

Abstract

The aim of the study was to assess the contamination with selected heavy metals in arable soils of the Odra river floodplain. In soil samples collected in the autumn of 2020 - after the vegetation period of plants from designated measurement points, heavy metals were determined: Mn, Fe, Cu, Zn, Ni, Cd and Pb. The concentration of analytes was measured with the use of an atomic absorption spectrometer (F-ASA). On the basis of the conducted research, a comparison was made of the concentrations of the determined heavy metals in soil samples taken from the areas flooded in 1997 and from the areas flooded as a result of rainfall, snowmelt and winter floods. The test results were compared with the data for soils collected from non-flooded areas. The obtained research results indicate that floods are a source of heavy metals introduced into arable soils.

Keywords: soil, floodplains, Odra river, heavy metals, atomic absorption spectrometry

Materials and methods

Soil samples for the study were collected in the autumn season of 2020 after the vegetation period of the plants. The material was collected from four areas, each with 6 samples of topsoil (Fig. 1). Study area no. I (Czepielowice village, Lubsza commune) is the area which was flooded in the so-called flood of the millennium in Poland in 1997. Soil collected from area no. II (Nowe Kolnie, Lubsza commune) was regularly flooded during rainfall, snowmelt and winter floods. Study site III (Kurznie, Popielow commune) was not affected by floods. Area IV (Kościarzyce, commune of Lubsza) is located in the direct vicinity of the Odra river.

Representative (averaged) soil samples of 0.500 ± 0.001 g d.m. (d.m. - dry mass) were mineralised in a mixture of nitric acid (V) and perhydrol (HNO_3 65 % : H_2O_2 30 % = 3:1) in a Speedwave Four microwave mineraliser from Berghof, DE. The mineralisation process was carried out at 180° C. Solutions were prepared using MERCK reagents. Heavy metals (Mn, Fe, Ni, Cu, Zn, Cd and Pb) in mineralised samples were determined by atomic absorption spectrometry (AAS) using an iCE 3500 instrument from Thermo Electron Corporation (USA). The calibration of the apparatus was performed using standards from ANALYTIKA Ltd. (CZ).

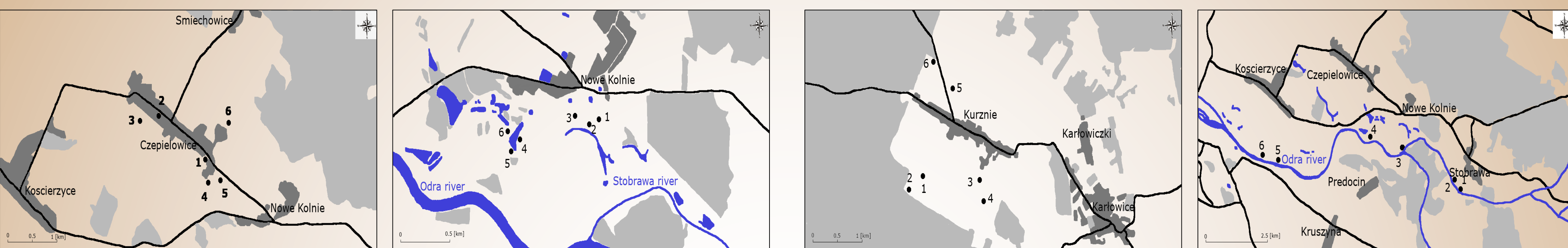


Fig. 1. Study area no. I (Czepielowice village, Lubsza commune), area II (Nowe Kolnie, Lubsza commune), area III (Kurznie, Popielow commune), area IV (Kościarzyce, commune of Lubsza) (from left to right)



Fig. 2. Speedwave Four Berghoff (DE), microwave oven



Fig. 3. F-AAS, iCE 3500 Thermo Electron Corporation (USA)

Results

Table 1. Values of min., max., standard deviation of concentrations of selected analytes determined in soil samples [mg/kg d.m.] and value of coefficient of variation CV[%]

Parameter	Mn	Fe	Ni	Cu	Zn	Cd	Pb
I Czepielowice, commune of Lubsza, Voivodeship Opolskie							
Min.	213	9657	2.62	7.67	38.9	< 0.65	20.3
Median	518	11644	5.25	10.51	56.9	0.94	25.2
Max.	964	13931	10.2	20.2	167	1.15	40.6
±SD	250	1801	2.63	5.00	49.7	-	7.00
CV	45.4	15.3	48.7	40.1	62.3	-	25.7
II Nowe Kolnie, commune of Lubsza, Voivodeship Opolskie							
Min.	1391	41409	37.4	68.0	861	4.25	200
Median	1653	49867	45.2	87.1	1151	5.35	218
Max.	1861	51417	47.3	107	1575	6.80	229
±SD	191	4180	3.60	15.2	269	1.02	10.0
CV	11.5	8.73	8.17	17.1	22.1	18.4	4.55
III Kurznie, Popielow Commune, Opole Voivodeship							
Min.	376	6661	<2.50	5.20	37.4	< 0.65	21.1
Median	482	7500	<3.35	7.33	51.8	<0.75	28.4
Max.	757	12318	7.05	11.8	74.0	1.15	31.8
±SD	135	2179	-	2.48	13.7	-	3.90
CV	26.9	26.0	-	31.2	25.4	-	14.3
IV Kościarzyce, commune of Lubsza, opolskie voivodeship							
Min.	413	18784	17.7	19.1	211	1.66	43.9
Median	720	21137	19.7	35.7	543	2.51	103
Max.	1270	43513	46.4	92.5	1534	6.88	172
±SD	302	9927	11.6	28.1	494	2.01	50.0
CV	38.3	38.1	45.2	62.5	71.2	61.1	47.2

