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Evaluation of Elements Uptake in Soil and Different Plants

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ABSTRACT

We carried out the conversion, rounding and placing into table with Microsoft Visual C# 2010 developing system. We saved the figures received when running the program into an Excel worksheet in order to make further data processing easier. The next step to save these data into a database. A stable relational database is needed which will handle data and also provide data for the query system. Since I aimed to apply standard solutions, I needed an SQL-based system and finally chose the MySQL database server, because it is free of charge, portable, compact and fast in case of bigger record numbers. We studied the environmental pollutant affect of the molybdenum by elements load experiment in Nagyhörcsök Experimental Station. We analyzed the contact between the uptake of molybdenum and other micro-elements and its effect on plant organs (loaf, seed) using by different statistical methods. The aim of investigations to search for answers on how to arable crops respond to a possible soil contamination. It is also important to determine the extent of mobilized elements from the soil into the plants, which type of effect on them, and how leach the harmful substances into deeper layers (groundwater).

Keywords: Multidisciplinary science, Micro-elements, Pollution, Molybdenum, Food chain, Data-processing, Hungary

1. INTRODUCTION

The informatics - especially applied informatics - undergone a significant development at the end of XXth. century. This is allowed analyzing of soil pollution by computer controlled system. The importance of this explains the soil is polluted especially by pesticides, wastes, nitrogen and phosphorus fertilizer, which through plants get into our food direct and indirect way. In this way polluted foods can cause ill our vitally important organs. On account of opening of the mentioned pollution we can process the experimental data fast and exactly so we can get such a large number of new information. Being aware of this valuable information we can make indispensable arrangements and we can hinder the impairing micro-elements – other elements as well – segregate in food chain. We studied the environmental pollutant affect of the

molybdenum by elements load experiment in Nagyhörcsök Experimental Station. We analyzed the contact between the uptake of molybdenum and other micro-elements and its effect on plant organs (loaf, seed) using by different statistical methods.

1.1 Experiment Description in Nagyhörcsök Experimental Station (Németh & Kádár, 2005)

The trial was set up in Nagyhörcsök (Hungary) in 1991 on a calcareous chernozem soil formed on loess (Szűcs, 1965), containing 5% $CaCO_3$ and 3% humus in average in the ploughed layer. Soil texture is loamy with 20% clay and 40% fine fraction.
Soil characteristics of the ploughed layer are: pH (KCl): 7.3, AL-P_2O_5 (ammonium lactate-soluble P_2O_5): 80-100, AL-K_2O (ammonium lactate-soluble K_2O): 140-160, KCl-Mg: 150-180, and KCl + EDTA soluble Mn, Cu and Zn are 80-150, 2-3 and 1-2 mg/kg, respectively.
The soil is well supplied with Mn, sufficiently supplied with Mg and Cu, moderately supplied with N and K, and weakly supplied with P and Zn. The water table is at a depth of 13-15 m, which practically excludes its contamination by leaching. The climate is dry and the area is drought sensitive with 500-550 mm annual precipitation and negative water balance.
The applied treatments simulate soil contamination conditions that may occur in industrial areas, near highways, settlements and in city gardens. The 4 load levels (0, 90, 270 and 810 kg element/ha) were applied as a single dose in the spring of 1991 in the form of $AlCl_3$, $NaAsO_2$, $BaCl_2$, $CdSO_4$, K_2CrO_4, $CuSO_4$, $HgCl_2$, $(NH_4)_6Mo_7O_{24}$, $NiSO_4$, $Pb(NO_3)_2$, Na_2SeO_3, $SrSO_4$, and $ZnSO_4$ (Kádár, 1995).
Fertilization was done yearly with 100-100-100 kg/ha N, P_2O_5 and K_2O active agents, in the form of ammonium nitrate, superphosphate, and potash fertilizers. The 13* 4 = 52 treatments with 2 replications were arranged in a split-plot design in altogether 104 plots.
Soils were sampled in 1993, 1996 and 2000 at the maximal depths of 60, 90 and 290 cm, respectively. In all cases the control and the maximal rate (810 kg/ha) treatments were analyzed.
The samples were dried at 40^{o}C, homogenized and the ammonium acetate + EDTA-soluble element contents were analyzed by the method of Lakanen and Erviö (Lakanen & Erviö, 1971).

