Acta Agrophysica, 2001, 51, 101-111

SULPHUR AND HEAVY METALS CONTENT IN THE SOIL OF MEADOW ECOSYSTEMS ADJOINING THE METALLURGIC PLANT "HUTA KATOWICE" AS AN INDICATOR OF ENVIRONMENT DEGRADATION

T. Kimsa, K. Pawełko, R. Ciepał, B. Palowski, A. Śliwińska-Wyrzychowska

Department of Ecology, Silesian University, Jagiellonska 28, 40-032 Katowice, Poland

A b s t r a c t. The content of Cu, Pb, Zn, Fe, Cd and S in the upper soil layer of meadow ecosystems surrounding the steelworks "Huta Katowice" was investigated. Sampling plots were located at a different distance and direction from the plant, but in a similar type of meadow community and soil.

Spatial and seasonal variability of the investigated elements content was found. Such results indicate that the investigated area was polluted both by that steelworks and by the industrial plants situated in the Industrial Region of Upper Silesia.

K e y w o r d s: sulphur, heavy metals, soil, meadow ecosystem, degradation indicator.

INTRODUCTION

Upper Silesian Industrial Region is listed among the most polluted areas in Europe [6]. Contaminants come from power plants such as: coal-burning steelworks, zinc and lead smelters, coking plants and chemical plants. Contamination of the biocenosis around industrial plants depends on the distance from the emitters, their height and dominating wind directions [5,11,13]. The wind rose (Fig. 1) suggests, that contamination of the surroundings of the "Huta Katowice" come mostly from the SW and W directions from Upper Silesian industry. "Huta Katowice" with the coking plant "Przyjaźń" adds to the background pollution.

The impact of air pollution on the soil depends on such soil properties as: its mineralogical composition, pH, humus content, duration of the contamination period, and others [1,14,16]. Analysis of heavy metals content in the upper soil layer is acknowledged as one of the most important methods of direct measurement, which could indicate degree of environment pollution.

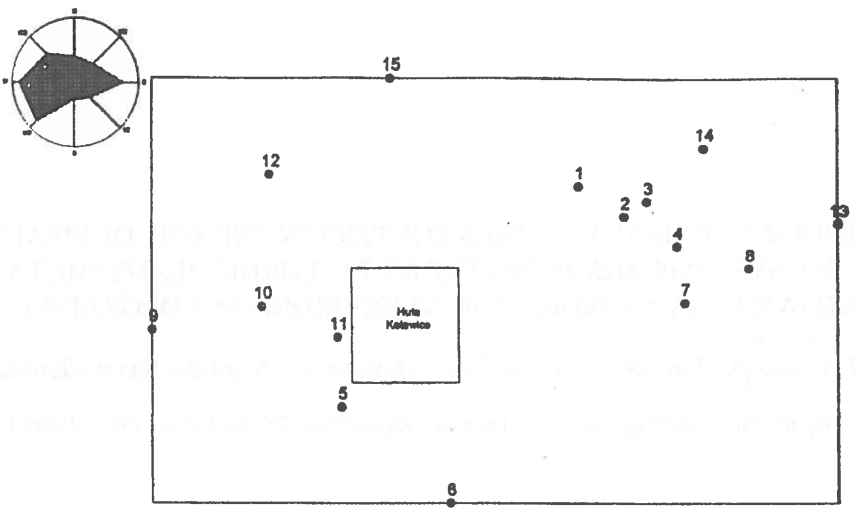

Fig. 1. Localisation of the study plots around metallurgic plant "Huta Katowice". Wind rose (1961-1990) of the investigated area [3].

The objective of present study was to evaluate contamination of the organic soil layer by determining some heavy metals and sulphur content, and to evaluate conditions of the environment around the steelworks "Huta Katowice".

MATERIAL AND METHODS

The study material were samples of the upper soil layer (0-10 cm) from 15 sampling plots (Fig. 1) situated at a distance of 2 to 12 km around the steelworks "Huta Katowice". All the plots were located in meadow ecosystems on pseudo-podzolic soil. Sampling was carried out since 1994 to 1996. Soil samples were air dried, passed through a sieve (1 mm mesh), and extracted with 0.1 N HCl [2]. After filtration, concentration of cadmium, lead, copper, iron and zinc was measured by means of the conventional atomic absorption spectrophotometry (AAS). Concentration of sulphur was measured with the colorimetric method [12,15]. Each soil sample was prepared in 3 repetitions, and the results were arithmetic means. The quality of analytical procedures was controlled by using internal samples with known values [7].

