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# HEAVY METAL CONTENT IN FLUE CURED AND AIR CURED TOBACCOS FROM MAIN PRODUCTION AREAS IN SERBIA

**Vesna Radojičić[1] and Olga Cvetković[2]**

**Abstract:** The aim of this work was to examine the influence of growing conditions on heavy metal content in virginia (flue cured) and burley (air cured) tobacco type. Moreover, some of these metals could appear in the tobacco cigarette smoke. This fact may cause negative consequences for cigarette consumers.

Examinations were carried out in five various production areas, for each tobacco type, during two years, 1998 and 1999; those were extreme years for production. Considering the results, it can be concluded:

The most important factor for heavy metal content in tobacco leaves are weather conditions, especially the amount of rainfall, since there is a direct correlation between the rainfall and size of roots, a dominant vegetation organ.

It is inevitable that the metals content in flue cured and air cured tobaccos, grown at different experimental lots, is still below the legally prescribed values.

Tobacco leaves from Šabac production area have a little higher metal content than tobacco grown in other production areas, because a larger amount of copper was found.

The metal content in plants can increase because of its absorption from soil, atmosphere, or mineral fertilizers and pesticides, and, what is very important, the content of metals can be high due to the vicinity of large industrial centers.

**Key words:** heavy metal content, flue cured and air cured tobaccos, atomic absorption spectroscopy (AAS).

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## Introduction

It is known that metals are normally present in cultivated plants in quantities which vary depending of plant variety, climate, and other factors.

Metals play an important role in tobacco metabolism during its growth (8):

-they build up materials in plant tissues;

-increase plant immunity to diseases and unfavorable environmental conditions, such as drought, high and low temperature;

-contribute to enzyme reactions which provide for plant metabolism;

-and burning process (they effect temperature and combustion conditions and ash characteristics).

Because of high pollution of human environment and its destruction, there are more and more the so-called "acid rains" containing heavy metals which are dissolved in soil solutions.

Metals are also found in tobacco in varying amounts, depending on many factors. Because of the importance of these problems, various investigations have been carried out all over the world on metal influence on plants but only a few were related to tobacco (4, 9, 11). The number of scientific works on this topic is especially small in our country (6). Some of the heavy metals could appear in tobacco smoke. For example, during the burning process about 5-20% of the original cadmium from tobacco, appears in the mainstream smoke (13). Therefore, the aim of our investigations was to show the presence of metals in flue cured and air cured tobaccos, because those tobaccos account for over 80% of the total tobacco production in our country, grown in five different areas. Also, the aim was to find out if the collected values are within the prescribed limits.

## Materials and Methods

Virginia tobacco type, variety Heveshy-9, and Burley tobacco type, variety B-92, from different production areas (Senta, Čoka, Sremska Mitrovica, Šabac, Bajina Bašta and Vranje) were used for investigations. Investigations were carried out during two years, 1998 and 1999, which were extreme years for the production especially because of the amount of precipitation. The year 1998 was extremely dry and 1999 was extremely rainy.

10 samples were taken for each year, which means 20 samples during the two years. Each sample was obtained as an average sample from a 10 ha production area. The NPK fertiliser in the ratio adapted to tobacco type was used at the experimental lots of all production areas. In tobacco seedlings, transplanting at a-80cm row distance and a-50cm stalk distance as the most suitable way for inter-row cultivation was applied to achieve a good yield and quality material.

The samples of cured tobacco and tobacco leaf after redrying were milled into a fine tobacco powder. Only the middle stalk position leaves were used as the leaves of the best quality. The whole leaf with the main stem was milled.

The metal content in the tobacco samples was determined by atomic absorption spectroscopy (AAS). The solutions for the metal content determination were prepared by a modified method applied for plant material destruction.

Tobacco powder was dissolved in nitric acid and heated at $80^0$C. Heating was stopped after the separation of yelow dark steam was finished. Then, we added perchloric acid and heating was done up to $200^0$C. The process was finished after the color of the sample disappeared.

A blind test was prepared in the same way.

The content of Fe, Cu, Cd, Zn, Pb, Hg has been determined in the prepared solutions.

## Results and Discussion

References of primary climate conditions, which are necessary for tobacco production, were obtained in RMIS (Republic Meteorological Institute of Serbia).

To make the results clear, we will present the references only for the vegetation period.

