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OVERVIEW OF THE QUALITY CRITERIA FOR SOIL IN THE EAST EUROPEAN COUNTRIES

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Abstract. The paper discusses criteria introduced into the several East European countries legislations concerning soil quality. The connected guideline values vary in a very broad range, combining scientific recommendations and common experience. Some soil standards are integrated and designed to protect both soil and drinking water quality. Soil guidelines certificate different contamination levels in different countries for the same hazardous elements and the same types of the land-use sites. All the applied criteria have been critically reviewed, and specific legal requirements enforced in particular countries presented.

Key words: east European countries, hazardous elements, soil quality requirements.

Abstrakt: W artykule przedstawiono kryteria określające jakość gleb, stosowane w krajach wschodnioeuropejskich. Odpowiednie wymogi różnią się w tych krajach w bardzo szerokim zakresie, chociaż wszystkie opierają się na naukowych podstawach oraz na praktycznym doświadczeniu. Niektóre standardy glebowe powiązane są z wymogami stawianymi wodom pitnym, chroniąc przed zanieczyszczeniem obydwa te środowiska. Przepisy stosowane w poszczególnych krajach dopuszczają jednak różne zawartości w glebach tych samych zanieczyszczających składników. Wszystkie kryteria dotyczące jakości gleb, stosowane w poszczególnych krajach wschodniej Europy, zostały w artykule dość szczegółowo przedstawione i krytycznie ocenione.

S³owa kluczowe: państwa wschodnio-europejskie, składniki niebezpieczne dla gleb, wymogi dotyczące jakości gleb.

INTRODUCTION

Guideline values are popular tools to characterize soils and contaminated land because of simple handling and comparison for legislation, partners, and the analytical laboratories. However, there are evident problems with derivation and use of guideline values depending on:

- general principles of deriving soil guideline values: site acceptance for particular purposes (agriculture, residence, uptake of drinking water); risk assessment of site for plants, animals, human or drinking water (exposure pathway is taken into account); sustainable soil quality;
- analytical dilemma: total contents (so-called totals); aqua regia contents; "bio-available" contents;
- soil variety and in-homogeneity: ratio of fine and coarse grained particles; amount of organic/humus matter; soil pH;
- specificity of hazardous compounds: synergy; effect of the exposure time;
- regulations for the particular levels of contamination: required actions (change of the land-use, remediation *in situ*, soil conservation out-site); who will pay; official supervision of the actions.

The soil guideline values in the East and Central European countries combine both authoritative science and policy judgements, and vary in a very broad range (Table 1). Terms and definitions denotative of soil guideline values for heavy metals are also different in soil standards of the individual country:

- *limit values* in Estonia and Poland;
- *critical concentration values* in Slovenia;
- *allowable standard* and *prevention value* in Bulgaria;
- *threshold* and *intervention values* in Romania;
- *pollution limit, intervention limit,* and *remediation limit value*s in Hungary;