The obtained data were used to draw contour maps with isolines with indentical concentration levels for each of the measured elements in the soil. Isolines were produced with the "SURFER for Windows".

RESULTS AND DISCUSSION

The investigations revealed some variability of heavy metals and sulphur content in the soil of meadow biocenosis in the vicinity of the steelworks "Huta Katowice", both in time and space.

Cadmium

A natural cadmium content in the Polish soils is about 0.2 μg Cd/g. However, in the polluted sites it could reach a few hundred μg of Cd/g of soil [8,17]. In the arable soil, one of the sources of cadmium are phosphate fertilisers. The upper limit of Cd content in the arable soil is 3-5 μg Cd/g of soil [8].

In the surroundings of the "Huta Katowice", it was 3.44-15.68 μg Cd/g of soil (Fig. 2). Differences in the soil cadmium content in one place were up to about 60%. The highest cadmium content was found west of the Huta Katowice (Fig. 3).

Lead

A soil solution from a non-polluted area usually contains about 10 μg Pb/g of soil. Lead concentration in the upper layer of a soil profile is higher than natural in the range of industrial pollution or near motorways. It is so due to the low mobility of lead. Farmlands should not contain more than 100-500 μg Pb/g of soil-depending on the pH level and amount of organic matter [8].

The Pb content the in soil samples collected in consecutive study years differed by up to about 200% (Fig. 4). The most contaminated plots were situated east of the "Huta Katowice" (Fig. 5).

Copper

Copper concentration in Polish soils ranges from 0.2 to 725 μg Cu/g of soil. Soils from the western and southern regions contain more Cu than from other parts of Poland [17]. Copper is introduced to the soil with industrial emissions and with mineral fertilisers and other agricultural chemicals. It is cumulated in the upper soil layers and could be the reason for soil degradation. The safety level in the arable soil was estimated for 100 μg Cu/g of soil.

It was found that the Cu level in the investigated soil ranged from 1.7 to 6.7 μg Cu/g (Fig. 6). Differences between consecutive years were about 30%. The highest content of copper in the soil was found to the east of the "Huta Katowice" (Fig. 7).

Iron

In Poland the upper soil layer contains 0.32-1.07% of iron. Concentration of this metal in the soil solution ranges from 30 to 550 μg/g. Fe is one of the most mobile elements in the soil [8].

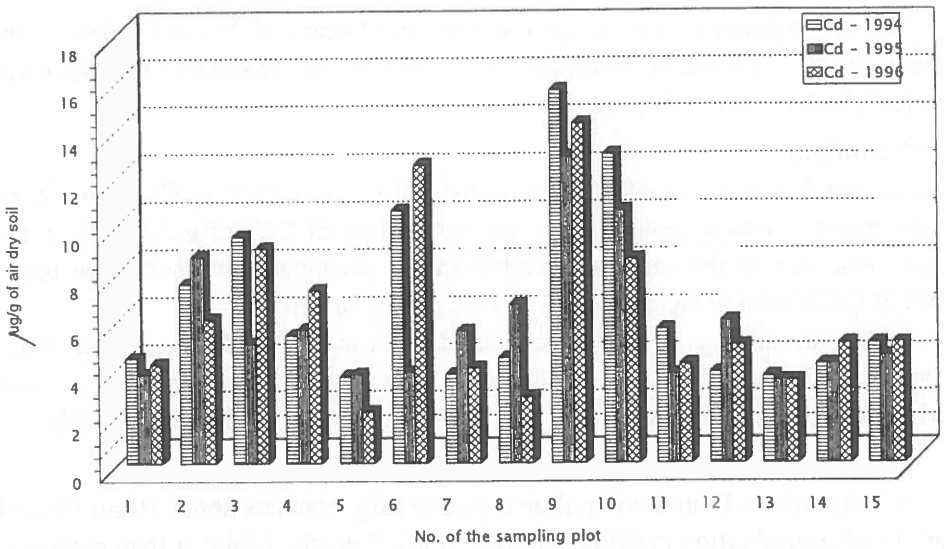

Fig. 2. Dynamics of cadmium content in soil of investigated plots during study period (µg Cd/g of air-dry soil).