2. MATERIALS AND METHODS

The study of plant and soil samples to determine the optimum measurement conditions for the content of elements and found that multi-element measurement method can be analyzed and most of the elements (i.e: As, Cd, Mo, Pb, and Se) investigate the theoretical detection limit of approximately 1 ng/kg (1 ppt), which is nowadays the best available value by physically.
However, the measurement of real samples showed an unexpected factor is greatly influenced the size of the intensity on the detector. At the time of analytical

measurements could figure out that the carbon content of samples significantly depends on the size of the intensity of the same concentration. Therefore is investigated the signals on the various mass peaks (interferences), and the effect of different carbon content in the sample for the intensity of elements.
The investigations are carried out by different alcohols, such as C-containing solvents, this can be the reason of the above phenomenon.
In the University of Debrecen Centre for Agricultural and Applied Economic Sciences, Central laboratory to the total element concentration determination for the plants and soils samples wet destruction sample preparation methods (HNO_3-H_2O_2) are used (Kovács et al., 2000). In case of higher concentrations - an Optima 3300 DV inductively coupled plasma optical emission spectrometer (ICP-OES), in case of relatively lower concentrations, an inductively coupled plasma mass spectrometer (ICP-MS) (Thermo Elemental manufactured X7-type) are used to the analytical determination. The analyzed elements are 45.
ICP-MS technique (Fig. 2.) is used to analyze the trace element contents (As, Cd, Mo, Pb and Se) of the plants. Inductively coupled plasma mass spectrometer (ICP-MS) is used for analyses for microelements due to ppb concentrations (ug/kg). During analysis, collision and reaction gas (CCT = collisional cell technique) is applied in order to reach the lower limit of detection of elements analyzed.

1. Table. The parameters of the ICP optical emission spectrometer

Inductive Coupled Plasma Optical Emission Spectrometer	
Type:	OPTIMA 3300 DV
Manufacturer:	Perkin-Elmer Ltd.
Optical system:	Echelle-system, argon purged
Range of wavelength:	160-782 nm
Detector:	Solid-state circuit detection, SCD
Plasma monitoring:	Axial
Type of nebulizer:	concentric (Meinhard Type A)
The type of peristaltic pump:	black-black
Resolution of the optical system:	Normal
Resolving parameter:	0.007 nm

2.1 Conversion of the Measured Data by ICP-OES/MS

The ICP-OES/MS instrument averages the measured data and calculates the deviation for each element. The measured data have to be converted, rounded and placed into a table on the basis of a certain aspect for further processing. This process takes a long time in spite of the fact that a fixed Excel macro was available at the department. Processing of the databases takes at least one hour depending on the number of measured elements and samples.

2. Table. The ICP-MS instrument settings and measurement parameters

ICP-MS	
Type:	Thermo Elemental X7
RF power output:	1400 W
Plasma gas flow rate:	14 $l \cdot min^{-1}$
Nebulizer flow rate:	0.8 $l \cdot min^{-1}$
Sample flow rate:	1 $l \cdot min^{-1}$
Pole Bias:	- 3.1 V
Hexapole bias	4.5 V
Extraction	-118 V
Focus:	3 V
Analog detector:	2500 V
PC detector	3850 V
CCT gas (H_2-He, 7%-93%) flow rate	5.9 $cm^3 \cdot min^{-1}$

2. RESULTS AND DISCUSSIONS

We carried out the conversion, rounding and placing into table with Microsoft Visual C# 2010 developing system (Fig. 1.), since its objects and programming opportunities provided more possibilities than an Excel macro. We saved the figures received when running the program into an Excel worksheet in order to make further data processing easier (Fig. 2.).

