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Rocks Havıng Hıgh Potentıally Toxıc Elements Contents and Interactıon with Envıronment

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Abstract

The aim of this study was to determine the effect of main materials on the heavy metals content of soil and water. While the heavy metals content of the soil in the study field was higher than the limit values, only the copper, manganese, nickel and chrome contents of the water samples were found higher than the limit values. Higher heavy metals content in the soil and water can be toxic to vegetable, fruit and other cultivated plants grown in the study field and can be passed on to humans via food chains if taken by the plants to be grown. Large amounts of heavy metals in the soil and water in the study field can be a major problem for the environment and human health.

Introduction

Factors controlling total and biologically viable concentrations of heavy metals in soil are very important for human toxicology and agricultural production (Alloway, 1995). The amount and distribution of heavy metals in soil depends on the nature of the main soil material from which the soil develops, weathering processes, biocycle, additions originating from the atmosphere and deposits originating from natural resources (Cortizas et al., 2003). The effect of each of these factors on the heavy metals content depends on the developmental stage of soil and the mobility of the specific element in the soil system. The weathering of minerals in rocks is one of the natural sources of heavy metals in the soil system, and the metal concentrations in soil can be estimated from the amount of elements in the main material (Palumbo et al., 2000).

Composition and stratigraphy of the main material, organic matter content, degree of development of soil, climatic conditions and human activity are influential on the element distribution in soil (Cortizas et al., 2003). Heavy metals are distributed in the soil profile by events such as eluviation and accumulation, and are driven by mechanisms such as weathering, changes in soil formation factors and bio-geochemical processes. In some studies on the long-term behavior of heavy metals in soil, it has been determined that the weathering rate and the distribution of elements in the soil profile increase (Sjöström and Qvarfort ,1992; Bain et al. 1994). Koons et al. (1990) have shown that heavy metals (Co, Cr) form compounds with Fe-oxide minerals during the formation of saprolite from the weathering of granite. Kasimov et al. (1996) determined that heavy metals (Cr, Cu, Ni, Pb, Zn) in Russian soil changed depending on soil types and horizons. These studies show that the distribution and transportation of heavy metals in soil profiles vary depending on (1) soil type, (2) horizons, (3) weathering and age, (4) Fe-oxide minerals, and (5) climatic conditions.

An environment containing heavy metals is the most important risk factor for cancer. Türkdoğan et al. (2002) found that soil, vegetables and fruits contained 2-340 times more carcinogenic heavy metals (Co, Cd, Pb, Zn, Mn, Ni, and Cu) than the limit values on volcanic soils and in heavy metals content of vegetables and fruits grown on these soils. They pointed out that the "upper gastrointestinal cancer" cases, which are very common in the Van region, may be due to high carcinogenic metals in soil, vegetables and fruits. Epidemiological studies have shown that cancer cases are caused by the pollution of the environment by heavy metals, radioactive elements and their products (Hayes, 1997).

Material and Methods

Study Field

The study area was located between 37°25' and 38°58' north latitudes and 33°10' and 35°25' east longitude. The average annual precipitation and average annual temperature were 338 mm and 10.8 °C, respectively.

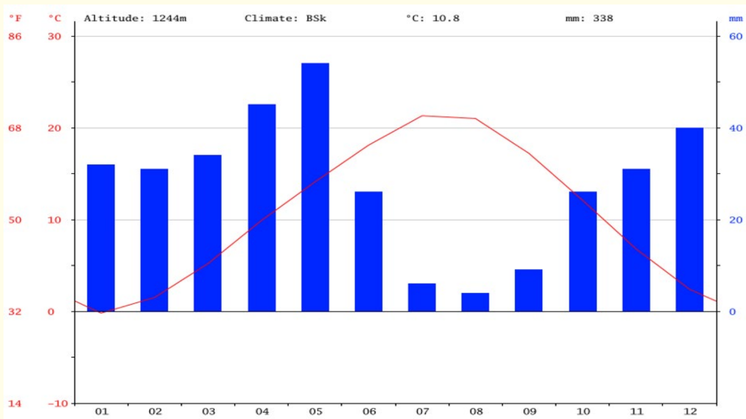


Figure 1: Average precipitation and temperature values of the study area.