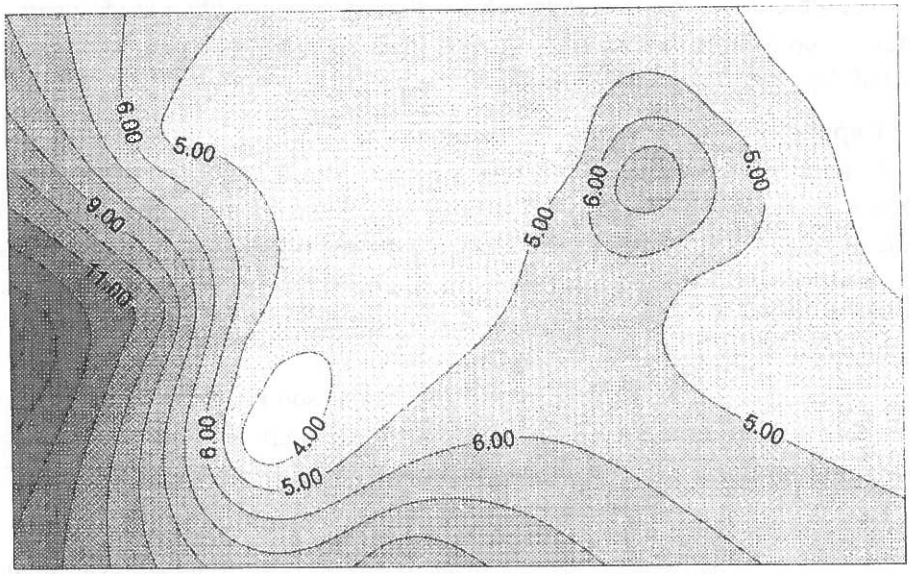

Fig. 3. Spatial variability of mean concentration of cadmium in the soil of investigated area.

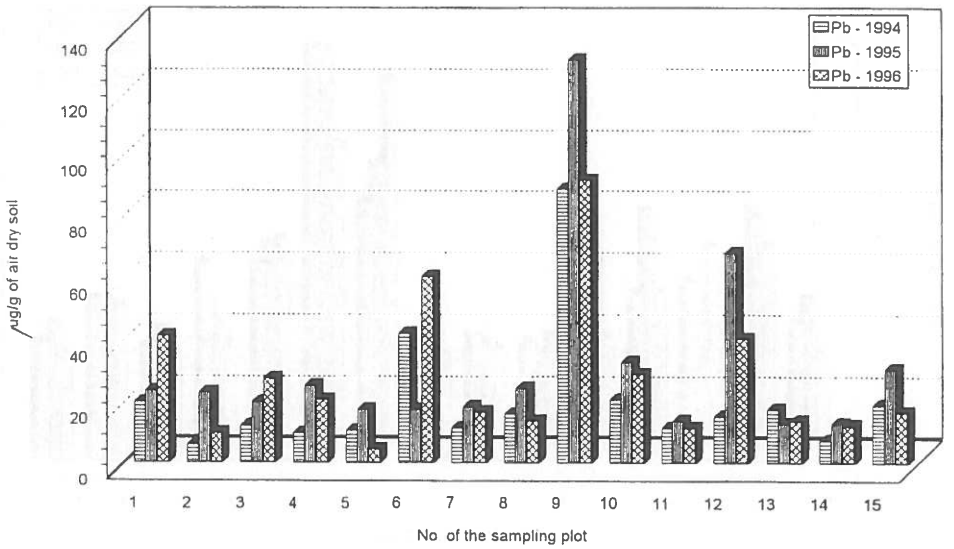

Fig. 4. Dynamics of lead content in soil of investigated plots during study period (µg Pb/g of air-dry soil).