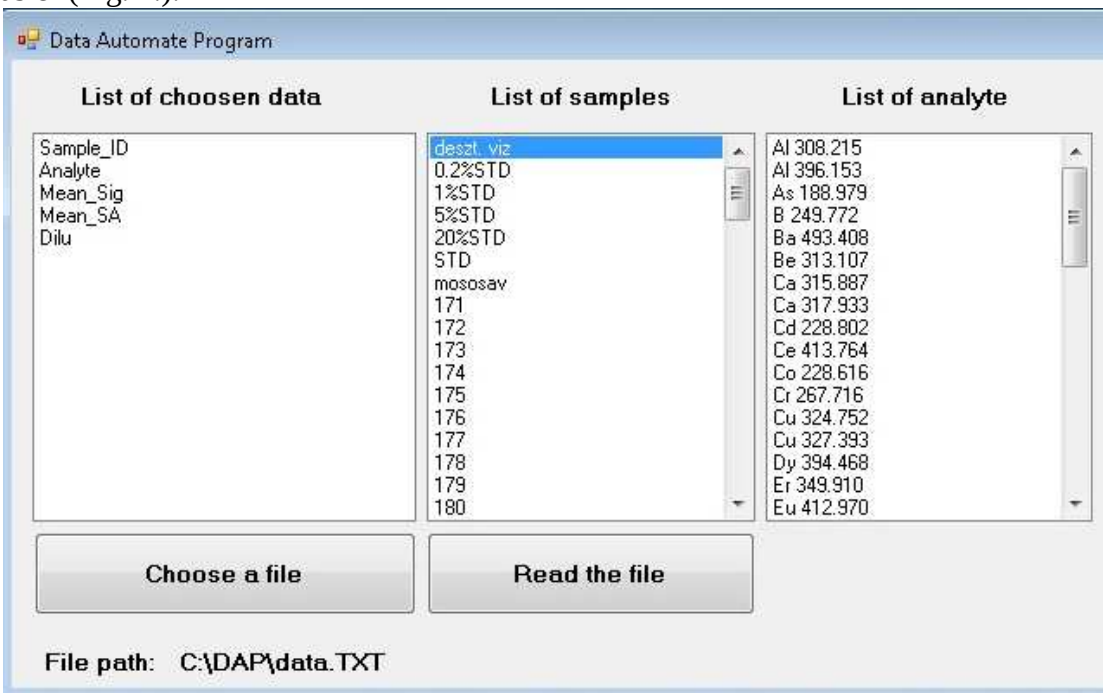

Figure 1. Conversion and rounding measured data

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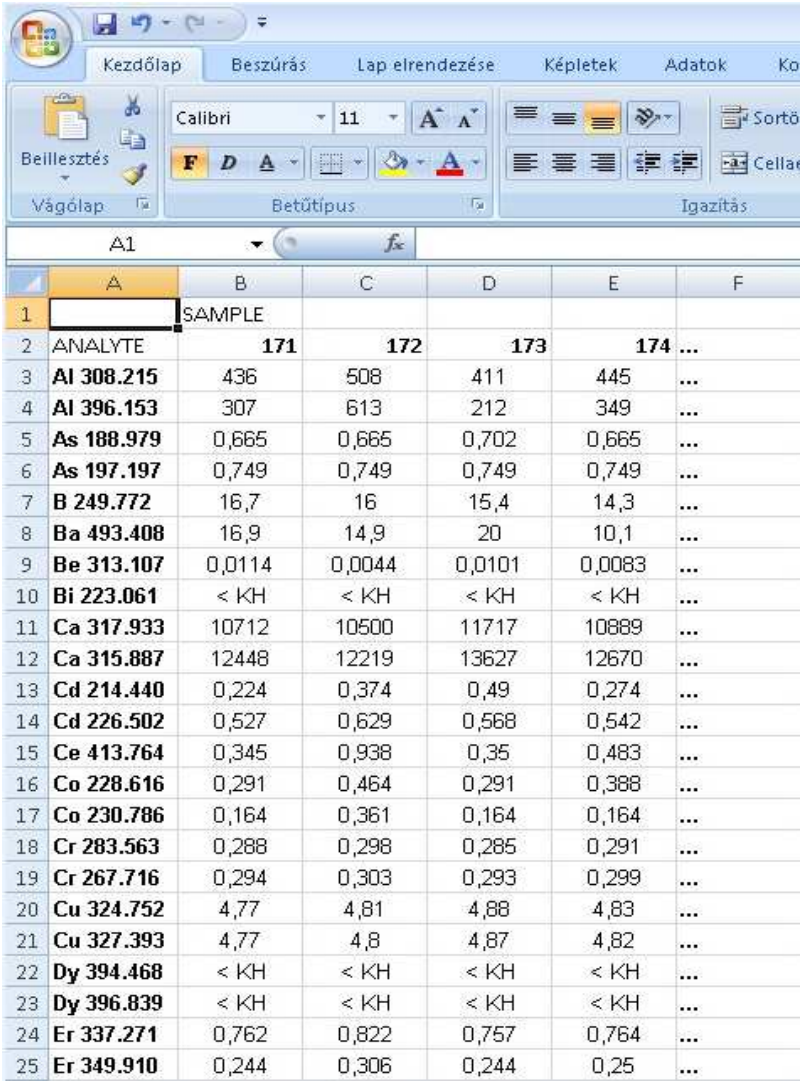
The first list shows the selected data file. The program reads the CSV file headers (Sample ID, Analytical lines, average signal size, average standard deviation and dilution) and forms the selected data file. This can be seen in the first list (Fig. 1.).
The program reads the ”sample_ID” to the second list. Distilled water wash, the standard samples measurement and the acid washing is done before any samples. The first sample always comes after the acid washing.
Various items analytical lines are visible in the third list. In case of ICP-OES/MS is given, which item line can be measured most efficiently.



	A	B	C	D	E	F
1		SAMPLE				
2	ANALYTE	**171**	**172**	**173**	**174**	...
3	**Al 308.215**	436	508	411	445	...
4	**Al 396.153**	307	613	212	349	...
5	**As 188.979**	0,665	0,665	0,702	0,665	...
6	**As 197.197**	0,749	0,749	0,749	0,749	...
7	**B 249.772**	16,7	16	15,4	14,3	...
8	**Ba 493.408**	16,9	14,9	20	10,1	...
9	**Be 313.107**	0,0114	0,0044	0,0101	0,0083	...
10	**Bi 223.061**	< KH	< KH	< KH	< KH	...
11	**Ca 317.933**	10712	10500	11717	10889	...
12	**Ca 315.887**	12448	12219	13627	12670	...
13	**Cd 214.440**	0,224	0,374	0,49	0,274	...
14	**Cd 226.502**	0,527	0,629	0,568	0,542	...
15	**Ce 413.764**	0,345	0,938	0,35	0,483	...
16	**Co 228.616**	0,291	0,464	0,291	0,388	...
