influence upon the heavy metal content in tobacco leaf.

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