- not calculated

Conclusions

Heavy metals include both elements essential for living organisms and elements with as yet unknown physiological roles. Their common feature is that even those which are essential in trace amounts have a toxic effect on plants and animals when the permissible dose is exceeded. The most toxic metals are cadmium, mercury and lead.

Soil sampled from all sampling points located in the village of Nowe Kolnie, commune of Lubsza and from two sampling points located in the village of Kościarzyce, commune of Lubsza, was characterized by exceeding permissible, according to the Regulation of the Minister of Environment on soil and land quality standards, amounting for soil group B concentrations of Zn, Cd and Pb. According to our research, their sources in soils used for agricultural purposes are among others the processes of frequent flooding as a result of periodic floods as well as enrichment by river flood waters.

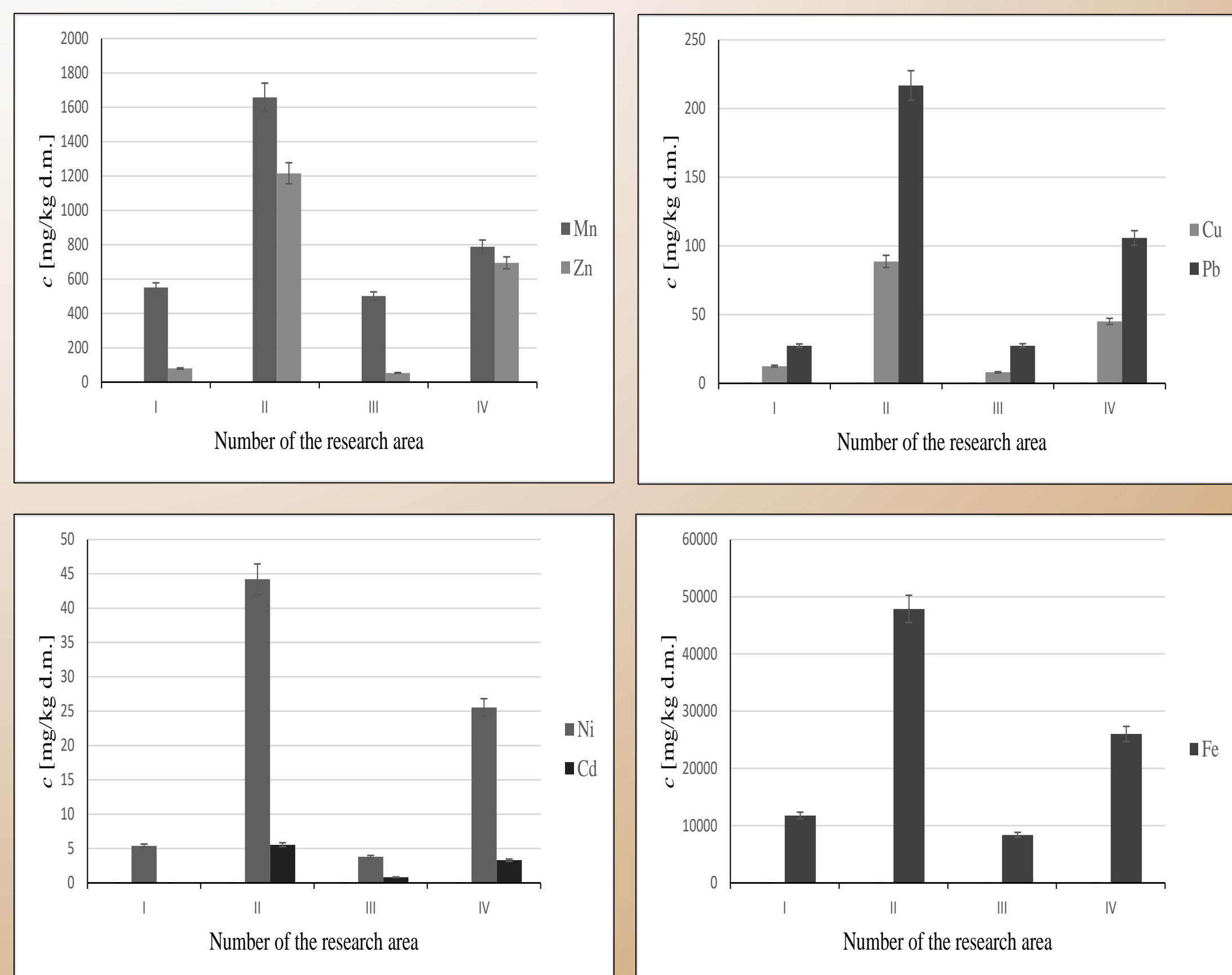


Fig. 4. Mean values of heavy metal concentrations determined in soil samples taken from the four study sites