17	**Co 230.786**	0,164	0,361	0,164	0,164	...
18	**Cr 283.563**	0,288	0,298	0,285	0,291	...
19	**Cr 267.716**	0,294	0,303	0,293	0,299	...
20	**Cu 324.752**	4,77	4,81	4,88	4,83	...
21	**Cu 327.393**	4,77	4,8	4,87	4,82	...
22	**Dy 394.468**	< KH	< KH	< KH	< KH	...
23	**Dy 396.839**	< KH	< KH	< KH	< KH	...
24	**Er 337.271**	0,762	0,822	0,757	0,764	...
25	**Er 349.910**	0,244	0,306	0,244	0,25	...

Figure 2. Converted and rounded data exported to Excel

The saved figures exported into an Excel worksheet (Fig. 2.). This data are converted and rounded. The column headers are the sample_IDs, the row headers are the analytical lines. The ”<KH” symbol meaning is under the detection limit.

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2.2 Storing Data in the Database Structure

The next step to save these data into a database.
The central table is the ”Element”, where we store the chemical symbols and the measured microelement concentrations of the plant and plant part, the type of soil and how much dose the soil were treated, where the plant was grown (Fig. 3.). It is important to store the year of the sampling.
The other three tables store the different plants, plant parts and the soil type. In case of soil measurement is important to know the soils derived from which depth profile.
The plants are the followings: carrot, maize, peas, winter wheat, potato etc.
The plant parts are the followings: root, stem, leaf, bloom, seed.