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T a b l e 1

Summary of soil standards valid in the East European countries

Country	Land-used based values	Methods of analyses	Soil texture based values	Soil reaction based values	Contamination levels
Bulgaria [1]*		aqua regia contents	Heavy metals prevention values for: – fine – medium – coarse – soil with natural high background values	12 levels of allowable values for heavy metals, based on pH (H_2O 1:2.5)	– reference – prevention – permissible – intervention values for organogenic contaminants
Czech Republic [2]	– agricultural – residential (C) – recreational(C) – industrial(C) – general(C)	– 2 M HNO_3 – total contents	Heavy metals maximum permissible values in agricultural soil: – light soils – other soils		– reference (A) – risk (B) values for heavy metals
Estonia [3] (cancelled)	– residential – industrial	aqua regia contents			– guidance – limit values
Hungary [4]	in agricultural and residential areas, only	total contents			– background – demonstrated (local) background – pollution – intervention – remediation values
Lithuania [5]	in agricultural, residential, and recreation areas, only	total contents	Heavy metals reference values for: – fine soil – coarse soil		– permissible – medium dangerous – dangerous – extremely dangerous according to the total contamination index Z_s
Poland [6]	in agricultural areas, only		– light (coarse) soil – medium soil – fine and organic soil in combination with soil reaction	– acid (4.5–5.5) – sub-acid, neutral (5.5–6.5, >6.5) soil in combination with soil texture)	– reference – threshold – low contamination – medium contamination – high contamination – extremely high contamination values
Romania [7]		1M HCl, HCl+HNO_3			– reference – alert sensitive – alert less sensitive – intervention sensitive – intervention less sensitive levels
Russian Federation [8, 9, 10]		– total contents – water extractable contents (F) – "bio-available" contents NH_4NO_3	Heavy metals optional allowable concentrations: – sand soil – sandy loam in combination with soil reaction	Heavy metals optional allowable concentrations: – acid soil (<5.5) – sub-acid (>5.5)	In agricultural and urban areas: – permissible – medium dangerous – dangerous – extremely dangerous according to the total contamination index Z_s
Serbia Republic [11]		total contents?			maximum permissible
Montenegro Republic [12]		total contents?			maximum permissible
Slovak Republic [13]		– total contents – 2 M HNO_3			– reference – reference (HNO_3) – indicative – sanitary indicative the highest admissible concentrations
Slovenia [14]		total contents			– limit value – warning value – critical value

[1]* – number in the list of References

– *the highest admissible concentration* in Slovak Republic;
– *maximum permissible limits* in Czech Republic;
– *maximum permissible concentrations* in Russian Federation, Lithuania, Republic of Serbia and Montenegro;
– *optional permissible concentrations* in Russian Federation.

Format of the most soil standards is obligatory, and recommendatory values are set in Bulgaria (prevention values), Russian Federation (optional permissible concentrations), and in the non-agricultural areas of Czech Republic (contamination criteria). Reference (background) values are given in soil standards of many countries (Bulgaria, Estonia, Hungary, Lithuania, Romania, and Slovak Republic), too.

REVIEW OF SOIL STANDARDS

Various principles were at the base of soil guideline values in different countries. Soil standards in Bulgaria are based on the soil reaction mainly, where several pH-bound grades of maximum permissible Pb, Cu, Zn, Cd, Ni, Cr, Hg, and As concentrations are derived from (Tables 2 and 3). Analytical methods of elements determinations are following the international standard ISO 11466 (aqua regia leach). Bulgarian soil standards were appended in 2002 by heavy metals prevention values, and for their preparation, soil textures were taken into account, too (Table 4).

In Czech Republic**,** the quality of the cultivated soil in the arable lands, gardens, orchards, meadows, and pastures is under control of the Ministry of Environment Decree No. 13/1993 [2]. Obligatory maximum permissible limits are based partly on the soil texture. They are applicable to sandy and sandy-loamy soils, and other soils separately, but do not apply to the organic one (Table 5). The maximum permissible limits are applied to mixed soil samples taken from 0.25 m top soil layer and analysed for the total contents or derived by the 2 M

Table 2

Norm of allowable values for lead, copper, and zinc in accordance with soil reaction (pH) in water suspension, year 1979 [1]

No.	Soil pH in water suspension (1:2.5)	Allowable value [mg/1 kg of soil]		
		lead	copper	zinc
1	3.5	<20	<15	<20
2	4.0	<25	<20	<30
3	4.5	<30	<25	<40
4	5.0	<40	<40	<60
5	5.5	<50	<60	<90
6	5.7	<60	<80	<110
7	6.0	<70	<120	<200
8	6.2	<75	<230	<300
9	6.5	<80	<250	<320
10	7.0	<80	<260	<340
11	7.5	<80	<270	<360
12	8.0	<80	<280	<370

Norm of allowable values for arsenic is < 25 mg per 1 kg of soil

Table 3

Norm of allowable values for cadmium, nickel, chromium, and mercury in accordance with soil reaction (pH) in water suspension, completed in year 1997 [1]

pH	Cd	Ni	Cr	Hg
pH ≥ 4	0.4	25	150	1
pH ≥ 5	0.8	35	170	1
pH ≥ 5.5	1.0	50	180	1
pH ≥ 6	1.5	60	190	1
pH ≥ 7	3.0	70	200	1