The study field was under different types of land use. These types of land use consisted of meadow/pasture, field, garden, dry farming and irrigated farming areas. Traditional tillage methods (plowing at a depth of about 20 cm, plowing with a cultivator at a depth of 15 cm, and plowing with a disc harrow at a depth of 10 cm) and, at the same time, diammonium phosphate, ammonium nitrate, urea and potassium sulphate fertilizers — with varying amounts depending on the product grown — were applied in the cultivated agricultural areas. Observations made during the study indicated that the soil profile thickness was usually very shallow (0-20 cm).

The main materials of the soil were metamorphic rocks such as gneisses, amphibolites, quartzite and marble (Anonymous, 2012c). The predominant minerals of these rocks were quartz, feldspar, hornblende and calcite.

Soil sampling

A total of 26 soil samples were taken from 0-20 cm depth. Air dried soil samples were sieved (<2 mm) and used for laboratory analyses. Soil samples were taken according to the random sampling method, and their GPS coordinates were recorded.

Sand, silt and clay fractions were determined using the pipette method (Gee and Bauder, 1986). The pH and electrical conductivity (EC) of the soil were determined in pure water (1:2.5 soil:water) (Blakemore et al., 1987). The soil organic matter content was determined by the wet ashing method (Walkley-Black, 1985), the cation exchange capacity by the ammonium acetate method (Thomas, 1982).

	Cd	*Co*	*Cr*	*Cu*	*Mn*	*Ni*	*Pb*	*Zn*
Soil (ppm)	0.06	8	16	20	850	40	10	50
Water (ppm)	0.01	0.02	0.05	1.5	0.05	0.02	0.05	15

Table 1: Limit values in soil and water of some potentially toxic elements (Rose at al., 1981).

The heavy metals content of soil samples was extracted in aqua regia (3 volumes of HCl acid + 1 volume of HNO_3 mixture) and measured by using ICP (ISO/CDT, 1995). Water samples from surface and drinking water were adjusted to pH 2 using nitric acid, and their heavy metals content was determined using ICP.

Results and Discussion

The physical, chemical properties and potentially toxic elements of the soil

According to the EC values, the soil was salt-free (50.7-229 µmhos/cm) and strongly alkali (7.85-8.88), with medium pH. The soil had a silty, clayey sand texture. Organic matter contents were found to be at medium and high levels (1.94-6.11%).

