Acta Agrophysica, 2001, 51, 121-130

HEAVY METALS IN SOILS SUBJECTED TO INDUSTRIAL EMISSION IN THE STALOWA WOLA REGION

M. Mikos-Bielak

Department of Chemistry, Agricultural University of Lublin
Akademicka 15, 20-950 Lublin, Poland

A b s t r a c t. The content of Cd, Pb, Ni, Co, Cu, Zu and Mn was analysed in 54 soil samples collected at 8 experimental sites in the Stalowa Wola region. The soils examined were characterized by an increased concentration of zinc and manganese. The concentrations of those remaining elements determined, could be reported as being low.

K e y w o r d s: soil, heavy metals, air polution, Stalowa Wola region.

INTRODUCTION

Air, polluted with dust containing heavy metals, results in an increased content of these pollutants in soil, water and plants [2,7,10]. Soil and plants encompassed by municipal, industrial and transport dust emission zones are in real danger of being polluted. The studies have been undertaken to evaluate the pollution of soil environment within the industrial plant region of Stalowa Wola. Some power stations, metallurgical industrial complexes together with converter and electrolytic steelworks are in evidence in the vicinity, as well as foundries which emit a considerable amount of harmful dust. The samples collected were subjected to some analyses on Cd, Pb and Ni content which is toxic for plants, as well as on elements which, although necessary at the vegetative period, are nonetheless prejudicial to their life function when present in excess (Cu, Zn, Co, Mn). This excess can also cause a potential health hazard in man.

RESEARCH AREA AND ENVIRONMENT POLLUTION SOURCES CHARACTERISTICS

The different geological structure of the Stalowa Wola region is the explanation for the considerable differentiation of the soil-forming horizon. Brown soils, podzolic ones and chernozems are in evidence. Fairly light soils compose some 17.6%; light soils compose 32.3%; medium soils 36.6% and heavy soils about 13.5% of all soils under examination. The agrochemical state looks far worse since as much as 65% of these soils exhibit an acid to very acid reaction [2,10,12]. The communal area whence the soil samples were collected lies between the largest towns in the region, namely those of Stalowa Wola and Tarnobrzeg - south-westerly direction (the Grębów Commune); Stalowa Wola and Sandomierz (the Zaleszczany Commune) - north-westerly direction. This region is situated within the southerly and westerly air currents. During the cold season a southerly current prevails, whereas during warmer periods - a westerly and a north-westerly one are prevalent [2].

This was a boom area during the 1930s at the onset of heavy industrialisation. The district included a steel mill, mechanical plants and electric power stations in Stalowa Wola. In the 50s, rich sulphur deposits were explored and this fact strengthened the economic development of the region. Yet, the development was connected with too intensive a consumption of the naturally occurring environmental resources leading ultimately to its degradation. In 1983, the area of ecology hazard was estimated as covering some 40% of the total area [1,4]. Dust emissions recorded in 1996 was as follows: 4,389 thousand t SO_2 , 7,153 thousand t NO_x , 3,168 thousand t of energetic dust, 333 thousand t of industrial dust and 1,265 thousand t of other pollutants [2,10]. Moreover, in the Grębów Commune there is the sulphur mine "Jeziórko", where 1,230 thousand t of the material output was reported in 1996. Sulphur is produced by the underground heating method. This method causes landscape deformation, there are subsiding troughs 3-6 m deep. The mine conducts land reclamation with the application of the relevelling method.

MATERIAL AND METHODS

In the autumn of 1996, soil samples were collected from the arable layer of the fields where potatoes were grown. Altogether, 54 samples were gathered at 8 experimental points located in the Grębów and Zaleszczany Communes, 4 points in each (Fig. 1). The air-dried screened soil samples were extracted with 1 M HCl by shaking for over 1 h, with a rate of soil: 1 M HCl = 1:10.

The contents of Zn, Cu and Mn were determined directly in a filtrate with the AAS method, whereas Pb, Cd, Ni, Co after transportation to the organic phase MIBK.

A potentiometric method was used to establish soil reaction in water solution and 1 M KCl. A variance analysis was applied for all the results obtained and difference significance - according to the Tukey's test.

