Trakia Journal of Sciences, Vol. 10, Suppl. 3, 125-129, 2012

Available online at:
http://www.uni-sz.bg

**ISSN 1313-7069 (print)**
**ISSN 1313-3551 (online)**

# HEAVY METALS IN PLANTS, SOIL AND WATER FROM STARA ZAGORA REGION: DEFINING LOCATIONS FOR EVALUATION OF POPULATION'S ENVIRONMENTAL EXPOSURE

**Hr. Gradeva[1], G. Sandeva[2*], P. Gidikova[2], M. Platikanova[2], R. Deliradeva[2], G. Prakova[3], V. Atanasov[4]**

[1]Medical Student, Medical Faculty, Trakia University, Stara Zagora, Bulgaria
[2]Department of Hygiene and Occupational Diseases, Medical Faculty, Trakia University, Stara Zagora, Bulgaria
[3]University Hospital, Stara Zagora, Bulgaria
[4]Faculty of Agriculture, Trakia University, Stara Zagora, Bulgaria

**ABSTRACT**
In order to evaluate the population's environmental exposure to heavy metals suitable locations must be selected. PURPOSE: To analyze data from previous studies on heavy metals in fruits, vegetables, soil, and groundwater form villages around the town of Stara Zagora and determine the most appropriate locations for blood level tests. METHODS: Statistical analysis of three reports on heavy metals from UIS Umweltinstitut synlab GmbH Stuttgart made in 2005, 2007, and 2008. RESULTS: Elevated concentrations of heavy metals were found mostly in samples of mushrooms and walnuts, followed by tomatoes and apples. The highest number of concentrations exceeding the permissible levels were recorded in Borilovo (n=11; 9.2%) and Zmeyovo (n=13; 7.4%). Lead, cadmium, nickel and zinc were the most frequently detected heavy metals in the samples. CONCLUSIONS: The villages of Zmeyovo and Borilovo are the most suitable for a study on the environmental exposure to heavy metals.

**Key words:** heavy metals, environment, exposure

## INTRODUCTION

The effects of atmospheric pollution in the region of the town of Stara Zagora and its surrounding villages have been monitored by several government institutions and NGOs, mainly because of large potential sources of pollution, e.g. the coal power plants "Maritsa Iztok" (a major source of particulate matter, sulphuric and nitric gasses), a military testing ground near the village of Zmeyovo (where activity can contaminate the air with nitrogen oxides, ammonia, chlorine compounds, and possibly some heavy metals ) and others. Routine measuring of air quality is being performed all year round to determine the levels of a standard set of atmospheric pollutants (1). Heavy metals in the air are rarely monitored with the exception of lead, cadmium, nickel, mercury, and arsenic. Studies on heavy metals in the soil, water, and plants from the region are even rarer. In recent years (2005, 2007, and 2008) some tests were commissioned by the Municipality of Stara Zagora as part of a regional study. Samples were taken from the soil, groundwater, and various plants and wild mushrooms from nine different villages and one location in the town's limits, Lake Zagorka. The concentrations of heavy metals and radioactive elements were determined at a certified laboratory in Stuttgart, Germany. Unfortunately, no samples were taken from blood or any other bodily fluids of local residents, so there are insufficient data on the population's exposure to heavy metals in the air, water, soil, and food for the region around Stara Zagora.

***Correspondence to**: *Gergana Sandeva, 11 Armeyska Str, 6000 Stara Zagora, Bulgaria,Phone: +35942664240, E-mail: geri_sandeva@yahoo.com*

The **PURPOSE** of this study was:
¬ to identify the most hazardous locations for environmental exposure to heavy metals based on existing research on fruits, vegetables, soil, and groundwater;
¬ to determine the heavy metals which most frequently exceed the recommended permissible levels for a subsequent study on blood levels in local residents.

**MATERIALS AND METHODS**

In this study, we used results from research on heavy metals (lead, cadmium, nickel, zinc, arsenic, chromium, copper, manganese, and iron) and radioactive elements in plants, soil, and groundwater on behalf of the Municipality of Stara Zagora, conducted by UIS Umweltinstitut synlab GmbH Stuttgart, Germany: Report No 1055075 of 25.11.2005, Report No UST-07-0001239/01-1 of 10.12.2007, Report No UST-08-0013304/04-1 of 10.11.2008. The reports were obtained by official inquiry to the Municipality of Stara Zagora in accordance with the Law on Access to Public Information (2).

