



XX International Seminar on Interaction of Neutrons with Nuclei



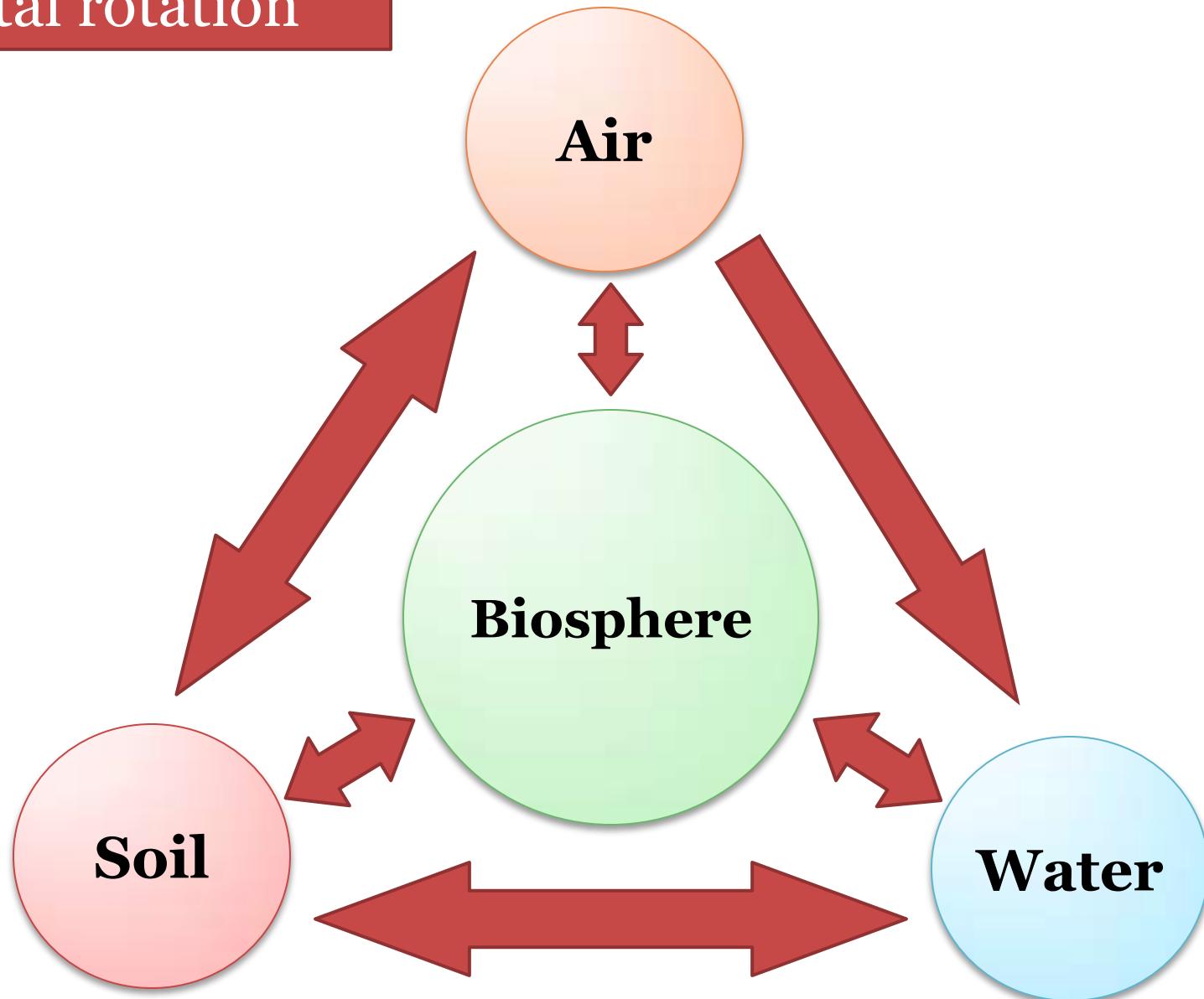
STUDY OF HEAVY METAL CONTENTS IN SOIL, RIVER WATER, SNOW, NEEDLES AND MOSSES OF IVANOVO REGION

Dunaev A.M., Rumyantsev I.V.