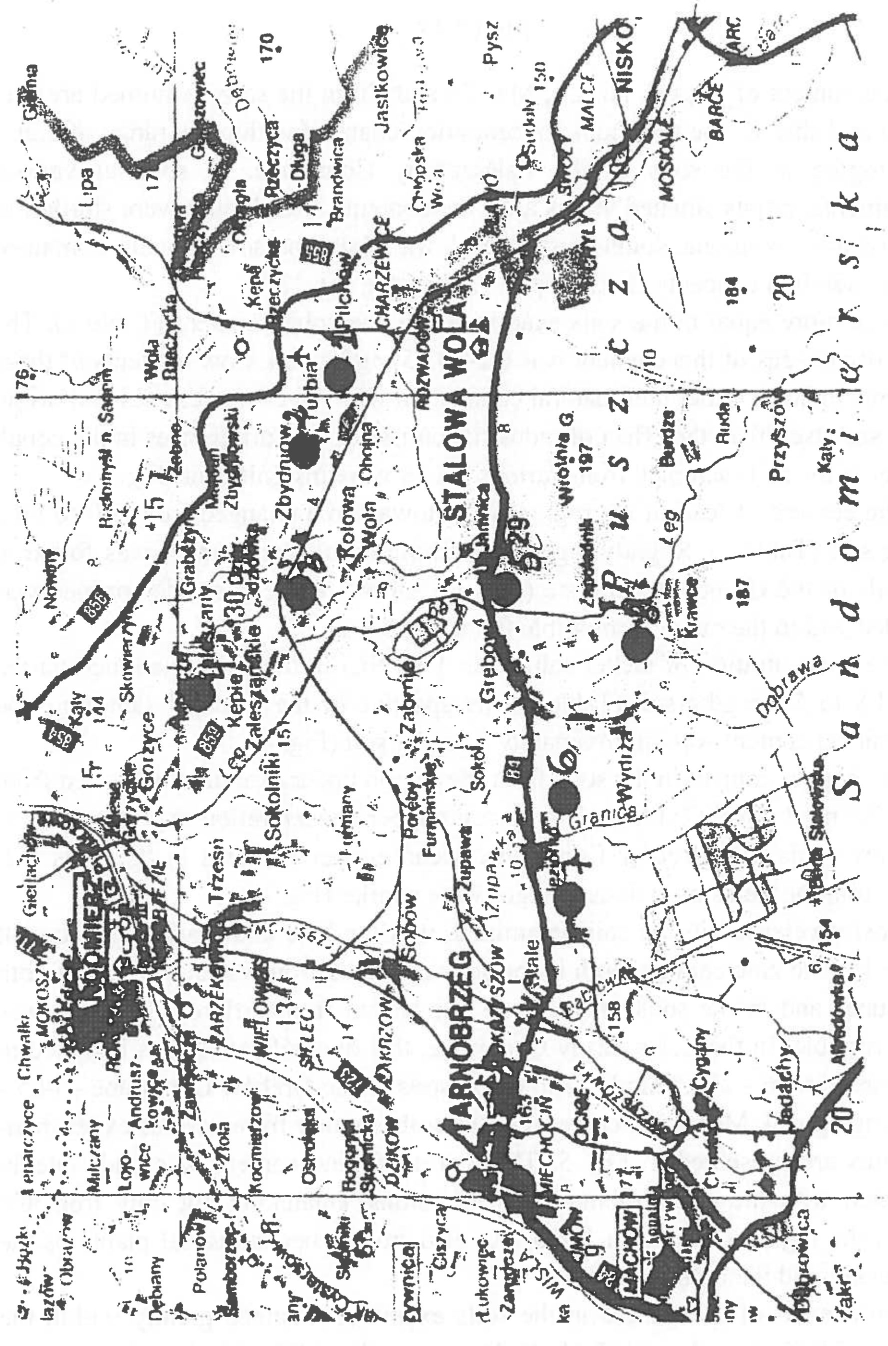

Fig. 1. Distribution of experimental points in the region.