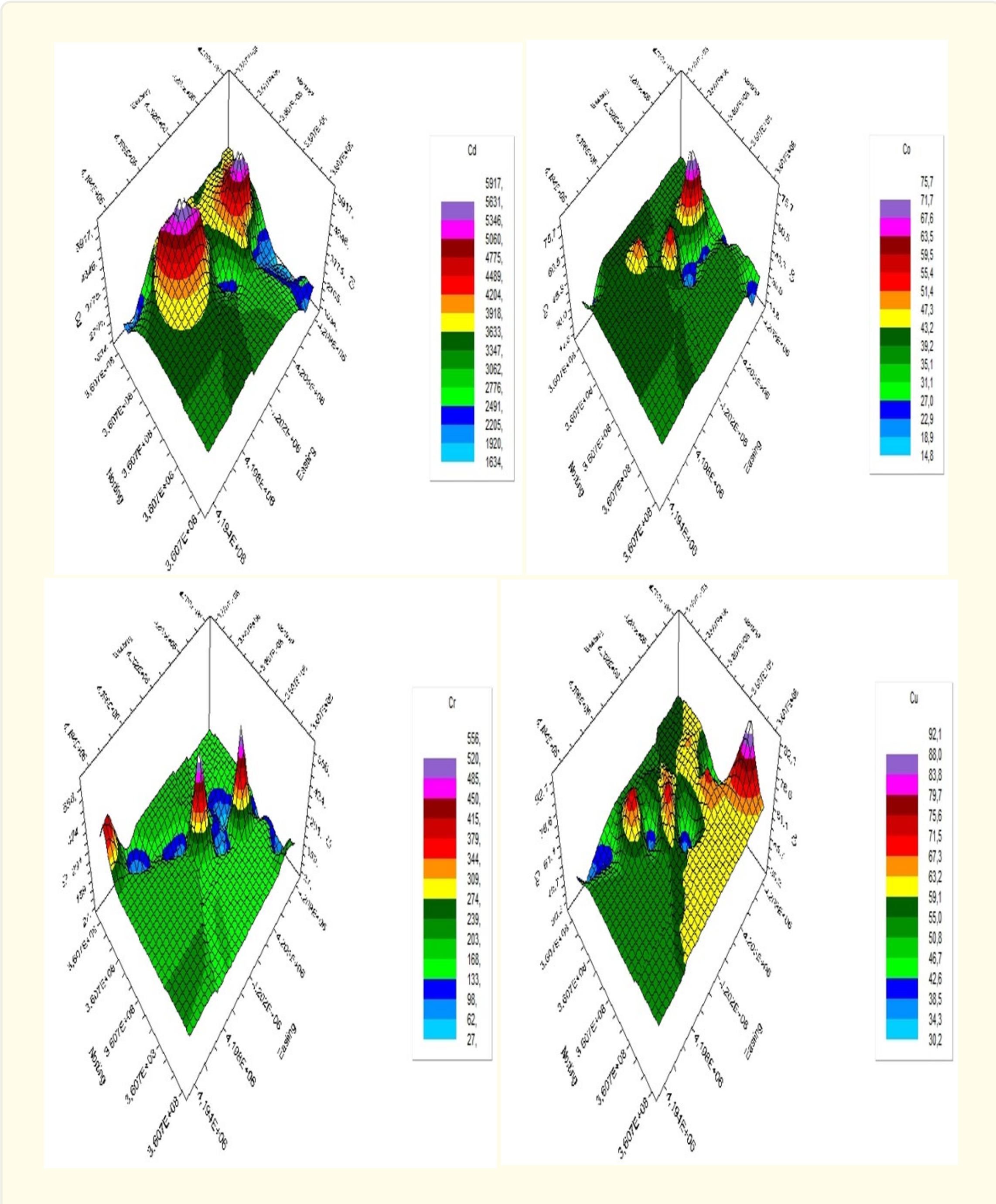
Spatial distribution maps showed that the cadmium values in the research field changed between 783 ppm at the lowest and 7015 ppm at the highest. Generally, cadmium values were found high in the northern, middle northern and north eastern parts of the study field. Cobalt values varied between 11 ppm at the lowest and 83 ppm at the highest. In general, the middle, northeast and north of the study field contained more cobalt than the other parts. The chrome values ranged from 18 ppm at the lowest to 609 ppm at the highest and were found to be high in the northwestern, middle, and northeastern parts of the study field. The copper values were between 28 ppm at the lowest and 94 ppm at the highest, and the north, southeast, middle and south of the study field contained more copper than the other parts. Manganese values were found to vary between 483 ppm at the lowest and 2715 ppm at the highest. In general, the manganese values were found high in the middle, northwestern and northeastern parts of the study field. Nickel values ranged from the lowest of 333 ppm to the highest of 5198 ppm. In general, the northwestern, southwestern and southeastern parts of the study field contained more nickel than the other parts. Lead values were found to vary between 6.2 ppm at the lowest and 71.5 ppm at the highest. The lead values are generally high in the northern and southeastern parts of the study field. Zinc values varied between 302 ppm at the lowest and 1843 ppm at the highest. In general, the middle parts of the study field contained more cobalt than the other parts.