Supervisor: Dr. Grinevich V.I.

Ivanovo State University of Chemistry and Technology, Ivanovo, Russia

Metal rotation



Motor transport

Mn

Fe

Zn

Cu

Firing

Nonferrous metallurgy

Ferrous metallurgy

Mechanical engineering

Chemical engineering

Solid waste

Liquid waste

Cd

Pb

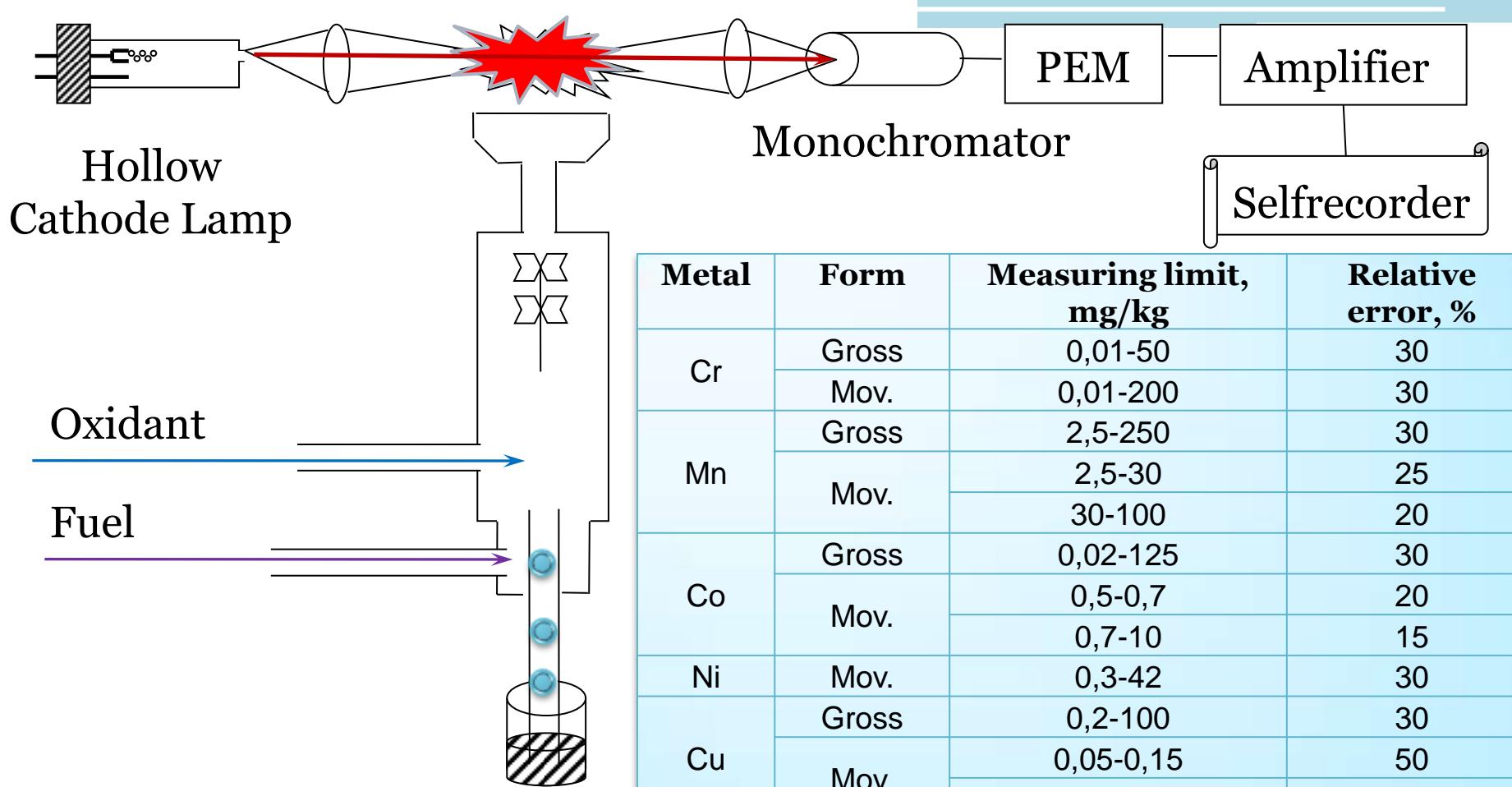
Co

Ni

Cr

Sampling map





Metal	Form	Measuring limit, mg/kg	Relative error, %
Cr	Gross	0,01-50	30
	Mov.	0,01-200	30
Mn	Gross	2,5-250	30
	Mov.	2,5-30 30-100	25 20
Co	Gross	0,02-125	30
	Mov.	0,5-0,7 0,7-10	20 15
	Mov.	0,3-42	30
Cu	Gross	0,2-100	30
	Mov.	0,05-0,15 0,15-10	50 30
	Gross	0,25-125	30
Zn	Mov.	18,4-25	30
	Gross	0,002-125	30
Cd	Mov.	0,002-10	30
	Gross	0,02-1250	30
Pb	Mov.	0,02-100	30
	Gross	0,02-1250	30

Metal content (mg/kg) in Ivanovo region soils

Metal	min-max	Mean	MPC_S (APC_S)
Cr	<0.01- 1.67	0.12	0.05
	<0.01-0.63	0.03	-
Mn	<2.5- 1880	420	1500
	<2.5-250	40.4	500
Fe	71.4-14400	5490	-
	<0.02-286	84	
Co	<0.02-4.58	1.3	-
	ND	ND	5
Ni	<0.3-56.4	8.67	(80)
	<0.02- 8.76	0.99	4
Cu	<0.2-20	6.24	(132)
	<0.2- 5.8	0.77	3
Zn	4.17-70	19.5	(220)
	<0.25- 35	3.66	23
Cd	<0.002-0.25	0.03	(2)
	<0.002-0.08	0.003	-
Pb	<0.02-3.32	0.23	32
	-	-	6