RESULTS

The content of Pb, Cd, Ni, Co, Mn, Zn and Cu in the soils examined are presented in Table 1. The cadmium concentration changed within the range of 0.26 - 0.41 mg/kg in the soils of the Zaleszczany Commune. In soils at various experimental points situated in this area, the contents of cadmium were similar. In the Grębów Commune, south-west of Stalowa Wola, the soils usually contained higher cadmium concentrations - up to 1.92 mg/kg (Fig. 2).

Even more equal in the soils examined was the cobalt content (Table 1). The range of changes of this element was 0.24-0.75 mg/kg soil. Low contents of these elements indicate rather their natural connection with the characteristics and origin of the soil itself than the effect of industrial emission. The differences in the cobalt content in the soils sampled from various places were insignificant (Fig. 2).

The content of lead in the region of Stalowa Wola changed from 7.0 to 20.6 mg/kg soil (Table 1). Slightly higher concentration of this element was found in the soils of the Grębów Commune (Fig. 3). All the lead content determined was included within the range permissible for arable soils.

The concentration of nickel soluble in 1 M HCl in the soils examined varied from 1.8 to 5.0 mg/kg soil (Table 1). Irrespective of the place of sampling, the mean nickel content was approximately 3 mg/kg soil (Fig. 4).

The copper content in the soils from the region under examination varied from 1.6 to 7.1 mg/kg soil (Table 1). The lowest copper concentration was found out in Sulechów soils, the Grębów Commune. Mean copper contents in the soils collected from the fields of various villages were similar (Fig. 4).

Most diversified in the soils examined, was the zinc and manganese content (Table 1). The zinc content, both in the soils collected from various points of both communes and in the soils of the same points, but from different samples, was much variable. In the Zaleszczany Commune, this diversification was included in the range of 67.6 - 252.9 mg/kg, and in the soils of the Grębów Commune - 14.5 - 335.7 mg/kg soil. Mean zinc contents in the soils coming from various experimental points are presented in Fig. 5. The increased zinc content was undoubtedly connected with the effect of industrial emissions, emanating not only from the sites in the region of Stalowa Wola, but also from other industrial plants of the Tarnobrzeg and Sandomierz region.

The content of manganese in the soils examined changed greatly within the range of 27.5-456.6 mg/kg soil (Table 1). There was a high differentiation of manganese

Table 1. Cadmium, cobalt, lead, nickel, cooper, zinc and manganese content in soils of the Stalowa Wola region (mg/kg soil)

Locality	Cd	Co	Pb	Ni	Cu	Zn	Mn
Commune Zaleszczany							
Turbia	0.26-0.40	0.24-0.80	7.0-13.0	2.2-3.6	2.50-6.70	89.2-172.6	75.2-447.3
Zbyniów	0.27-0.41	0.40-0.45	8.0-10.0	2.8-5.0	1.60-4.50	72.5-116.0	341.0-343.6
Kotowa W1.	0.26-0.35	0.30-0.70	8.2-20.0	2.2-3.6	4.00-5.40	78.6-252.9	85.3-292.0
Zaleszczany	0.27-0.38	0.40-0.75	9.6-12.4	2.3-3.4	3.20-6.00	67.6-150.5	169.3-225.0
Mean for commune	0.26-0.41	0.24-0.75	7.6-20.6	2.2-5.0	1.60-6.70	67.6-252.9	75.2-447.3
Commune Grębów							
Grębów	0.35-1.70	0.40-0.70	9.2-14.2	1.8-3.1	1.90-6.80	60.3-132.9	87.5-292.0
Sulechów	0.38-0.45	0.35-0.40	13.0-16.5	2.7-3.0	1.70-2.60	122.0-335.7	100.7-113.5
Jeziórko	0.29-0.37	0.30-0.50	10.0-19.0	2.4-3.0	1.40-4.30	14.5-212.2	27.5-120.0
Stale	0.30-1.92	0.30-0.56	12.6-16.4	1.8-3.6	2.90-7.10	71.3-291.5	53.0-456.6
Mean for commune	0.29-1.92	0.30-0.56	7.0-20.0	1.8-3.6	1.70-7.10	14.5-335.7	27.5-456.6