Table 4

Prevention values for heavy metals and metalloids in soil, if soil pH ≤ 6 (mg/kg dry matter) supplemented in year 2002 [1]

Soil	Element								
	As	Cd	Cu	Cr	Ni	Pb	Zn	Hg	Co
Background values *	10	0.4	34	65	46	26	88	0.03	20
Clay soil	20	1	70	130	90	50	180	0.08	40
Sandy clay soil	15	0.8	60	110	80	45	160	0.07	35
Clay sand ad sand soil	15	0.6	50	90	60	40	110	0.05	30
Soil naturally enriched with heavy metals	set on the base of local background values								

* – background values calculated by statistical methods on the data set below 90 percentile

HNO_3 extraction. The recommended contamination criteria for soil from other sites are listed in a Methodological Guide *Soil and Groundwater Contamination Criteria of the Ministry of Environment of the Czech Republic* (Table 6). The criteria (total contents) are based on the land-use type: different values (C-criteria) of heavy metals and hazardous hydrocarbons are set for residential, recreational, industrial, and general areas. Reference value (A-criteria) and risk value (B-criteria) which is more or less an arithmetical mean of A and C criteria are introduced by the Methodological Guide, too.

Estonia has also developed a soil standard to protect both soil and groundwater [3]. The standard has been valid since 1999, and was cancelled after Estonia joined EU. Guidance (reference) value and separate limit values (total contents) for soil in living and industrial areas as well as for groundwater were derived for heavy metals, inorganic compounds, PAHs,

Table 5

Hazardous elements (metals) in soils falling into the agricultural land fund [2]

Elements	Concentration of hazardous elements in soils [mg/kg]			
	extracted by 2 M HNO_3		total concentration	
	maximum permissible limits		maximum permissible limits	
	light soils	other soils	light soils	other soils
As	4.5	4.5	30	30
Be	2	2	7	7
Cd	0.4	1	0.4	1
Co	10	25	25	50
Cr	40	40	100	200
Cu	30	50	60	100
Hg	–	–	0,6	0,8
Mo	5	5	5	5
Ni	15	25	60	80
Pb	50	70	100	140
V	20	50	150	220
Zn	50	100	130	200

Table 6

Soil contamination criteria from Methodological Guide of the Ministry of Environment of the Czech Republic, August 1996 [2]

Elements	A	B	C-residential	C-recreational	C-industrial	C-general
	Metals (total content) [mg/kg]					
As	30	65	70	100	140	55
Be	5	15	20	25	30	
Cd	0.5	10	20	25	30	12
Co	25	180	300	350	450	240
Cr (total)	130	450	500	800	1000	380
Cu	70	500	600	1000	1500	190
Hg	0.4	2.5	10	15	20	10
Ni	60	180	250	300	500	210
Pb	80	250	300	500	800	300
V	180	340	450	500	550	
Zn	150	1500	2500	3000	5000	720

Table 7

Limit values of dangerous substances in groundwater and soil [3]

No.	Dangerous substance	Limit values in soil [mg/kg]			Limit values in groundwater [µg/l]	
		Guidance value	Limit value in living area	Limit value in industrial area	Guidance value	Limit value
1	Mercury (Hg)	0.5	2	10	0.4	2
2	Cadmium (Cd)	1	5	20	1	10
3	Lead (Pb)	50	300	600	10	200
4	Zinc (Zn)	200	500	1500	50	5000
5	Nickel (Ni)	50	150	500	10	200
6	Chromium (Cr)	100	300	800	10	200
7	Copper (Cu)	100	150	500	15	1000
8	Cobalt (Co)	20	50	300	5	300
9	Molybdenum (Mo)	10	20	200	5	70
10	Tin (Sn)	10	50	300	3	150
11	Barium (Ba)	500	750	2000	50	7000
12	Selenium (Se)	1	5	20	5	50
13	Vanadium (V)	50	300	1000	–	–
14	Antimony (Sb)	10	20	100	–	–
15	Thallium (Tl)	1	5	20	–	–
16	Beryllium (Be)	2	10	50	–	–
17	Uranium (U)	20	50	500	–	–

and pesticides (Table 7). The regulatory papers of Bulgaria, Czech Republic, and Estonia do not provide for requirements on particular actions in the contaminated soil.