Upper row contains data for gross form of metal, lower row – for movable forms

Comparison of metal content (mg/kg) in soils of Ivanovo and neighboring regions

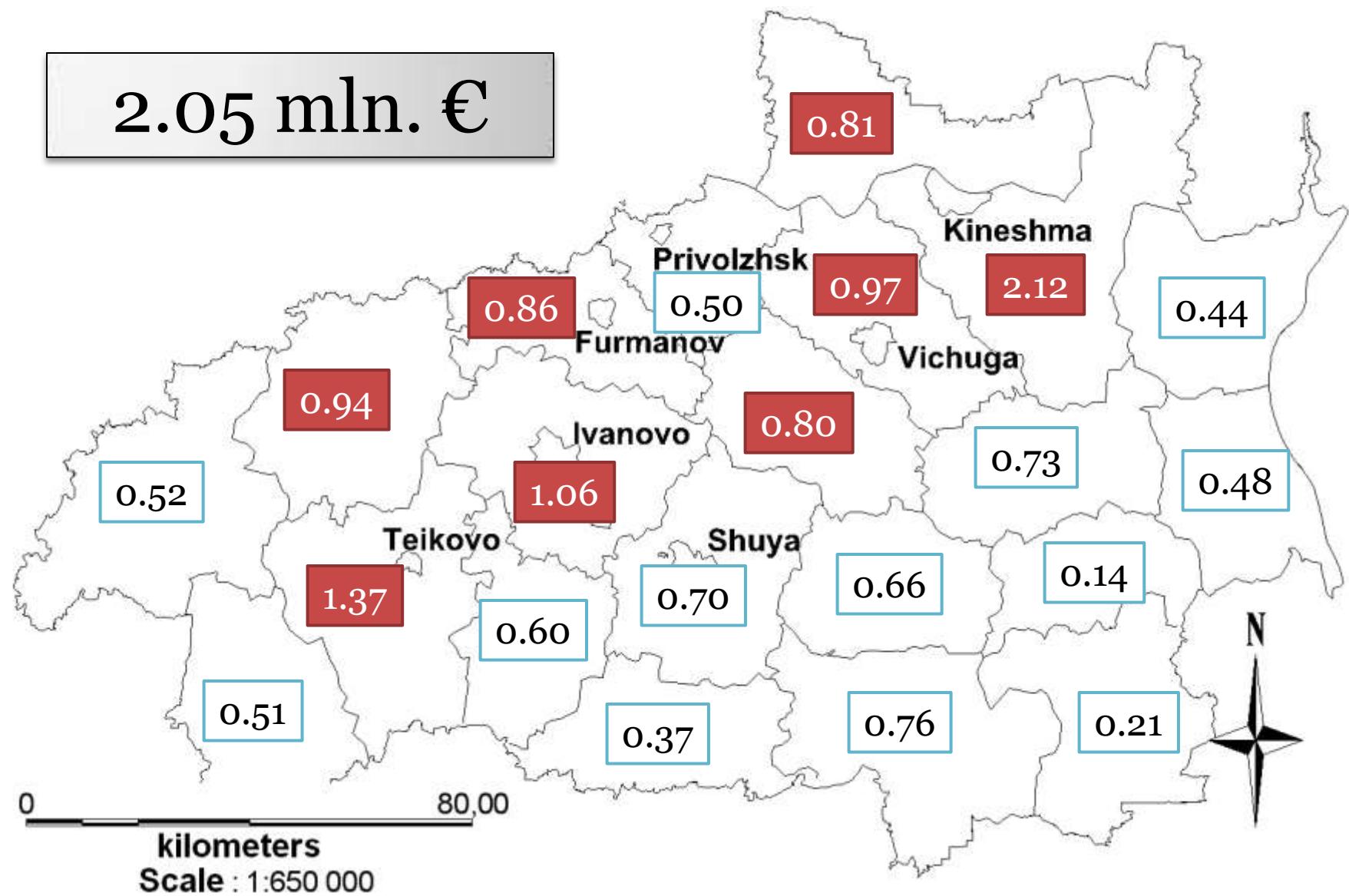
Metal Year	Kostroma, 2010 /1/	Vladimir, 2000 /2/	Nizniy Novgorod, 2007 /3/		Ivanovo, 2010	
Form	Gross	Gross	Gross	Mov.	Gross	Mov.
Cr	73	80	11,91	0,29	0,12	0,03
Mn	650	692	-	-	420	40,4
Fe	18000	27700	-	-	5490	84
Co	16	6	-	-	1,3	-
Ni	23	29	20,46	0,78	8,67	0,99
Cu	23	-	8,05	0,29	6,24	0,77
Zn	48	47	25,91	0,59	19,5	3,66
Cd	-	-	0,39	0,13	0,03	<0,003
Pb	-	16	6,17	0,64	0,23	-

1. Lebedeva O.Yu. Abstract of candidate thesis of geography. – St.Peterburg: RSPU, 2011. 21 P.
2. Karpova D.V. Abstract of doctor thesis of agriculture. – M.: VladRICS, 2009. 55 P.
3. Kuznetsov V.A. Abstract of candidate thesis of agriculture. – Saransk: NNAA, 2010. 21 P.