Heavy Metal Contents of the Water Samples

Copper contents of the water samples were found to be between 0.77 and 4.04 ppm. The highest copper values were determined in the eastern, northeastern, northwestern and western parts. Manganese values ranged from 2.5 to 10.1 ppm, with the highest values being found in the middle northern and eastern parts. Nickel values ranged from 0.04 to 0.63 ppm, with the highest values being found in the southeastern parts. Zinc values ranged from 0.34 to 0.67 ppm, with high values in the middle northwestern and western parts. Cobalt values ranged from 0.03 to 0.20 ppm, with high values in the north-south direction. Chrome values ranged from 0.02 to 1.22 ppm, and the highest value was found in the north and northeast-southwest direction. Lead values were between 0.07 and 0.17 ppm and reached the highest values in the western and northwestern parts. In general, copper, manganese, zinc, cobalt, chrome, lead and cadmium were high in the water in the northern, northeastern, northwestern and western parts of the study field, while nickel values were found high in its southeastern parts.

Sample number	*Silt (%)*	*Clay (%)*	*Sand (%)*	*Organic Mat. (%)*	*pH*	*EC (µS/cm)*
1	8	6,72	85,28	2,37	8,60	200,04
2	14	8,72	77,28	1,94	8,88	162,0
3	20	8,72	71,28	2,37	8,78	170,8
4	12	12,72	75,28	3,67	8,36	147,0
5	16	10,72	73,28	3,24	8,72	162,2
6	12	8,72	79,28	3,45	8,80	131,3
7	14	8,72	77,28	3,89	8,48	90,0
8	8	4,72	87,28	3,89	8,32	50,7
9	8	2,72	89,28	4,04	8,36	41,2
10	10	4,72	85,28	2,76	8,16	123,6
11	16	4,72	85,28	5,83	7,85	113,8
12	20	4,72	75,28	3,30	8,73	104,3
13	14	6,72	79,23	2,37	8,21	90,8
14	16	10,72	73,28	2,87	8,15	134,7
15	10	6,72	83,28	3,28	8,03	191,4
16	12	8,72	79,28	5,98	8,03	208,8
17	10	2,72	87,28	6,11	7,96	193,3
18	10	4,72	85,28	5,83	8,02	87,3
19	8	4,72	87,28	5,61	8,21	219,5
20	14	6,72	79,28	4,86	8,28	168,5
21	10	6,72	93,28	5,83	8,49	184,6
22	10	10,72	79,28	5,98	7,94	229,0
23	14	12,72	73,28	3,24	8,54	192,2
24	12	8,72	79,28	3,09	8,03	149,4
25	12	4,72	83,28	3,71	8,32	67,6
26	12	4,72	83,28	3,82	8,81	103,1

Table 2: Some physical and chemical properties of the soil.


Cd
5917,
5631,
5346,
5060,
4775,
4489,
4204,
3918,
3633,
3347,
3062,
2776,
2491,
2205,
1920,
1634,
Co
75,7
71,7
67,6
63,5
59,5
55,4
51,4
47,3
43,2
39,2
35,1
31,1
27,0
22,9
18,9
14,8
Cr
556,
520,
485,
450,
415,
379,
344,
309,
274,
239,
203,
168,
133,
98,
62,
27,
Cu
92,1
88,0
83,8
79,7
75,6
71,5
67,3
63,2
59,1
55,0
50,8
46,7
42,6
38,5
34,3
30,2
Northing
Easting