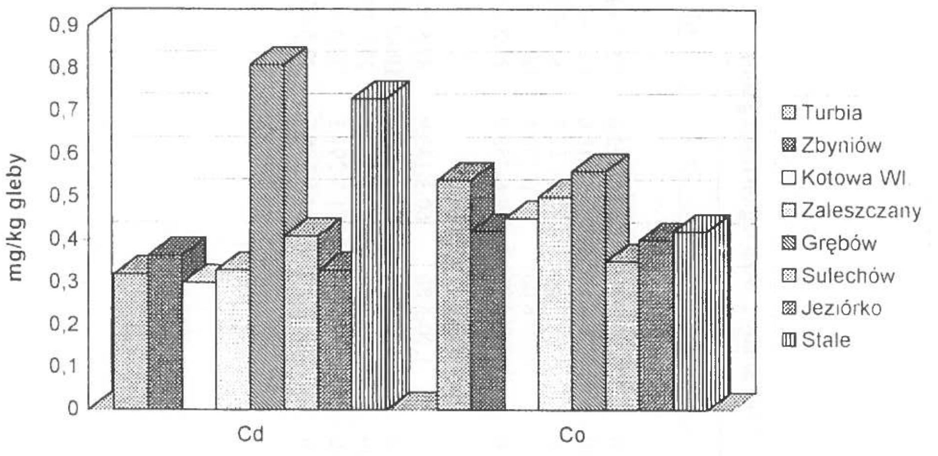

Fig. 2. Mean cadmium and cobalt contents depending on the sampling site (mg/kg soil).

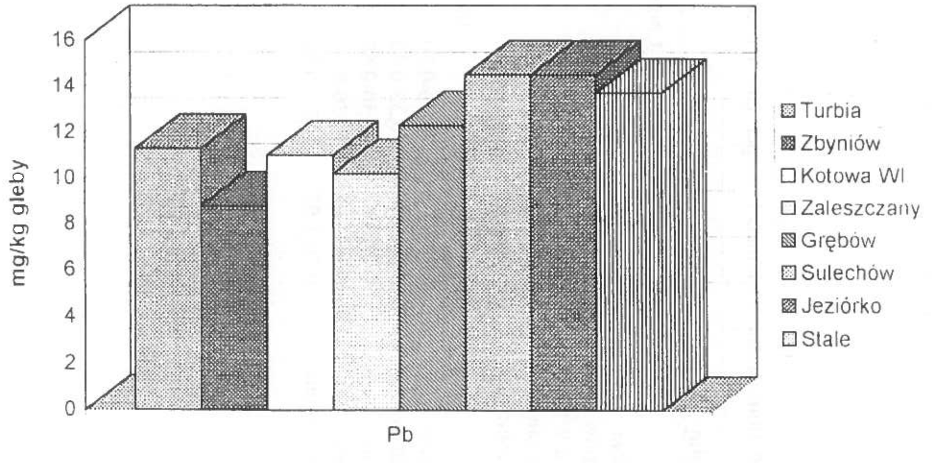

Fig. 3. Mean lead content in the examined soils (mg/kg soil).

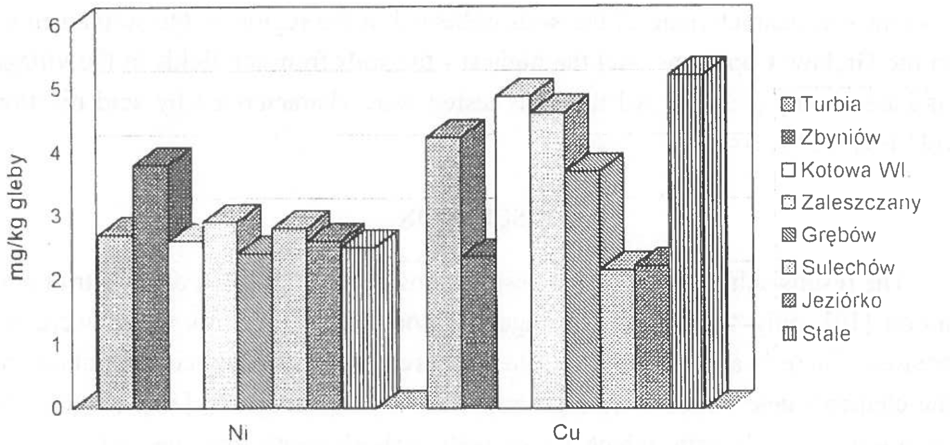

Fig. 4. Mean nickel and copper concentrations in the soils examined (mg/kg soil).