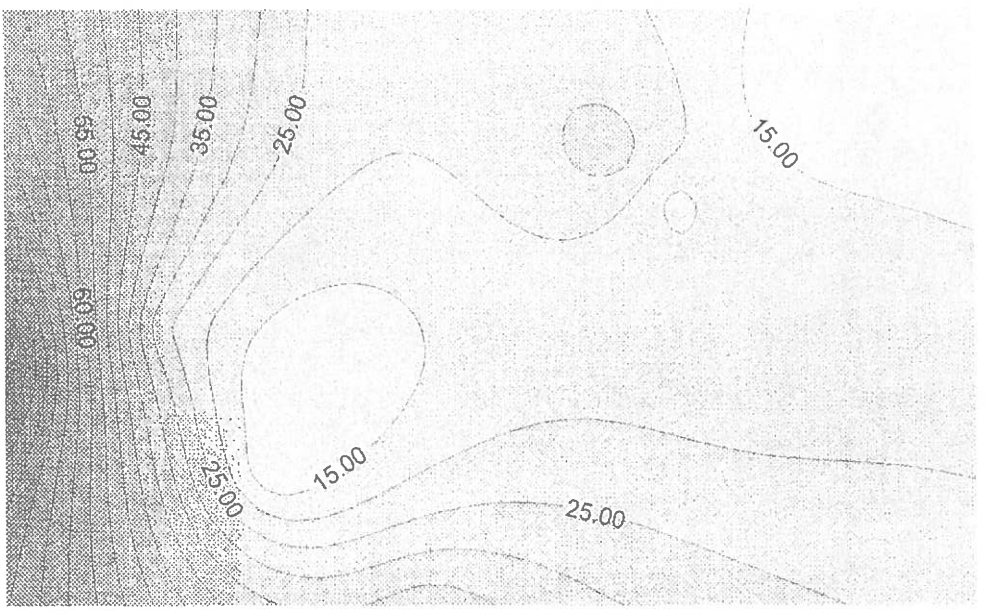

Fig. 5. Spatial variability of mean concentration of lead in the soil of investigated area.

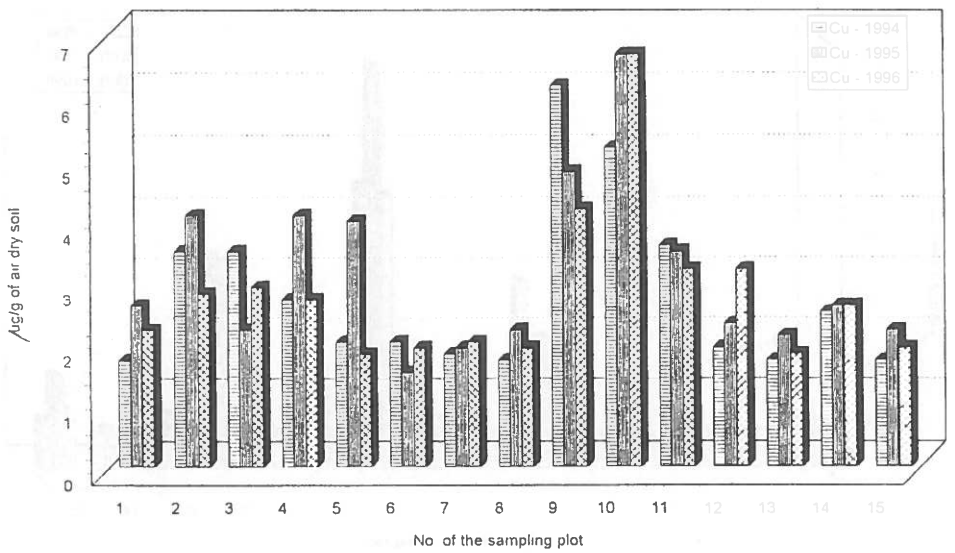

Fig. 6. Dynamics of copper content in soil of investigated plots during study period (µg Cu/g of air-dry