A total of 141 samples of plants and mushrooms from ten locations around Stara Zagora were examined, distributed as follows:

***Table 1.*** *Number of samples taken by year.*

| Year / Location | 2005 | 2007 | 2008 | Total |
|---|---|---|---|---|
| Borilovo | 4 | 4 | 9 | 16 |
| Zmeyovo | 7 | 8 | 10 | 25 |
| Lake Zagorka | 2 | 5 | - | 7 |
| Kozarevets | 5 | 2 | - | 7 |
| Ostra mogila | 3 | 1 | 9 | 13 |
| Bratya Kunchevi | 4 | 10 | - | 14 |
| Benkovski | 4 | 11 | - | 15 |
| Pustrovo | 2 | - | 9 | 11 |
| Starozagorski bani | 3 | 5 | 8 | 16 |
| Kazanka | 4 | 3 | 9 | 16 |
| **Total** | **38** | **49** | **54** | **141** |

In 2008, six samples each from soil and groundwater of Borilovo, Zmeyovo, Ostra Mogila, Pustrovo, Kazanka, and Starozagorski Bani were also examined.

We compared the recorded concentrations with the permissible levels of heavy metals laid down in the following regulations: Ordinance № 31 of 29.07.2004 on the maximum levels for contaminants in foodstuffs (State Gazette № 88 from 10/08/2004); Ordinance № 3 of 01.08.2008 on the limit values for harmful substances in soil (State Gazette №71 from 08/12/2008); Ordinance № 1 of 07.07.2000 on research, use and protection of groundwater (State Gazette № 57 from 07/14/2000).

***Table 2.*** *Permissible levels of heavy metals in some foods (Ordinance № 31 on the maximum levels for contaminants in foodstuffs).*

| **Food item** | **Pb** [mg/kg] | **Cd** [mg/kg] | **Ni** [mg/kg] | **Zn** [mg/kg] | **As** [mg/kg] | **Cr** [mg/kg] | **Cu** [mg/kg] |
|---|---|---|---|---|---|---|---|
| Fruits | 0,1 | 0,05 | 0,5 | 10 | 0,5 | 0,1 | 5 |
| Vegetables | 0,1 | 0,05 | 0,5 | 10 | 0,5 | 0,2 | 10 |
| Mushrooms | 0,3 | 0,2 | - | 10 | 0,5 | - | 10 |
| Cabbage | 0,3 | 0,2 | 0,5 | 10 | 0,5 | 0,2 | 10 |

All data were processed and analyzed using Microsoft Excel 2007.

## RESULTS

By examining 141 samples of fruits and vegetables for seven heavy metals (lead, cadmium, nickel, zinc, arsenic, chromium, copper) the laboratory in Stuttgart reported a total of 987 measured concentrations **(Figure 1).** From all obtained results, excessive concentrations were registered in 39 samples (4%), and borderline concentrations in 67 (6.8%). The highest number of concentrations exceeding the permissible levels were recorded in Borilovo (n=11; 9.2%), Zmeyovo (n=13; 7.4%), and around Lake Zagorka (n=4; 8.2%). The total percentage of excessive and borderline concentrations is highest also in samples from Borilovo (22.9%) and Zmeyovo (14.7%), as well as Starozagorski bani (17.9%) and Kazanka (14.3%). All of these villages are situated northwest of Stara Zagora.