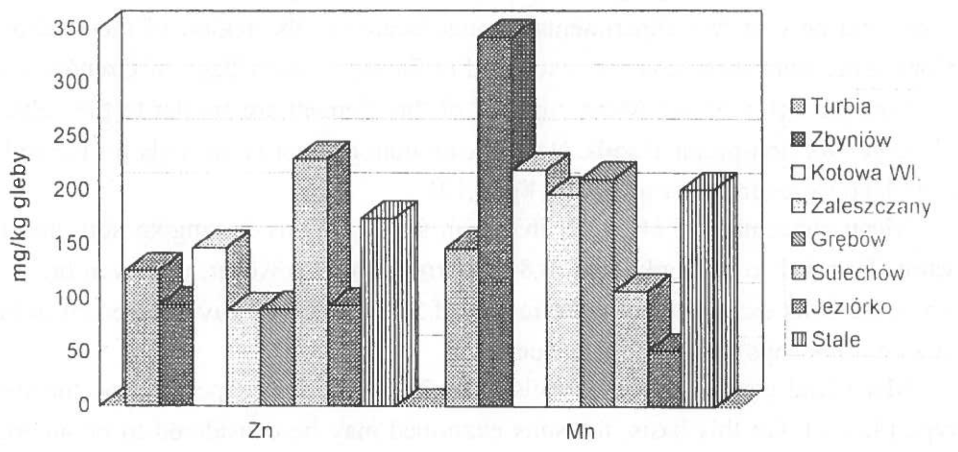

Fig. 5. Mean zinc and manganese contents in the soils examined (mg/kg soil).

content concerning both those from the various experimental points and those from the soils taken from different fields at the same point. The lowest manganese content was characteristic of the soils collected in the region of the sulphur mine in the Grębów Commune, and the highest - the soils from the fields in the village of Zaleszczany (Fig. 5). All the soils tested were characterized by acid reaction (pH 1 M KCl 4.71-4.91).

DISCUSSION

The results achieved show that despite considerable emission of industrial pollution [10], only the zinc and manganese contents in the soils tested were increased. There is a possibility that the main reason for the low concentrations of the elements determined were high emissions of SO_2 and NO_x [10], causing the occurrence of acid rain, which rinses well such elements from the soil. On the other hand, according to the studies of Terelak *et al.* [11], 88.9 to 98.0% of Poland's soils reveal zero level of pollution by metals determined by the present study. According to Kabata-Pendias *et al.* [4,5] as well as Piotrowska and Terelak [6], the cadmium content in Polish sandy soils does not exceed 0.24 mg/kg, and in the brown ones - 0.96 mg/kg soil. The soils examined by us belonged to such soil types and only at two experimental points located in the region of the Grębów Commune, were these contents exceeded (1.70 mg in the village of Grębów and 1.92 mg/kg soil in Stale). Mean contents of this element are similar to the values presented for non-polluted soils. Natural cadmium content in the soils for the soils of Poland varies from 0.1 to 1.7 mg/kg [1,12].

Mean concentration of cobalt in Polish sandy soils is 5.0 mg/kg soil, and it varies from 0.1 to 12 mg/kg soil [4,8]. In brown soils, however, it is even higher. Thus, the soils examined from the region of Stalowa Wola may be deemed to be among soils unpolluted with this element.

Mean lead content in Polish soils is 16-26 mg/kg soil, depending on the soil type [4,5,12]. On this basis, the soils examined may be considered to be among those of low lead content.