District	Damage mln. €	Probability metal pollution								Risk mln. €
		Cu	Cd	Pb	Zn	Mn	Cr	Co	Ni	
Ivanovo	7,00	0,52	0,13	0,1	0,64	0,37	0,01	-	0,57	1,06
Teikovo	4,84	0,35	-	-	0,68	0,42	0,1	-	1	1,37
Privolzhsk	2,29	0,54	-	-	0,36	0,52	-	-	0,57	0,50
Rodniki	4,66	0,37	0,4	0,1	0,5	0,53	-	-	0,16	0,80
Vichuga	3,74	0,215	-	-	0,25	0,9	0,1	-	0,88	0,97
Kineshma	7,98	0,58	0,06	0,17	0,38	1	-	-	1	2,12
Furmanov	2,02	0,6	-	-	0,3	1	-	-	0,82	0,86
Lezhnevo	1,32	0,2	-	-	0,88	-	-	-	0,82	0,60
Yuzha	8,53	0,29	0,08	0,17	0,19	0,34	0,06	-	0,24	0,76
Il'inskoe	4,26	0,27	-	-	0,08	0,42	-	-	0,16	0,52
Komsomolsk	3,23	0,55	-	-	0,48	0,53	-	-	0,31	0,94
Gavrilov posad	2,54	0,45	-	-	0,26	0,3	-	-	0,28	0,51
Savino	1,50	0,43	-	-	0,24	0,36	-	-	-	0,37
Zavolzhsk	4,24	0,42	0,06	-	0,52	0,53	-	-	0,19	0,81
Palekh	2,22	0,7	-	-	0,21	0,6	-	-	0,4	0,66
Lukh	2,53	0,45	-	-	0,86	0,4	-	-	0,13	0,73
Yurievets	1,37	0,61	-	-	0,25	0,5	-	-	-	0,44
Puchezh	4,36	0,67	0,06	-	0,11	0,2	0,01	-	0,27	0,48
Pestyaki	1,09	-	-	-	0,16	0,3	-	-	-	0,21
Verhniy Landekh	0,61	-	-	-	0,1	0,47	-	-	-	0,14

Risk assessment

2.05 mln. €



Comparison of metal content (mg/kg) in mosses of Ivanovo and other regions

	Tver+Yaroslavl' (2000-2002) /1/				Tula (1998-2000) /2/				Udmurtia (2005-2006) /3/				Ivanovo This work (2010)			
	min	max	mean	loc back	min	max	mean	loc back	min	max	mean	loc back	min	max	mean	loc back
Cr	0.2	27	1.5	0.26	0.6	28	5	0.7	3	48	6.2	4	<0.01	16.7	1.7	<0.01
Mn	45	2200	400	95	35	820	300	150	43	700	210	90	<2.5	1250	231	23
Fe	68	3690	550	165	350	19700	2200	400	380	3545	890	480	4.17	750	262	110
Co	0.05	3.5	0.41	0.11	0.14	2.66	0.63	0.2	0.07	2.13	0.4	0.2	<0.02	<0.02	<0.02	<0.02
Ni	0.25	22	2	0.28	0.7	11.7	3.7	1.4	1	16	4.7	2.5	<0.3	16.6	4.3	<0.3
Cu	3.2	9.2	5.1	3.6	4	36	9	4.5	3	22	8.5	3.6	<0.2	44	8.6	2
Zn	13	85	34	20	16	105	54	24	18	115	42	26	2.4	120	31	14
Cd	0.03	0.82	0.27	0.07	0.04	1.22	0.32	0.12					<0.05	1.25	0.14	<0.05
Pb	2.1	12.2	6	3.1	3.8	18.6	8.7	5					<0.02	41.7	3.5	<0.02

1. Ermakova E.V., Frontasyeva M.V. et all. // J. Atm. Chem. № 49 (2004) 549–561,
2. Ermakova E.V., Frontasyeva M.V. et all. // J. Radioanalytical and Nuclear Chem., Vol. 259, No. 1 (2004) 51-58.
3. Pankratova Yu.S., Zelnichenko N.I. et all. // Problemy regionalnoy ekologii. № 1 (2009) 57-63

Atmospheric depositions in Ivanovo region

$$\text{Pb: } C_{\text{air}}(\text{kg/km}^2) = (C_{\text{moss}} \text{ (mg/kg)} - 0,378)/5,6$$

$$\text{Cd: } C_{\text{air}}(\text{kg/km}^2) = (C_{\text{moss}} \text{ (mg/kg)} - 0,032)/4,2$$

	$C_{\text{air}}\text{Cd, kg/(km}^2\cdot\text{year)}$		$C_{\text{air}}\text{Pb, kg/(km}^2\cdot\text{year)}$
Critical load	1-5	Critical load	10-15
Ivanovo region.			
2007 /1/	0,04-0,05	2007 /1/	1-2
2006 /2/	0,04-0,06	2006 /2/	0,5-0,7
2005 /3/	0,04-0,05	2005 /3/	0,7-1
2002 /4/	0,04-0,05	2002 /4/	1-2
This work, districts:		This work: districts:	
Savino1	0,13	Palekh	2,41
Savino2	0,29	Savino	0,03
Teikovo	0,29	Yurievets	2,41
Komsomolsk	0,09	Ivanovo	3,24
Zavolzhsk	0,01	Rodniki	7,37