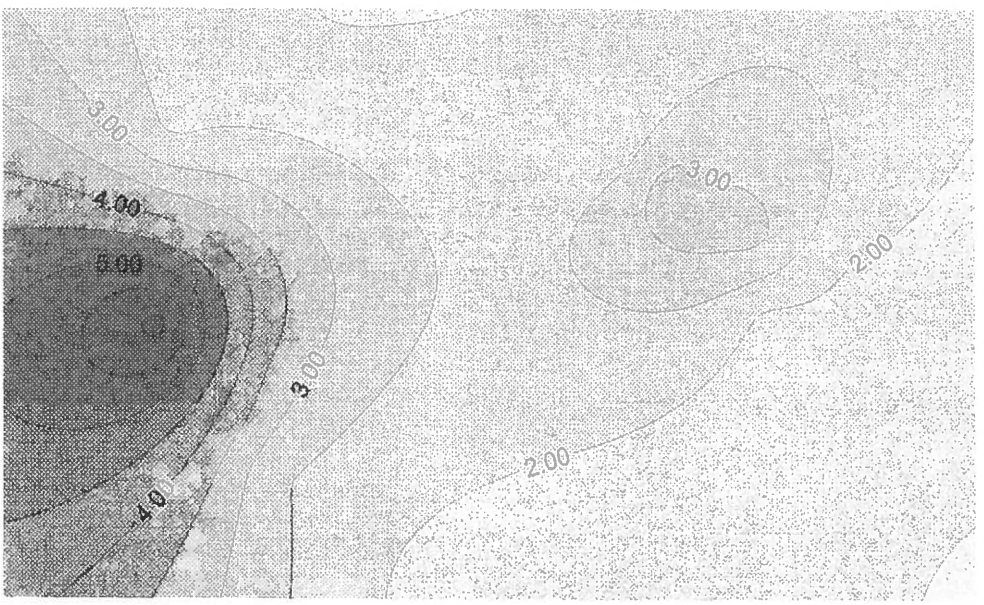

Fig. 7. Spatial variability of mean concentration of copper in the soil of investigated area.

Fe concentration in the soil of a meadow biocenosis in the surroundings of the "Huta Katowice" was different both between the sampling plots and consecutive years of sampling (Fig. 8). The highest Fe content was found in the soil from the sampling plots situated north-east of the steelworks (Fig. 9). A relatively low Fe concentration could result from high soil acidification.

Zinc

The average zinc concentration in the Polish soil is 33-725 μg Zn/g of soil, and ranges from 0.5 to 5750 μg/g of soil [4,17]. The admissible content of Zn in the arable soil is 250-300 μg/g [8].

Zn concentration in the investigated samples ranged from several to more than one thousand of Zn μg/g of soil (Fig. 10). Differences between consecutive years were lower than between sampling plots. The highest content of zinc in the soil was found south of the "Huta Katowice" (Fig. 11).

Sulphur

A natural sulphur concentration in the soil ranges from 10 to 18 000 μg S/g of soil. Usually, it is less than 2 000 μg/g of soil [10]. Sulphur comes to soil with acid depositions and could lower soil pH [9].

Sulphur content in the soil of the investigated area was differentiated in the consecutive years and sampling plots (Fig. 12). It ranged from 100-1370 μg S/g of soil. The highest sulphur content was found west and east of the steelworks "Huta Katowice" (Fig. 13).

Statistics

A non-parametric test of the Sperman's rank correlation showed that there are no statistically important relations between concentration of the investigated elements and accepted independent variables e.g., soil acidity, distance and direction from the emission centre (Table 1). The probable reason could be an impact of a contaminants mixture from the Upper Silesian Industrial Region, not only from the ivestigated steelworks.

Table 1. Spearman's correlation coefficient between mean concentration of the elements and the independent variables accepted

Variable	Mean pH	Distance	Direction
Cadmium	0.382	-0.161	0.262
Lead	0.207	-0.146	0.304
Copper	0.112	-0.332	0.052
Iron	0.008	-0.075	0.229
Zinc	0.366	-0.179	0.246
Sulphur	-0.266	-0.996	0.337

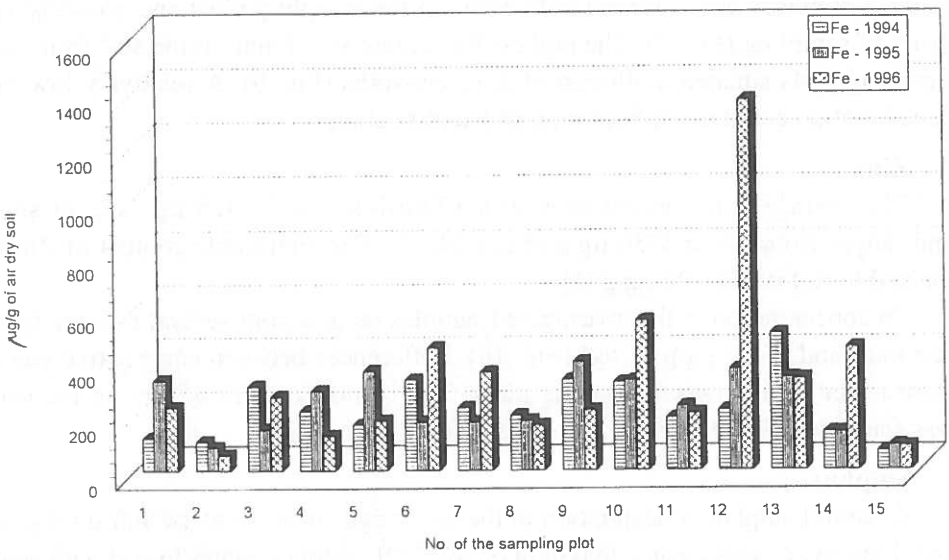

Fig. 8. Dynamics of iron content in soil of investigated plots during study period (µg Fe/g of air-dry soil).