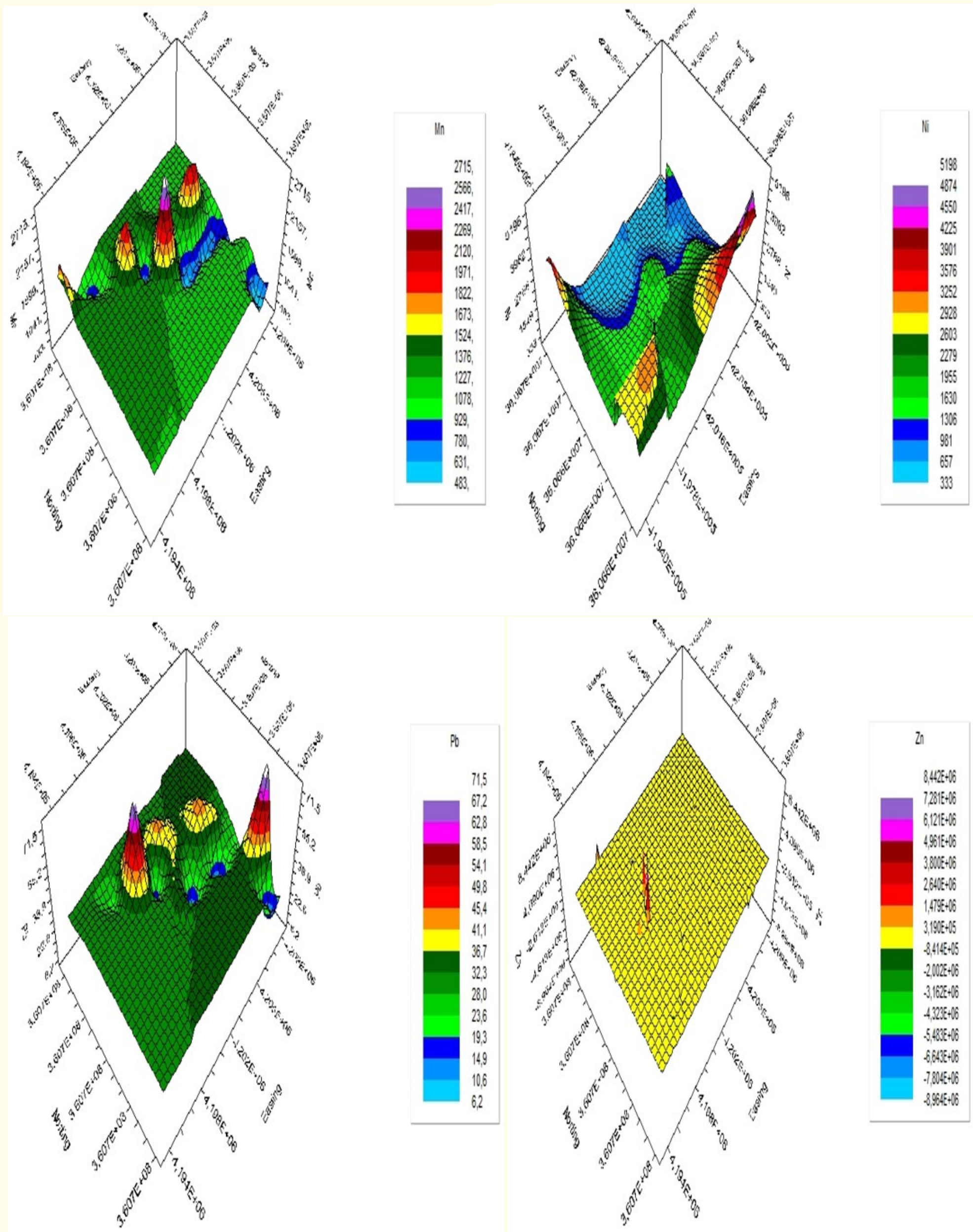