Experts of the Institute of Soil Science and Plant Cultivation in Poland have constructed soil standard for agricultural soil based on both soil reaction and soil texture [6]. Soil was divided into three groups according to the following combinations of the pH_{KCl} values and soil texture:

a) the whole "very light" soils with fine fraction <10%, and "light" soil with fine fraction 10–20% and acid / sub-acid pH 4.5–6.5;
b) "light soil" with fine fraction 10–20% and neutral pH >6.5, soil with fine fraction 20–35% and acid pH <4.5–5.5, and the whole minerogenic-organogenic soils with 6–10% of organic matter;
c) "medium heavy soil" with fine fraction 20–35%, "heavy soil" with fine fraction >35% with sub-acid pH 5.5–6.5 or neutral pH >6.5, and minerogenic-organogenic soil with >10% of organic matter.

Six levels of soil contamination were established (Table 8):

0 – natural value;
I – increased value;
II – slight contamination;
III – moderate contamination;
IV – strong contamination;
V – very strong contamination.

The required actions were determined for each contamination level:

0 – no restrictions;
I – restricted cultivation of plants for children food;
II – restricted cultivation of some "kitchen-garden" vegetables (lettuce, cauliflower, spinach);
III – heavy metal contents in cultivated tuber; grain and green crops must be under control; cultivation of technical and legume crops allowed;
IV – light soil must be re-cultivated with the use of lime and addition of organic matter or be afforested; fertile soil could be used for technical crops cultivation (flax, willow for wattle, hemp, potatoes for spirit, rape for technical oil);
V – land can not be used for agriculture.

Soil standards of the most East-European countries were developed on the basis of the protection of either human health or ecological receptors, and on the assessed site condition. A three limit values were set by a Government Decree (10/2000) of Hungary on the limit values necessary to protect the quality of groundwater and geological medium [4]. Total background concentrations (A), pollution limit values (B), intervention pollution limit values for the areas: especially sensitive (C_1), sensitive (C_2), and less sensitive (C_3), were provided in the regulation (Table 9). Remediation limit values of pollution (D) could be prescribed in the official ruling under a remediation procedure, on the basis of a complex assessment involving the distribution of the risk substance among the environment elements, the measurements, or model investigations on the risky substances behaviour and spreading, the quantitative risk analyses, and the land use. The required actions for the exceeded intervention limit values depend in each case on the competent environmental authority (inspectorate).

Soil standard of Romania defines the threshold and intervention values in soil of sensitive and less sensitive areas [7]. Reference (background) values are included in the standard, too (Table 10). The appropriate actions are prescribed for the exceeded intervention values at each level of contamination of the both areas.

Table 8

Limit values of trace metals [mg/kg] in topsoil (0–20 cm) of arable land indicative of different level of contamination [6]

Metals	Soil group	Level of soil contamination					
		0	I	II	III	IV	V
Lead (Pb)	a	30	70	100	500	2500	>2500
	b	50	100	250	1000	5000	>5000
	c	70	200	500	2000	7000	>7000
Zinc (Zn)	a	50	100	300	700	3000	>3000
	b	70	200	500	1500	5000	>5000
	c	100	300	1000	3000	8000	>8000
Copper (Cu)	a	15	30	50	150	750	>750
	b	25	50	80	100	500	>500
	c	40	70	100	150	750	>750
Nickel (Ni)	a	10	30	50	100	400	>400
	b	25	50	75	150	600	>600
	c	50	75	100	300	1000	>1000
Cadmium (Cd)	a	0.3	1.0	2	3	5	>5
	b	0.5	1.5	3	5	10	>10
	c	1.0	3.0	5	10	20	>20

Table 9

Background concentrations (A) and limit values by groups of compounds for soils and geological medium (mg/kg dry substance) [4]