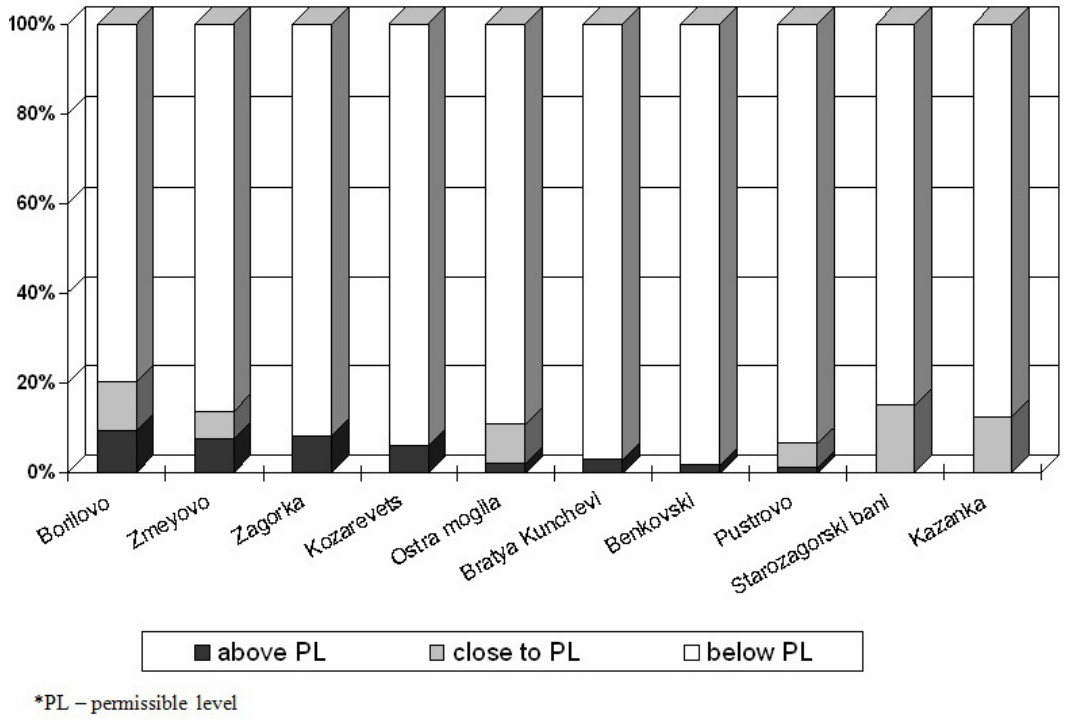


**Figure 1.** Distribution of all tested samples depending on heavy metal content

Most often, elevated concentrations of heavy metals were found in samples of mushrooms and walnuts, followed by tomatoes and apples **(Table 3)**. Significant concentrations of heavy metals were also found in pine needles from the same regions, but data could not be interpreted due to the lack of regulation levels or comparison concentrations from an unpolluted region.

Excessive levels of heavy metals were not registered in any of the tested samples of soil and groundwater. Nickel, zinc, lead, and cadmium were the heavy metals most often reported at abnormal levels.

## DISCUSSION

The analysis of heavy metal concentrations in plants from Stara Zagora region directed our team to undertake a future study. The study will compare blood samples from residents of the villages Borilovo and Zmeyovo, and blood samples from people living in an unpolluted area (a control group). At this stage, of greatest interest is measuring the blood levels of lead, cadmium, nickel and zinc, given the frequency of abnormal concentrations (as shown on **Table 3)**, and the fact that as environmental pollutants, these metals enter the body mainly through food and drinking water (especially in non-smokers). Guidelines for intake of the four metals, as well as permissible blood levels, are presented on **Table 4**.

***Table 3.*** *Registered heavy metal concentrations in fruits and vegetables from locations around Stara Zagora.*

| Location | Pb | Cd | Ni | Zn | As | Cr | Cu |
|---|---|---|---|---|---|---|---|
| **Borilovo** | **mushrooms 2005** | **mushrooms 2007** | **mushrooms 2005** | **mushrooms 2005** | **mushrooms 2005** | **walnuts 2008** | **mushrooms 2005** |
| | **mushrooms 2008** | | **walnuts 2008** | **walnuts 2008** | | **grapes 2008** | **walnuts 2008** |
| | | | **mushrooms 2008** | **mushrooms 2008** | | **apples 2008** | **mushrooms 2008** |
| | | | | | | **pears 2008** | |
| | | | | | | **mushrooms 2008** | |
| **Zmeyovo** | **mushrooms 2005** | **walnuts 2007** | **apples 2005** | **walnuts 2007** | | **walnuts 2007** | **walnuts 2007** |
| | **walnuts 2007** | | **walnuts 2007** | **walnuts 2008** | | **walnuts 2008** | **walnuts 2008** |
| | **mushrooms 2007** | | **walnuts 2008** | **mushrooms 2008** | | | **mushrooms 2005** |
| | | | | | | | **mushrooms 2008** |
| Lake Zagorka | | **tomatoes 2005** | **tomatoes 2005** | **walnuts 2007** | | | **walnuts 2007** |
| | | | **walnuts 2007** | | | | |
| Kozarevets | **tomatoes 2005** | | **apples 2005** | | | | |
| | | | **tomatoes 2005** | | | | |
| | | | **cabbage 2005** | | | | |
| Ostra mogila | | | **walnuts 2008** | **walnuts 2008** | | | **walnuts 2008** |
| | | | | **mushrooms 2008** | | | **mushrooms 2008** |
| Bratya Kunchevi | | **tomatoes 2007** | **pears 2005** | | | | |
| | | | **tomatoes 2005** | | | | |
| Benkovski | | | **apples 2005** | | | **apples 2007** | |
| Pustrovo | | | **walnuts 2008** | **walnuts 2008** | | | |
| | | | | **mushrooms 2008** | | | |
| Starozagorski bani | | | **walnuts 2008** | **walnuts 2008** | | | **walnuts 2008** |
| Kazanka | | | **walnuts 2008** | **walnuts 2008** | | **walnuts 2008** | |