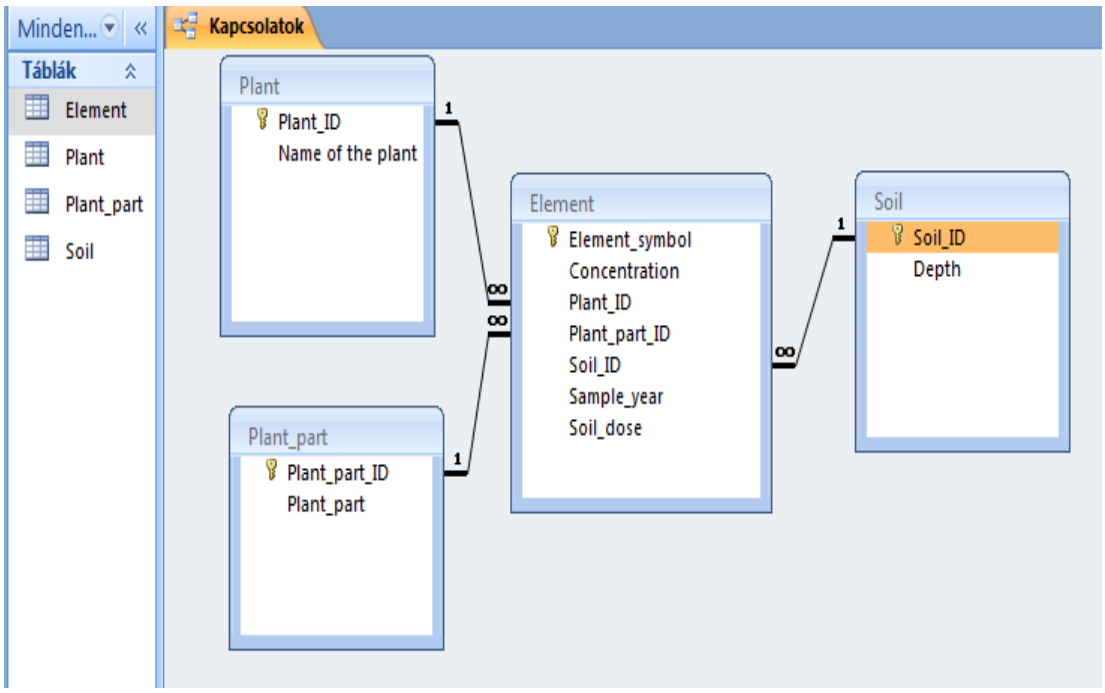

Figure 3. Database schema

A stable relational database is also needed which will handle data and also provide data for the query system. Since I aimed to apply standard solutions, I needed an SQL-based system and finally chose the MySQL database server, because it is free of charge, portable, compact and fast in case of bigger record numbers. Another gain, if we want to access these data through the Internet by a browser program, we can use this database system with the PHP server-side language efficiently, no need any conversion.
Through the authorisation system, the authorisation level of each user can easily be determined. In case of database administrator authorisation, almost any kind of query can be made in connection with the database through the general query module.
We can create special queries to give the ”Soil”, the ”Plant” and the ”Plant_part”, the ”Sample_year” and ”Soil dose” parameters. Using these parameters we can get the give

element concentration value and exported to Excel or SPSS to analyze the data by statistical method.
The first step is to test this new program. Two examples on the Fig. 4. and 5. can be seen for the molybdenum concentration changes (Anke, 1996) in the leaf and seed of maize (Ráthonyi et al.,2010). The molybdenum treatment was (90, 270, 810 kg/hectare).