CAS	No.	A	B	C_1	C_2	C_3
7440-47-3	Cr total	30	75	150	400	80
	Cr VI	*k	1	2.5	5	10
7440-48-4	Co	15	30	100	200	300
7440-02-0	Ni	25	40	150	200	250
7440-50-8	Cu	30	75	200	300	400
7440-66-6	Zn	100	200	500	1000	2000
7440-38-2	As	10	15	20	40	60
7782-49-2	Se	0.6	1	5	10	20
7439-98-7	Mo	3	7	20	50	100
7440-43-9	Cd	0.5	1	2	5	10
7440-31-5	Sn	5	30	50	100	300
7440-39-3	Ba	150	250	300	500	700
7439-97-8	Hg	0.15	0.5	1	3	10
7439-92-1	Pb	25	100	150	500	600
7440-22-4	Ag	0.3	2	10	20	40

*k – detection limit

Table 10

Limit values of chemical elements in soil, inorganic compounds (mg/kg dry substance) [7]

Metals	Reference value (totals)	Threshold value for sensitive areas	Threshold value for less sensitive areas	Intervention value for sensitive areas	Intervention value for less sensitive areas
Sb	5	12.5	20	20	40
Ag	2	10	20	20	40
As	5	15	25	25	50
Ba	200	400	1000	625	2000
Be	1	2	7.5	5	15
B	1	2	5	3	10
Cd	1	3	5	5	10
Co	15	30	100	50	250
Cr_{total}	30	100	300	300	600
$Cr_{hexavalent}$	1	4	10	10	20
Cu	20	100	250	200	500
Mn	900	1500	2000	2500	4000
Hg	0.1	1	4	2	10
Mo	2	5	15	10	40
Ni	20	75	200	150	500
Pb	20	50	250	100	1.000
Se	1	3	10	5	20
Sn	20	35	100	50	300
Tl	0.1	0.5	2	2	5
V	50	100	200	200	400
Zn	100	300	700	600	1500

A Government Decree of Slovenia of the 1996 year defined the limit of the specific dangerous substances in soil, as well as their warning and critical concentration values (total contents), except for radioactive substances, and throughout the entire territory of the Republic regardless of the soil composition or type of it use (Table 11) [14]. Cultivation of plants intended for human or animal consumption, and water retaining or filtering is prohibited in areas of critical concentration values. Warning values indicate in certain soil use types the probability of damaging effects or influence on human health or the environment. At the limit values, their effects and influence on human health or the environment are still acceptable.

Table 11

Limit, warning, and critical concentration of dangerous substances in soil (mg/kg dry soil) [14]

Dangerous substance	Limit value	Warning value	Critical value
Metals extracted by aqua regia (except for Cr^{6+})			
Cadmium and its compounds, expressed as Cd	1	2	12
Copper and its compounds, expressed as Cu	60	100	300
Nickel and its compounds, expressed as Ni	50	70	210
Lead and its compounds, expressed as Pb	85	100	530
Zinc and its compounds, expressed as Zn	200	300	720
Total chromium Cr	100	150	380
Six valent chromium Cr^{6+}			25
Mercury and its compounds, expressed as Hg	0.8	2	10
Cobalt and its compounds, expressed as Co	20	50	240
Molybdenum and its compounds, expressed as Mo	10	40	200
Arsenic and its compounds, expressed as As	20	30	55

Table 12

The highest admissible concentration of pollutants in soil (mg/kg dry matter) [13]

Metals	A	A_1	B	C
As	29	5.0	30	50
Ba	500	x	1 000	2 000
Be	3	x	20	30
Cd	0.8	0.3	5	20
Co	20	x	50	300
Cr	130	10.0	250	800
Cu	36	20.0	100	500
Hg	0.3	x	2	10
Mo	1	x	40	200
Ni	35	10.0	100	500
Pb	85	30.0	150	600
Se	0.8	x	5	20
Sn	20	x	50	300
V	120	x	200	500
Zn	140	40.0	500	3 000

Risk element contents in agricultural soil of Slovakia are set by a Resolution of Ministry of Agriculture [13]. The reference values (A) in total content and in 2 M HNO_3 extract (A_1) are presented in the Slovak Republic standards as well as the indicative (B) and sanitary indicative (C) values (Table 12). The indicative value (B) means that the soil contamination was analytically checked, but further study and contaminated site control is required when the cause, area, and contamination can have negative impacts on human health or on other environmental components. If the substance concentration is equal or greater than sanitary indicative value (C), the immediate analytical mapping of the pollution extent in the referred site is required with follow-up proposal for decontamination. Similar procedures should be followed when values were within the B or C ranges.