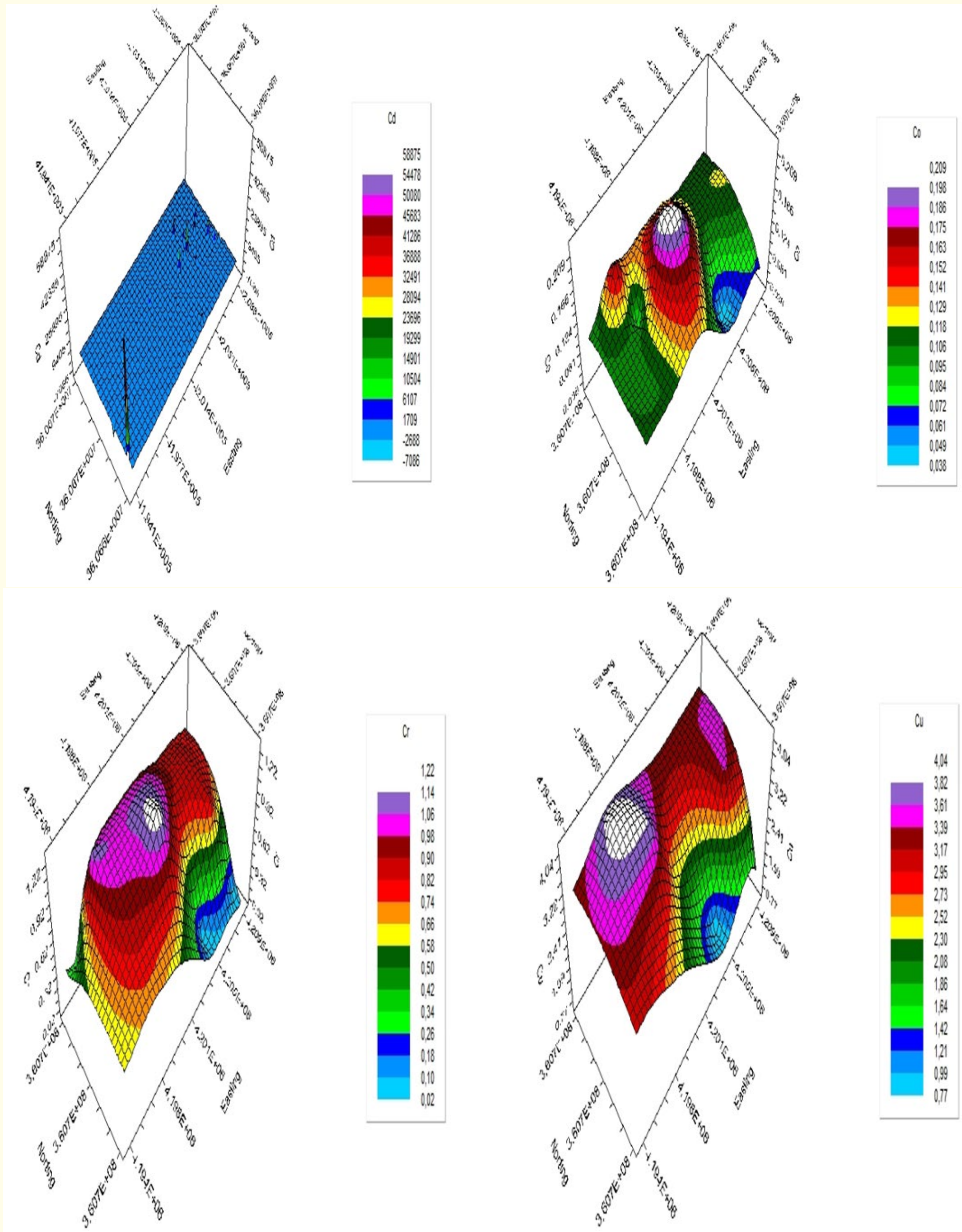