Above permissible levels

Around permissible levels

***Table 4.****Guidelines for dietary intake and blood levels of lead, cadmium, nickel, and zinc.*

| | Pb | Cd | Ni | Zn |
|---|---|---|---|---|
| Recommended daily intake[1] | - | - | 100 μg | 1,0-1,4 mg |
| Tolerable daily intake[2] | 3,5 μg/kg | 0,5 μg/kg | 50 μg/kg | 500 μg/kg |
| Permissible level in blood[3] | 10 μg/dl | 2 μg/l | 1 pg/l | 90 μg/dl |

[1] WHO (7)
[2] A.J. Baars et al. (9)
[3] EPA

The majority of cadmium is released in the atmosphere due to human activities such as ore smelting, fossil fuel combustion, and waste incineration. Its main environmental source is food, especially for non-smokers. Cadmium exposure from drinking water is relatively insignificant (3,4). Lead is also a typical anthropogenic pollutant. Exposure to lead or lead compounds occurs primarily through food and drinking water, and less frequently through air because of the declining use of leaded fuel (5). Tobacco smoke is another source of lead for the human body. The blood level of lead is the best available indicator of current and recent environmental exposure (6). Nickel and zinc are important trace elements and are involved in a number of enzymes (7), but can become toxic in large quantities. Nickel is a known allergen and a possible carcinogen (8). In nonsmokers, about 99% of the estimated daily nickel absorption stems from food and drinking water; for smokers the figure is about 75% (6). Zinc is naturally present in a variety of foods, such as lean red meat, whole grains, cheese, and legumes (6), and only by exceeding the regulations (Table 2) can it be considered a contaminant. Water is an insignificant source of zinc.

Measurement of heavy metal concentrations in blood samples of the population in the above mentioned region will clarify whether the exposure to heavy metals and the risks to those people's health are actually heightened. The results will determine the necessity for preventative measures or decrease public tension caused by the proximity of the military testing ground.

**ACKNOWLEDGEMENTS**

This study was conducted as part of Project 15/2012 “Analysis of heavy metals in blood from residents of Stara Zagora Municipality” of the Medical Faculty, Trakia University, Stara Zagora. The authors would like to thank the Faculty for its support and the opportunity to participate in the Project.

**REFERENCES**

1. Закон за чистотата на атмосферния въздух, Държавен вестник №45 от 28.05.1996, последно изм. ДВ №42 от 03.06.2011.
2. Закон за достъп до обществена информация, Държавен вестник №55 от 07.07.2000, последно изм. ДВ №39 от 20.05.2011.
3. WHO, Exposure to cadmium – a major public health concern, *World Health Organization*, Geneva, Switzerland, 2010.
4. Bull, S., HPA Compendium of Chemical Hazards - Cadmium, *CRCE HQ*, HPA, USA, 2011.
5. Bull, S., HPA Compendium of Chemical Hazards - Lead, *CRCE HQ*, HPA, USA, 2011.
6. WHO, Air Quality Guidelines for Europe, Second Edition, *World Health Organization*, Geneva, Switzerland, 2000.
7. WHO, Trace elements in human nutrition and health, *World Health Organization*, Geneva, Switzerland, 1996.
8. Bull, S., Foxall, K., HPA Compendium of Chemical Hazards – Nickel, *CHAPD HQ*, HPA, USA, 2008/9.
9. Baars, A.J., Theleen, R.M.C., Janssen, P.J.C.M., Hesse, J.M., van Apeldorn, M.E., Meijerink, M.C.M., Re-evaluation of human-toxicological maximum permissible levels, RIVM, Bilthoven, The Netherlands, 2001.