The nickel cotent in the soils of Poland is greatly differentiated - from 1 mg in sandy soils to 104 mg/kg in clay ones [4,11,12]. The limit of its natural content in cultivated soil reaches 50 mg/kg soil [13]. Therefore, the content of 2.2-5.0 mg Ni/kg should be recognised as low.

The concentration of copper in Polish arable soils varies from 1 to 40 mg/kg [4,9,13]. The concentration of copper discovered in the soils studied is within the limits of the most frequently recorded concentrations [3-5,11].

Zinc concentration in Polish soils studied by some authors varies within a very vast range [4,7,9,11,12]. However, the zinc concentrations found in the soils from the vicinity of Stalowa Wola may be described as high. Undoubtedly, such zinc concentration results from the anthropogenic activity of man. Zinc is an extremely volatile element and therefore the area surrounding steelworks reveals various levels of contamination [10,12]. In the region of Stalowa Wola, the pollution of soils with zinc is moderate, as in highly contaminated soils, its concentration may reach as high as 1500 mg/kg [4,12].

Manganese content in soils, similarly to that of zinc, undergoes significant variations. Kabata-Pendias [4] presents its variation in sandy soils as 15-1500 mg. In the podzols and brown soils, examined by Goworek and Jeske [3], such values equalled 100-560 mg. Although the manganese contents determined for the soils in the region of Stalowa Wola are fairly high, they do not exceed the concentration limits presented for the arable soils [4,8].

CONCLUSION

Soils examined from the Stalowa Wola region demonstrated elevated content of zinc and manganese. Content of toxic metals, i.e. Pb, Cd, Ni, Co and Cu was usually low.

REFERENCES

1. **Bem E., Turzyńska E.:** Impedance with cadmium in Poland. Part I. Cadmium level in various parts of the environment. Brom. Chem. Toksykol., 25(24), 361-371, 1992.
2. **Błoniarz J., Buliński R.:** Effect of emission in the vicinity of Stalowa Wola steelworks and power plant on the content of some microelements in selected vegetables and fruit. Roczn. PZH, 35, 29-36, 1984.
3. **Gworek B., Jeske K.:** Microelements and iron in cultivated soils of glacial origin. Roczn. Glebozn., 47, Supl., 51-63, 1993.
4. **Kabata-Pendias A., Pendias H.:** Biochemistry of Microelements. PWN, Warszawa, 1993.
5. **Kabata-Pendias A.:** Evaluation of pollution level of soils and plants with heavy metals and sulphur. IUNG, Pulawy, 5-20, 1993.
6. **Piotrowska M. Terelak H.:** Cadmium in the soils in Poland. Zesz. Probl. Post. Nauk. Roln., 448b, 251-257, 1997.
7. **Rostanski A.:** Content of heavy metals in soil and plants from the vicinity of some pollution emitters in Górny Śląsk. Arch. Ochr. Środ., 23,(3-4), 181-189, 1997.
8. **Skłodowski P., Zarzycka H.:** Effect of soil utilization on the content and distribution of heavy metals. Roczn. Glebozn., 48, (1/2), 5-13, 1997.

9.**Spiak Z.:** Current state of studies on the problem of excess heavy metals in soils and plants. Zesz. Probl. Post. Nauk Roln., 434, 769-776, 1996.

10.The state of the Environment in the Tarnobrzeg Province in 1996. Raport WIOŚ-PIOŚ-Tarnobrzeg, 1996.

11.**Terelak H., Piotrowska M., Motowicka-Terelak T., Stuczyński T., Budzyńska K., Pietruch C.:** Content of heavy metals and sulphur in the cultivated soils of Poland as well as their contamination with these elements. Zesz. Probl. Post. Nauk Roln., 418, I, 45-60, 1995.

12.**Terelak H., Piotrowska M., Motowicka-Terelak T., Stuczyński T., Budzyńska K., Pietruch C.:** Cd,Cu, Ni, Pb, Zu and S content in the soils of the Katowice Province. Arch. Ochr. Środ., 23, 3/4, 167-180, 1997.

13.**Terelak H. Piotrowska M.:** Nickel in the soils of Poland. Zesz. Probl. Post. Nauk Roln., 448b, 317-323, 1997.