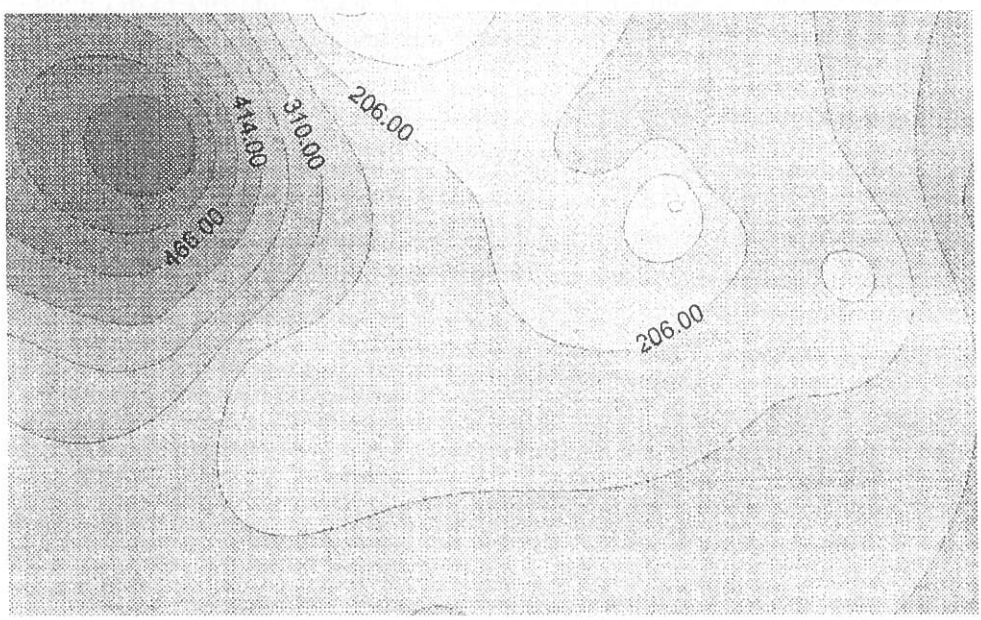

Fig. 9. Spatial variability of mean concentration of iron in the soil of investigated area.

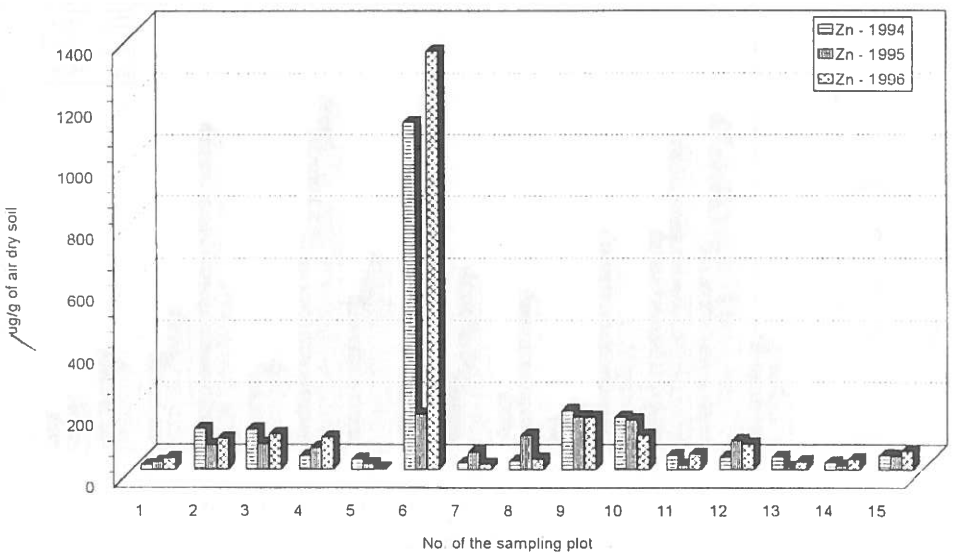

Fig. 10. Dynamics of zinc content in soil of investigated plots during study period (µg Zn/g of air-dry