Republic of Serbia and Montenegro developed separate soil standards for both republics. Maximum permissible values in soil and waste-water are existing in Serbia Republic with the intention to protect soil as a habitat, taking into account a potential use of surface and groundwater (Table 13) [11]. Maximum permissible values for the same list of hazardous elements are obligatory in Republic Montenegro but only for soil, and with particular consideration for areas close to industrial, mining, and waste and sludge deposits sites (Table 14) [12].

Soil standards of Russian Federation are of complex structure [9]. The obligatory maximum permissible concentrations (MPC) related to background values are provided for water soluble F, bio available Cu, Ni, Zn, Co, Cr, and F, and total Sb, Mn, V, As, Hg, Pb, Pb+Hg, Cu, Ni, and Zn in all soils (Table 15). A contaminants synergy is pointed out by lower MPC for lead and attendant mercury. The translocation MPC intends to protect soils against pollution spreading through the soil-to-plant pathway, and migration MPC – through the soil-to-water pathway. The purpose of the establishment of sanitary MPC is protection of soil ecology and prevention of the micro organisms migration through soil-to-soil pathway. A peculiar soil total contamination index Z_s is also used for the estimation of soil contamination level in Russian soil guidelines.

Table 13

The maximum permissible values (MPV) of hazardous elements in soil and waste-water (mg/kg and mg/l) [11]

No.	Element	MPV in soil [mg/kg]	MPV in waste-water [mg/l]
1	Cd	<3	<0.01
2	Pb	<100	<0.1
3	Hg	<2	<0.001
4	As	<25	<0.05
5	Cr	<100	<0.5
6	Ni	<50	<0.1
7	F	<300	<1.5
8	Cu	<100	<0.1
9	Zn	<300	<1.0
10	B	<50	<1.0

Table 14

The maximum permissible values (MPV) of hazardous elements in soil [mg/kg] [12]

No.	Element	MPV in soil [mg/kg]
1	Cd	2
2	Pb	50
3	Hg	1.5
4	As	20
5	Cr	50
6	Ni	50
7	F	300
8	Cu	100
9	Zn	300
10	B	5
11	Co	50
12	Mo	10

Table 15

The maximum permissible concentrations (MPC) of chemical elements in soil and their permissible levels according to hazard index, valid since 1991 [9]

Substance	MPC related to the background [mg/kg]	Hazard index		
		Translocation	Water migration	Sanitary
Water soluble content				
F	10.0	10.0	10.0	10.0
Bioavailable content				
Cu[1]	3.0	3.5	72.0	3.0
Ni[1]	4.0	6.7	14.0	4.0
Zn[1]	23.0	23.0	200.0	37.0
Co[2]	5.0	25.0	>1000	5.0
F[3]	2.8	2.8	–	–
Cr[1]	6.0	–	–	6.0
Total content				
Sb	4.5	4.5	4.5	50.0
Mn	1500.0	3500.0	1500.0	1500.0
V	150.0	170.0	350.0	150.0
Pb	30.0	35.0	260.0	30.0
As	2.0	2.0	15.0	10.0
Hg	2.1	2.1	33.3	5.0
Pb+Hg	20+1	20+1	30+2	30+2
Cu	55	–	–	–
Ni	85	–	–	–
Zn	100	–	–	–

1 – in ammonium acetate leach at pH 4.8;
2 – in sodium acetate leach at pH 4.8;
3 – in 0.006M HCl leach at pH < 6.5 or in 0.03 M K2SO4 leach at pH 4.8

Table 16

Estimation of soil contamination level according to the total contamination index Z_s in residential and industrial areas [9]