T a b. 1. - Temperature variability for 1998

| | Bajina Bašta | | | | | | | Vranje | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | air temperature | | | extreme | | | | air temperature | | | | extreme | | |
| month | max | min | middle | max | day | min | day | max | min | middle | max | day | min | day |
| 6 | - | 13.1 | 20.1 | - | - | 9 | 16 | 27.4 | 13.3 | 20.5 | 34 | 30 | 8.4 | 20 |
| 7 | - | 14.5 | 21.5 | - | - | 7.5 | 9 | 29.6 | 14.1 | 22.3 | 37.6 | 2 | 6 | 10 |
| 8 | - | 13.9 | 20.7 | - | - | 8 | 27 | 30.6 | 15.2 | 22.8 | 37.7 | 4 | 7.6 | 31 |

| | Senta | | | | | | | Sremska Mitrovica | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | air temperature | | | extreme | | | | air temperature | | | | extreme | | |
| month | max | min | middle | max | day | min | day | max | min | middle | max | day | min | day |
| 6 | 29 | 16.3 | 22.6 | 35.3 | 6 | 10.5 | 14 | 28.3 | 14.8 | 21.6 | 34 | 8 | 8.5 | 14 |
| 7 | 29.2 | 16.4 | 22.8 | 36.1 | 24 | 9 | 9 | 29.3 | 14.9 | 21.7 | 35.6 | 24 | 8 | 9 |
| 8 | 28.9 | 16.2 | 22.3 | 38.1 | 4 | 9 | 26 | 28.8 | 15 | 21.3 | 37.3 | 3 | 7.3 | 31 |

| | Šabac | | | | | | |
|---|---|---|---|---|---|---|---|
| | air temperature | | | extreme | | | |
| month | max | min | middle | max | day | min | day |
| 6 | 29.1 | 15.6 | 22.5 | 35.5 | 28 | 8.3 | 15 |
| 7 | 30.7 | 15.9 | 22.8 | 39 | 2 | 9 | 9 |
| 8 | 30.1 | 15.7 | 22.2 | 38.5 | 3 | 8.2 | 31 |

T a b. 2. - Temperature variability for 1999

| | Bajina Bašta | | | | | | | Vranje | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | air temperature | | | extreme | | | | air temperature | | | | extreme | | |
| month | max | min | middle | max | day | min | day | max | min | middle | max | day | min | day |
| 6 | - | - | 19.2 | - | - | - | - | 25.9 | 13.1 | 19.3 | 31.6 | 11 | 8.3 | 27 |
| 7 | - | - | 20.1 | - | - | - | - | 28.1 | 14.8 | 21.3 | 33.7 | 7 | 11 | 19 |
| 8 | - | - | 20.8 | - | - | - | - | 30.6 | 15.1 | 22.9 | 38.4 | 10 | 8.8 | 27 |

| | Senta | | | | | | | Sremska Mitrovica | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | air temperature | | | extreme | | | | air temperature | | | | extreme | | |
| month | max | min | middle | max | day | min | day | max | min | middle | max | day | min | day |
| 6 | 26.4 | 14.9 | 20.8 | 31.8 | 28 | 9.5 | 23 | 26.5 | 14.4 | 20.3 | 31.9 | 7 | 7.8 | 26 |
| 7 | 28.6 | 17.3 | 22.8 | 35 | 6 | 14 | 24 | 27.2 | 16.1 | 21.4 | 34.1 | 6 | 12.6 | 17 |
| 8 | 28 | 16 | 21.6 | 36 | 10 | 10.5 | 27 | 28.3 | 15.2 | 21.3 | 36.3 | 10 | 8.1 | 25 |

| | Šabac | | | | | | |
|---|---|---|---|---|---|---|---|
| | air temperature | | | extreme | | | |
| month | max | min | middle | max | day | min | day |
| 6 | 27.3 | 15.2 | 20.7 | 32.7 | 4 | 9.6 | 26 |
| 7 | 28.3 | 16.7 | 21.9 | 36 | 6 | 13.5 | 18 |
| 8 | 29.9 | 16.2 | 22.2 | 39 | 10 | 9.5 | 26 |

The temperature conditions during the two years were within optimal range, except for a slight decrease ($1^0$C-table 2) in 1999.

Optimal conditions for virginia and burley tobaccos production was in the Šabac production area with the average temperature of 21.6-22.8$^0$C during the vegetation period. The Vranje production area, where the variation in temperature values was very large (13.3$^0$C-VII 1998; 30.6$^0$C-VIII 1998).

Likewise relations were in 1999.

The difference in relative air humidity and quantity of rainfall differ from year to year, depending on study year.

Even extreme amount of rainfall, which was characteristic of 1999, did not provide sufficient amount of available water.

The amount of relative air humidity was minimum in the production area of Vranje in both study years and mostly in Senta (84-85%) in 1998 and the Šabac production area (79-82%) in 1999.