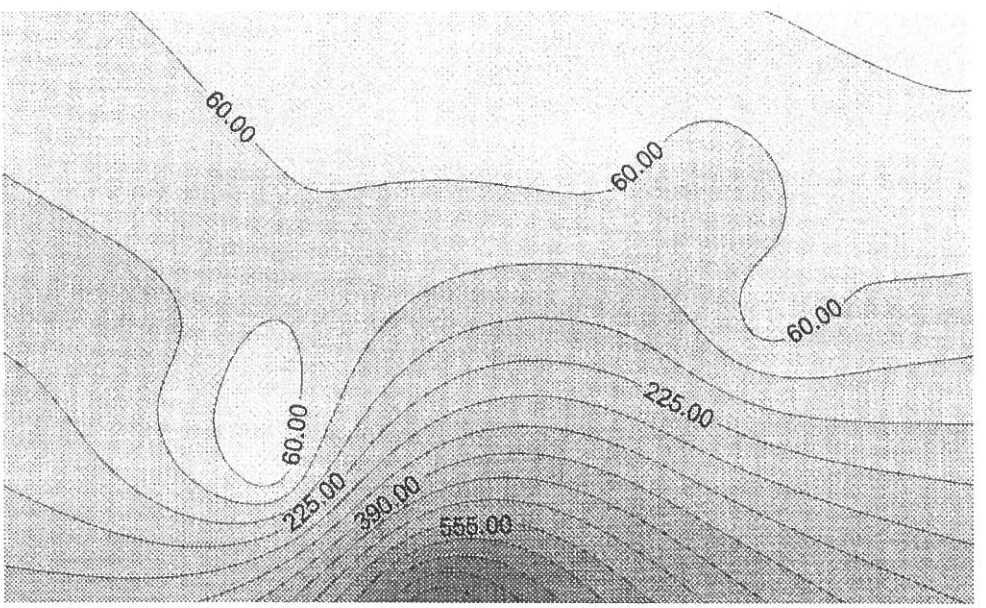

Fig. 11. Spatial variability of mean concentration of zinc in the soil of investigated area.

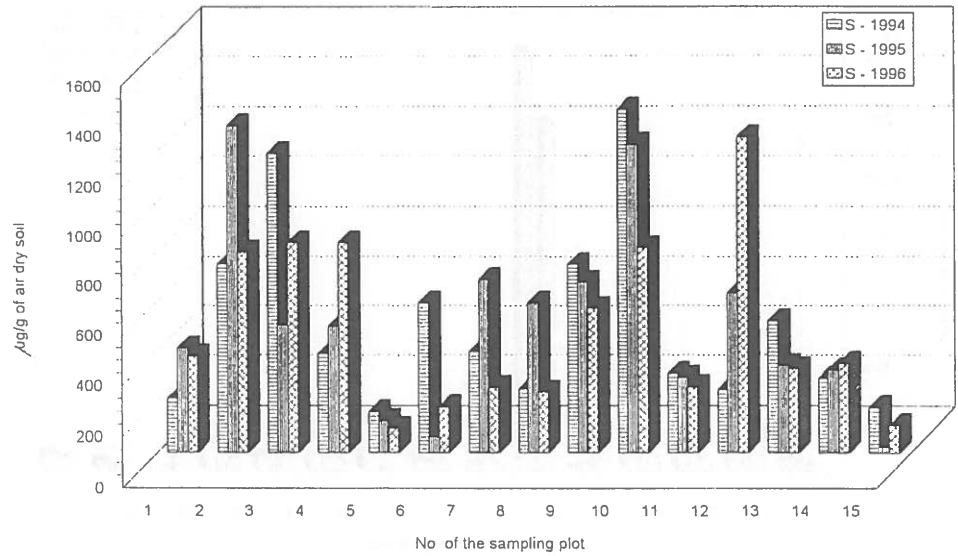

Fig. 12. Dynamics of sulphur content in soil of investigated plots during study period (µg S/g of air-dry