Contamination level	Z_s value	Change of population health indices in the contaminated areas
I. Permissible	<16	the lowest level of sick children rate and minimum frequency of functional divergences
II. Medium dangerous	16–32	the increase of total sick rate
III. Dangerous	32–128	the increase of total sick rate, number of children that are frequently sick, have chronic diseases or cardiovascular disorders
IV. Extremely dangerous	>128	the increase of sick children rate, disturbance of reproductive function of women (increase of pregnancy intoxications, premature child birth, number of still-born and hypotrophic newborns)

Table 17

Estimation of soil contamination level according to the total contamination index Z_s in agricultural areas [9]

Contamination level	$\frac{Z_s \text{ value}}{\text{MPC exceeded}}$	Possible soil use	Required actions
Permissible	$\frac{Z_s \text{ value}}{\text{no exceeded}}$	used for any crop	reducing of impact from pollution sources. Reducing of pollutants accessibility to plants
Medium dangerous	$\frac{16.1 - 32}{\text{translocation, migration to water MPC exceeded}}$	used for any crop under crop quality control	the same as foregoing actions; quality control of surface and groundwater in case of water migration MPC exceeding
Dangerous	$\frac{32.1 - 128}{\text{translocation, migration to water MPC exceeded}}$	used for technical crop only and recall from cultivation plants- concentrators of chemical elements	the same as foregoing actions; necessary quality control of food and forage crop in case of sanitary MPC exceeding; limitation of green crop use, particularly of plants-concentrators
Extremely dangerous	$\frac{>128}{\text{over all MPC}}$	land must be taken out of agriculture use	reducing of contamination by binding elements-contaminants in air, soil and water

Z_s index is calculated by the following formula:

$$Z_s = \Sigma K_{ki} - (n-1)$$

where:

$$K_{ki} = C_i / C_b$$

C_i – measured content of i element-pollutant in a soil sample (mg/kg),

C_b – background value of i element-pollutant (mg/kg),

n – number of elements-pollutants.

The index is based on the significant quantity of coherent geochemical, medical, and agricultural data. In the residential and industrial areas, the Table 16 is used for estimation of the soil contamination level and required actions, according to the total contamination index Z_s. An assessment and remediation actions of agricultural soil are performed in accordance with requirements shown in the table (Table 17). The recommended optional permissible concentrations (total contents) were derived in 1995 for three groups of soils according to soil texture and pH combination (Table 18).

Soil sanitary standard of Lithuania is of complex structure in the same way as the Russian one [5]. The maximum permissible concentrations related to the background values and refer-

Table 18

The optional permissible concentrations (OPC) of heavy metals and arsenic in soil with different physical-chemical properties (total contents mg/kg), valid since 1995 [9]

Elements	Group of soil	OPC related to the background
Nickel (Ni)	sand and sandy loam	20
	acid loam and clay at pH <5.5	40
	loam and clay close to neutral at pH >5.5	80
Copper (Cu)	sand and sandy loam	33
	acid loam and clay at pH <5.5	66
	loam and clay close to neutral at pH >5.5	132
Zinc (Zn)	sand and sandy loam	55
	acid loam and clay at pH <5.5	110
	loam and clay close to neutral at pH >5.5	220
Arsenic (As)	sand and sandy loam	2
	acid loam and clay at pH <5.5	5
	loam and clay close to neutral at pH >5.5	10
Cadmium (Cd)	sand and sandy loam	0.5
	acid loam and clay at pH <5.5	1.0
	loam and clay close to neutral at pH >5.5	2.0

ence values for sand and sandy loam soils as well as for loam and clay are given as standards (Table 19). The synergy of contaminants is again pointed out by the lower MPC for manganese and attendant vanadium. The reference values are necessary for calculation of the total contamination index Z_s and the estimation of the soil contamination level in residential, recreational, and agricultural areas. A risk index K_0 is also used for estimation of soil contamination level, and calculated by the following formula:

$$K_0 = C/\text{MPL}$$

where:

C – content of particular element in a soil sample (mg/kg),

MPC – maximum permissible concentration of the same element (mg/kg).

The criteria of different soil contamination levels and for the required actions in residential and recreational sites are presented for each level in Table 20.