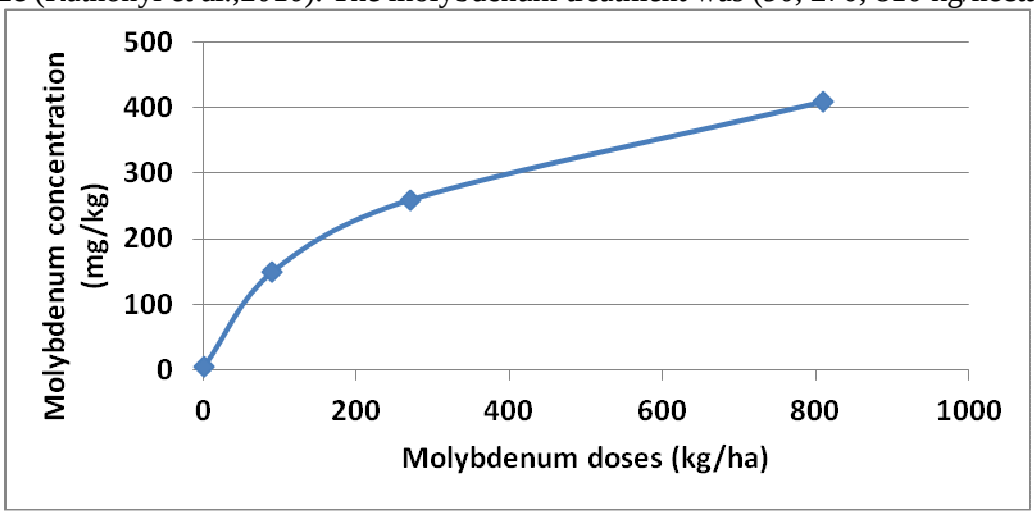

Figure 4. Change of the molybdenum concentration of the leaf of maize

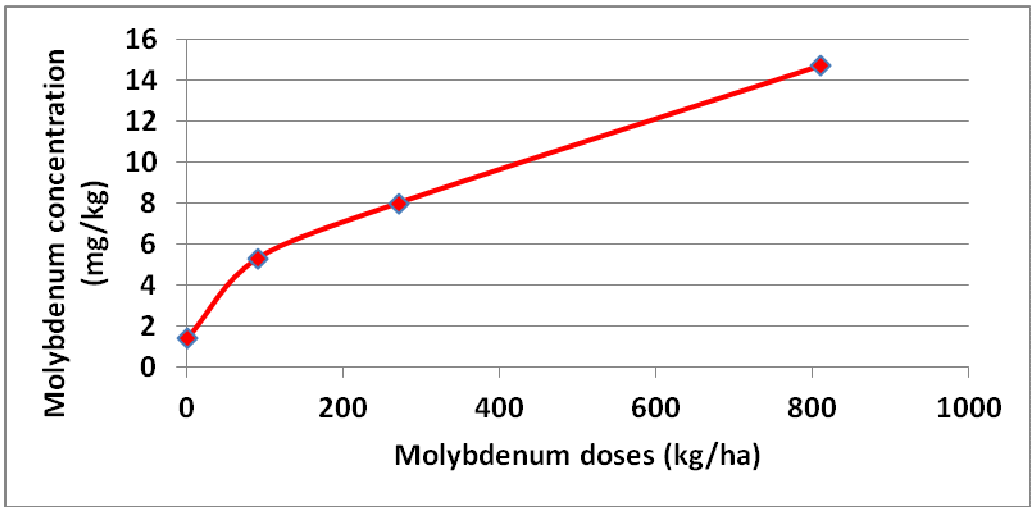

Figure 5. Change of the molybdenum concentration of the seed of maize

The aim of investigations to search for answers on how to arable crops respond to a possible soil contamination. It is also important to determine the extent of mobilized elements from the soil into the plants, which type of effect on them, and how leach the harmful substances into deeper layers (groundwater).
The investigates shall be carried out in several crop and elements, have to pay attention to the interactions, each element response to changes of other elements. It is also important that the mechanisms of action in the food chain better understand and the given data has to be accurate information content.

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The data are processed in a single database, perform a variety of statistical analyzes, which are extremely important the time-series analysis. These long-term conclusions can be drawn in the case of soil contamination in the environment. It is important to correct resolve the problem.

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