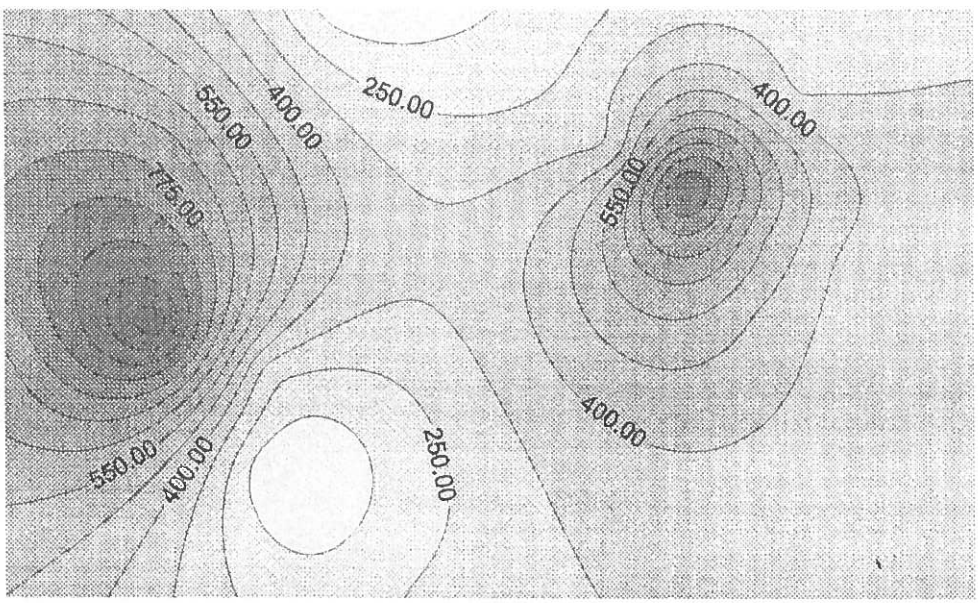

Fig. 13. Spatial variability of mean concentration of sulphur in the soil of investigated area.

CONCLUSIONS

Concentration of lead, copper, iron and sulphur in the soil of meadow ecosystems around the steelworks "Huta Katowice" was lower than the acceptable limits for an arable soil, except for cadmium and zinc, which were above the acceptable limits in some of the investigated samples. The highest content of the investigated elements was observed south and west of the steelworks. The area was contaminated both by the steelworks and other industry of the Upper Silesia.

REFERENCES

1. **Alloway B. J.:** Heavy Metals in Soils. (Ed.) Alloway B. J. Blackie, Glasgow & London, 1990.
2. **Barona A., Romero F.:** Water, Air, Soil Pollut., 95, 59-74, 194.
3. **Instytut Meteorologii i Gospodarki Wodnej.** Charakterystyka klimatologiczna województwa katowickiego, 1992.
4. **Ciepał R.:** Prace Nauk. Uniw. Śląskiego, Katowice, 1774, 1999.
5. **Ciepał R., Wysocka M.:** Acta Biol. Sil., 26/43, 52-61, 19941.
6. **Grodzińska K., Szarek G.:** Wiad. Botaniczne, 39, 1/2, 31-38, 1995.
7. **Houba V. J. G., Novozamsky I., Van Der Lee J. J.:** Comm. Soil Sci. Plant Anal., 27(3/4),,327-348, 1996.
8. **Kabata-Pendias A., Pendias H.:** Biogeochemia pierwiastków śladowych. Wyd. PWN, Warszawa, 1999.
9. **Kaczor A.:** Roczn. Glebozn., 45, 3/4, 43-58, 1994.
10. **Lityński T., Jurkowska H.:** Żyzność gleb i odżywianie się roślin. Wyd. PWN, Warszawa, 1982.
11. **Mukherjee A.B., Nuorteva P.:** Sci. Total Env., 151, 191-204, 1994.
12. **Ostrowska A., Gawliński S., Szczubiałka Z.:** Metody analizy i oceny właściwości gleb i roślin. Wyd. IOŚ, Warszawa, 1991.
13. **Pilgrim W., Hughes R.N.:** Env. Monit. Assessm., 32, 1-20, 1994.
14. **Ross S.M.:** (Ed.) Toxic Metals in Soil - Plant Systems. Wiley & Sons Ltd. Chichester, New York, Brisbane, Toronto, Singapore, 1994.
15. **Saalbach E., Kessen G., Judel G.K.:** Z. Pflanz. Dung. Bodenkunde, 93, 17-26, 1961.
16. **Strzyszcz Z.:** Arch. Ochr. Środ., 1, 149-159, 1981.
17. **Terelak H., Stuczyński T., Motowicka-Terelak T., Piotrowska M.:** Arch. Ochr. Środ., 23/3-4, 167-180, 1997.