Figure 2: Spatial variability of the potentially toxic elements.


Cd
58875
54478
50080
45683
41286
36888
32491
28094
23696
19299
14901
10504
6107
1709
-2688
-7086
Co
0,209
0,198
0,186
0,175
0,163
0,152
0,141
0,129
0,118
0,106
0,095
0,084
0,072
0,061
0,049
0,038
Cr
1,22
1,14
1,06
0,98
0,90
0,82
0,74
0,66
0,58
0,50
0,42
0,34
0,26
0,18
0,10
0,02
Cu
4,04
3,82
3,61
3,39
3,17
2,95
2,73
2,52
2,30
2,08
1,86
1,64
1,42
1,21
0,99
0,77
Easting
Northing

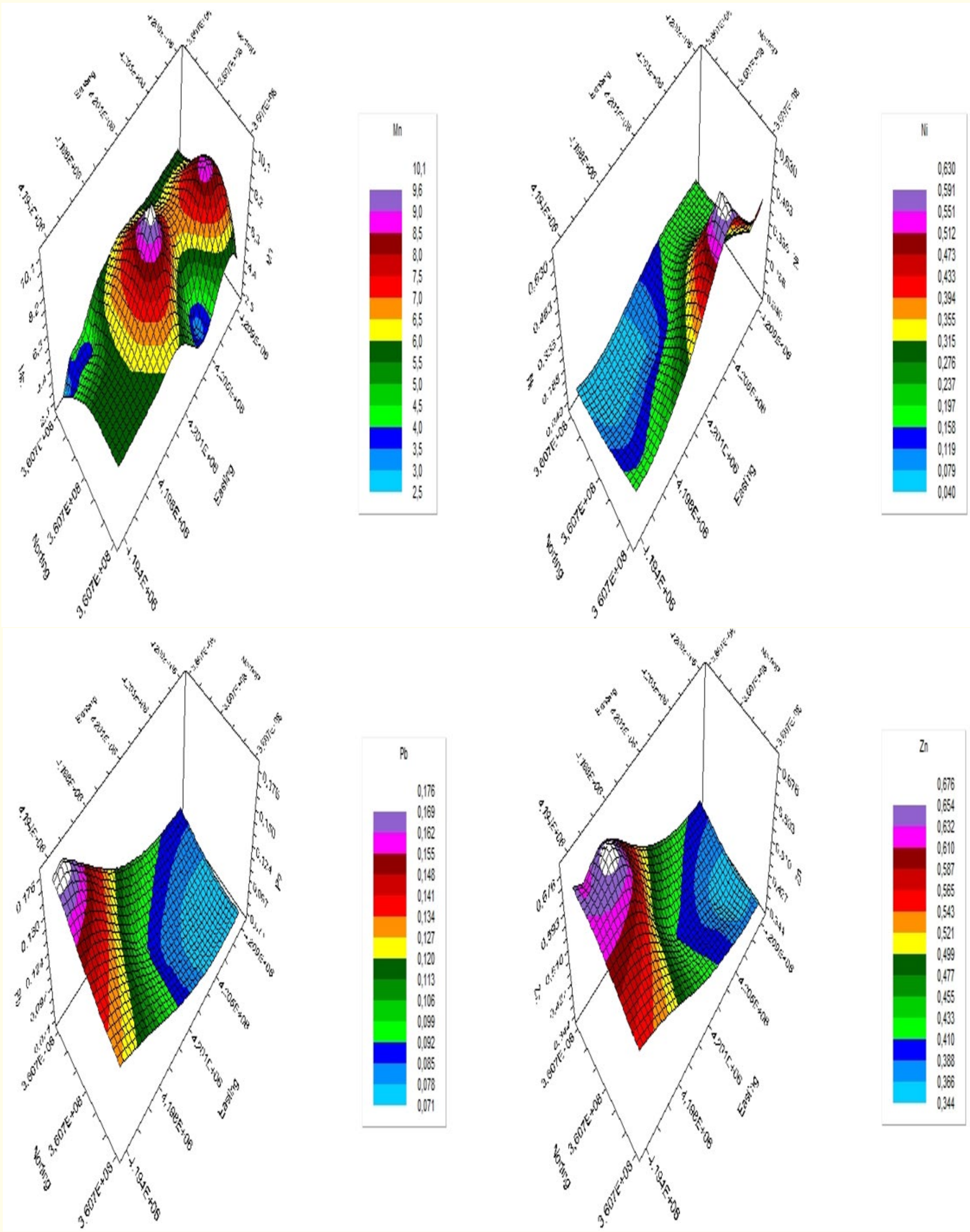


Figure 3: Spatial variability of the waters.

Conclusions

The heavy metals content of the soil consisting of rocks in the study field were higher than the limit values. Copper, manganese, nickel and chrome contents of the water samples taken from the study field were higher than the limit values. High levels of heavy metal content in the soil and water can be toxic to vegetable, fruit and other cultivated plants grown in the study field and can also be passed on to humans via food chains if taken by the grown plants in high amounts. The fact that the soil and water samples contained large quantities of heavy metals can be a major problem for human and environmental health.

Acknowledgement

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