Table 19

The maximum permissible concentrations (MPC) of chemical substances and their background values in soil [5]

Name of substance	CAS No.	MPC [mg/kg]	Background value [mg/kg]	
			Sand and loamy sand	Loam and clay
1. Tin (Sn)	7440-31-5	10	2.1	2.3
2. Arsenic (As)	7440-38-2	10	2.5	3.6
3. Barium (Ba)	7440-39-3	600	345	426
4. Berillium (Be)	7440-41-7	10	1.0	1.5
5. Boron (B)	7440-42-8	50	26	34
6. Chromium (Cr)	7440-47-3	100	30	44
7. Zinc (Zn)	7440-66-6	300	26	36
8. Mercury (Hg)	7439-97-6	1.5	0.075	0.1
9. Cadmium (Cd)	7440-43-9	3	0.15	0.2
10. Cobalt (Co)	7440-48-4	30	4.,3	6.4
11. Manganese (Mn)	7439-96-5	1500	427	451
12. Manganese (Mn) + vanadium (V)	–	1000+100	–	–
13. Molibdenum (Mo)	7439-38-7	5	0.64	0.71
14. Nickel (Ni)	7440-02-0	75	12	18
15. Selenium (Se)	7782-49-2	5	0.2	0.3
16. Silver (Ag)	7440-22-4	2	0.071	0.069
17. Antimony (Sb)	7440-36-0	10	1.0	1.5
18. Lead (Pb)	7439-92-1	100	15	15
19. Uranium (U)	7440-61-1	20	2.2	3.0
20. Vanadium (V)	7440-62-2	150	32	49
21. Copper (Cu)	7470-50-8	100	8.1	11
22. Sulfur	7704-34-9	160	–	–
23. Cianides (total)	–	5	0.5	0.5
24. Fluorides	–	200	20	20
25. Potassium chloride	7447-40-7	500	150	150
26. Nitrates (according to NO)	–	130	–	–

Table 20

Estimation of soil contamination level according to the total contamination index Z_s and risk index K_o, and required actions in contaminated areas [5]

Contamination level	Z_s value	K_o value	Required actions in contaminated areas
I. Permissible	<16	$K_o \leq 1$	detailed soil investigation and monitoring is recommended
II. Medium dangerous	16–32	$1 < K_o \leq 3$	obligatory is soil remediation (liming, adding of compost, dilution with clean soil) up to permissible level in residential and recreation areas; agriculture areas must be used for technical crops or afforested
III. Dangerous	32–128	$3 < K_o \leq 10$	
IV. Extremely dangerous	>128	$K_o > 10$	polluted soil layer must be removed to landfill of hazardous substances or remediate *in situ* up to superior level of contamination

SUMMARY

The integrated soil guideline values for protection of human health and ecological receptors represent in the most countries an "intervention value", which warns an assessor that soil component concentrations above this level could pose an unacceptable risk to the health of site users, and that further investigation and/or remediation are required.

Some soil standards are integrated and designed to protect both soil and drinking water (ground- and surface) quality. Estonia developed coherent guideline values for soil and ground water, Romania – for waste-water. The water extractable contents are used in Russia to prevent contamination of the soil-to-water pathway.

Soil guidelines of different East European countries require different formal actions at a particular level of historical soil contamination to prevent soil from being polluted. Soil guidelines certificate different contamination levels in different countries for the same hazardous elements and the same land-use sites, but generally, the risk/action values are lower than in the West European countries. The lowest *risk* values (prevention, pollution, limit values in residential, recreational, and agriculture areas) intended to protect soil as habitat have been developed from background values of soil of different texture and pH. The highest *action* values based on oral /dermal pathway exposure were prescribed for industrial areas.

Soil standards of Russian Federation and Lithuania sum up a synergy of elements-pollutants, and assess the soil contamination according to the complex indices.

Estonian soil guidelines were cancelled after Estonia entry to EU, and authorities of many new EU Member countries do also intend to harmonise soil quality standards in the frames of the developing EU Thematic Strategy for Soil Protection. Subject of organogenic soils is still open, and some countries with large areas covered by peat soil are developing guideline values for themselves.

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