T a b. 3. - Relative air humidity and quantity of rainfall during 1998

| | Bajina Bašta | | | | Vranje | | | | Senta | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | φmiddle | rainfall (mm) | | | φmiddle | rainfall (mm) | | | φmiddle | rainfall (mm) | | |
| month | (%) | Σ | max | day | (%) | Σ | max | day | (%) | Σ | max | day |
| 6 | 74 | 62.2 | 21.2 | 18 | 64 | 100 | 36.4 | 12 | 84 | 28.4 | 7.3 | 18 |
| 7 | 69 | 29.7 | 11.2 | 30 | 57 | 43.5 | 24.2 | 16 | 85 | 72.9 | 29.4 | 8 |
| 8 | 71 | 100.8 | 32 | 22 | 56 | 38.5 | 18.5 | 29 | 84 | 69.6 | 25.6 | 23 |

| | Sremska Mitrovica | | | | Šabac | | | |
|---|---|---|---|---|---|---|---|---|
| | φmiddle | rainfall (mm) | | | φmiddle | rainfall (mm) | | |
| month | (%) | Σ | max | day | (%) | Σ | max | day |
| 6 | 74 | 81.9 | 22.9 | 12 | 73 | 50.4 | 18 | 13 |
| 7 | 73 | 90.9 | 40.8 | 29 | 73 | 49.2 | 12.5 | 29 |
| 8 | 73 | 41.5 | 15.8 | 23 | 73 | 41.9 | 12.5 | 29 |

T a b. 4. - Relative air humidity and quantity of rainfall during 1999

| | Bajina Bašta | | | | Vranje | | | | Senta | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | φmiddle | rainfall (mm) | | | φmiddle | rainfall (mm) | | | φmiddle | rainfall (mm) | | |
| month | (%) | Σ | max | day | (%) | Σ | max | day | (%) | Σ | max | day |
| 6 | 79 | 119.2 | 36 | 22 | 70 | 82.6 | 43.6 | 17 | 77 | 123 | 24.7 | 9 |
| 7 | 76 | 122.2 | 48.4 | 30 | 67 | 20 | 11 | 11 | 77 | 156.1 | 62.4 | 26 |
| 8 | 75 | 23 | 11.2 | 14 | 57 | 8.6 | 6.6 | 31 | 76 | 63.4 | 16.9 | 8 |

| | Sremska Mitrovica | | | | Šabac | | | |
|---|---|---|---|---|---|---|---|---|
| | φmiddle | rainfall (mm) | | | φmiddle | rainfall (mm) | | |
| month | (%) | Σ | max | day | (%) | Σ | max | day |
| 6 | 73 | 96.7 | 36.8 | 29 | 79 | 57.7 | 20 | 18 |
| 7 | 77 | 154.2 | 67 | 30 | 82 | 173.8 | 48.5 | 30 |
| 8 | 70 | 26.3 | 11.5 | 8 | 79 | 19.5 | 16.5 | 31 |

The results of investigation on heavy metals content in flue cured and air cured tobaccos are presented in tables 5. and 6.

Contents of heavy metals in tobacco samples (table 5. and 6.) are very discriminating according to the production areas and study years.

- Concentrations of iron (Fe) in virginia samples are 170.72-995.87ppm and in burley tobacco 217.81-698.48ppm. It's very interesting that the extreme difference in iron (Fe) content was found in the same production areas: minimum in samples of virginia from 1999 (170.72ppm) and maximum from 1998 (995.87ppm), from Čoka production area. Remarkable concentration of iron was measured in virginia leaf from Senta, (662.83ppm) by 1999 and Šabac, (519.01-788.02ppm) in both years, and in burley leaf from Čoka (698.48ppm) in 1999.

- Copper (Cu) was present in tobacco samples in the amounts of 16.42-31.45ppm in virginia tobacco and 13.31-22.72ppm in burley tobacco.

T a b. 5. - Heavy metals content in virginia tobacco type, Heveshy-9 variety (ppm)

| | Senta | | Čoka | | Šabac | | Bajina Bašta | | Sr. Mitrovica | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| Fe | 182.11 | 672.83 | 995.87 | 170.72 | 788.02 | 519.01 | 185.92 | 173.06 | 457.28 | 264.43 |
| Cu | 20.44 | 16.69 | 16.60 | 24.45 | 29.08 | 31.45 | 17.81 | 20.69 | 16.42 | 21.02 |
| Zn | 27.13 | 29.91 | 32.74 | 42.70 | 57.22 | 73.37 | 44.22 | 62.98 | 35.23 | 34.52 |
| Pb | 1.11 | 0.82 | 0.81 | 0.80 | 1.26 | 1.94 | 0.79 | 0.90 | 0.65 | 1.51 |
| Cd | 0.13 | 0.26 | 0.35 | 0.56 | 0.48 | 0.60 | 0.35 | 0.27 | 0.44 | 0.44 |
| Hg | 0.03 | 0.21 | 0.37 | 0.05 | 0.5 | 0.2 | 0.11 | 0.06 | 0.03 | 0.06 |

T a b. 6. - Heavy metals content in burley tobacco type, B-92 variety (ppm)

| | Čoka | | Senta | | Šabac | | Bajina Bašta | | Vranje | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| Fe | 392.12 | 698.48 | 463.26 | 217.81 | 360.33 | 377.93 | 412.82 | 377.48 | 410.74 | 457.52 |
| Cu | 18.17 | 20.51 | 13.31 | 16.22 | 21.46 | 22.72 | 17.21 | 20.18 | 19.31 | 19.22 |
| Zn | 44.12 | 45.24 | 38.17 | 40.81 | 41.78 | 50.95 | 49.22 | 61.12 | 50.21 | 56.19 |
| Pb | 1.98 | 1.39 | 1.91 | 1.99 | 2.02 | 2.31 | 0.91 | 0.99 | 1.12 | 1.82 |
| Cd | 0.2 | 0.33 | 0.14 | 0.39 | 0.38 | 0.61 | 0.31 | 0.22 | 0.17 | 0.38 |
| Hg | 0.08 | 0.19 | 0.48 | 0.32 | 0.51 | 0.59 | 0.18 | 0.07 | 0.08 | 0.11 |

The content of copper (Cu) above 20ppm, as the highest allowed limit value, appears only in the area of Šabac in both years and both types of tobacco.

- Zinc (Zn) is in all samples within the prescribed values (20-100ppm). It could be noticed that the content of this element in tobacco samples, produced in 1999, increased by about 30%.

Maximal concentrations of zinc (Zn) were measured in virginia from the Šabac production area (57.22-73.37ppm), in both years and Bajina Bašta (62.98ppm) in 1999, while the maximal concentrations of this metal have burley samples from the Vranje production area (50.21-56.19ppm) in both years, and also Bajina Bašta (61.12ppm) in 1999.

- The content of lead (Pb) is also within the prescribed limits. The highest concentrations of this element were found in both tobacco types from the Šabac production area: 1.26-1.94ppm in virginia samples and 2.02-2.31ppm in burley samples.

- The content of cadmium (Cd), found in both tobacco types, (0.13-0.61ppm), were substantially below than legally prescribed values (1.25-7.02ppm). The cadmium (Cd) content for 1999 was increased at all examined lots, except for the lot of Bajina Bašta. High concentrations in both tobacco types were also measured at the lot of Šabac.

- The mercury (Hg) content was found to be within the prescribed values. The content of this element in virginia samples, from the Čoka production area, was decreased by seven times compared to 1998. In contrast, the content of mercury in the same tobacco, from the neighboring Senta production area, was increased by 6.14 times in 1999.

## Conclusion

Concerning the results, it can be concluded as follows:

The use of NPK as a fertilizing agent has no influence on the content of heavy metals in tobacco leaves.

The most important factor for heavy metal content in tobacco leaves are weather conditions, especially precipitation.

Tobacco leaves from the Šabac production area have slightly higher heavy metal content than tobacco grown in the other production areas, because a higher amount of copper was found. This could be a consequence of the vicinity of large industrial centers.

In order to obtain final good quality products and thereby protect the health of consumers, it is necessary to carry out constant control of heavy metal content in tobacco plants.

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# SADRŽAJ TEŠKIH METALA U KRUPNOLISNIM DUVANIMA GAJENIM U GLAVNIM PROIZVODNIM PODRUČJIMA SRBIJE

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R e z i m e

Poznato je da su metali prisutni u biljkama u količinama koje zavise od vrste biljke, klime i drugih faktora. Cilj ovog rada je ispitivanje direktnih uslova gajenja na sadrжaj teških metala u duvanima tipa virdжinija, sorta Heveši-9 i tipa berlej, sorta B-92. Neki od ovih metala mogu da pređu u duvanski dim cigarete, što može imati neжeljene posledice za pušača.

Ispitivanja su vršena u po 5 različitih proizvodnih područja Srbije, za svaki tip duvana, tokom dve godine, 1998. i 1999., koje su bile ekstremne za proizvodnju duvana.

Sumirajući rezultate dvogodišnjih istraжivanja možemo zaključiti sledeće:

Upotreba NPK đubriva nije imala uticaja na sadrжaj teških metala u duvanima.

Od klimatskih faktora, na sadrжaj teških metala u duvanu najveći značaj imaju padavine. Usled različite količine padavina, dolazi do razlike u ekspanziji korena biljaka, pa su posledica toga različite količine mikroelemenata, koje se preko korena asimiluju.

Duvani iz proizvodnog područja Šapca, sadrже bakar u koncentracijama nešto većim od dozvoljenih za duvan, kao i nešto više vrednosti sadrжaja ostalih teških metala u odnosu na duvan gajen na drugim lokalitetima. Na ovu pojavu bi mogla da utiče blizina industrijske zone, kao i sastav zemljišta i primena zaštitnih sredstava.

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