1. Report of environmental protection in Russia in 2009. – M.: MNR, 2010. 502 P.

2. Report of environmental protection in Russia in 2008. – M.: MNR, 2009. 496 P.

3. Report of environmental protection in Russia in 2007. – M.: MNR, 2008. 472 P.

4. Report of environmental protection in Russia in 2002. – M.: MNR, 2003. 470 P.

pH of melted snow and metal content in solid phase of snow (mg/kg)

	pH	Zn	Mn	Fe	Cu, Cr, Cd, Pb, Co, Ni
Background /1/		610	520	-	Cu (100), Cr (52), Cd (0,5) Pb (90), Co (7), Ni (57)
Iv. region. Districts:					
Teikovo	7,4	1790	208	4930	ND
Il'inskoe1	7,5	400	500	1830	ND
Il'inskoe2	7,3	256	ND	1270	ND
Furmanov	7,2	139	417	4270	ND
Privolzhsk	7,3	146	ND	2510	ND
Vichuga	7,1	463	278	2670	ND
Kineshma	7,6	43,9	ND	4800	ND
Rodniki	7,5	53,8	ND	5360	ND

Metal content of melted snow (mg/kg)

	Cu		Zn		Mn		Fe	Cr, Cd, Pb, Co, Ni
Nizniy Nov. region /1/ mean Districts:	17		218,2				Ni (26,2) Pb (20,2)	
B.-Murash.	35	9	170	68	-	-	-	-
Vadskiy	11	2	88	41	-	-	-	-
Spasskiy	11	4	44	12	-	-	-	-
Sergachskiy	11	2	743	532	-	-	-	-
B.-Boldinsk.	17	8	46	16	-	-	-	-
Iv. reg. Districts:								
Teikovo	ND		16	5	5	2	22	7
Il'inskoe1	6	2	12	4	ND	ND	ND	ND
Il'inskoe2	15	4	10	3	ND	ND	ND	ND
Furmanov	14	4	8	2	ND	25	8	ND
Privolzhsk	6	2	5	2	ND	ND	ND	ND
Vichuga	ND		6	2	ND	ND	ND	ND
Kineshma1	ND		10	3	29	9	ND	ND
Kineshma2	ND		4	1	ND	8	3	ND
Rodniki	ND		6	2	13	4	ND	ND

Atmospheric depositions (kg/(km²·year)) in Ivanovo region calculated from data of snow

$$U \text{ (kg/km}^2\cdot\text{day)} = P^o(\text{mm})/T(\text{day}) \cdot (m(\text{mg})/V(\text{ml}) + \rho_e(\text{mg/ml}))$$

	Cu	Zn	Mn	Fe
U _{bg} /1/	0,292-0,584	0,256-0,511	2,08-4,16	-
U _{city} /1/	21,5	69,4	162	-
Iv. reg. Districts:				
Teikovo	-	31,9	15,8	44,1
Il'inskoe1	14,1	23,1	14,4	0,03
Il'inskoe2	18,3	12,6	-	0,02
Furmanov	11,9	6,97	7,25	21,8
Privolzhsk	12,9	10,6	-	0,03
Vichuga	-	5,04	4,64	-
Kineshma1	-	16,2	48,7	-
Kineshma2	-	10,6	26,4	21,6
Rodniki	-	13,8	27,5	-

Metal content (mg/kg) in needles of *Picea Abies* in Ivanovo region

	Mean	min-max	Deficient	Normal	Toxic
Cu	1.60	0.2-21	2-5	5-30	20-100
Cd	0.002	0.002-0.11	-	0.05-0.2	5-30
Pb	<0.02	<0.02	-	5-10	30-300
Zn	26	4-88	10-20	27-150	100-400
Mn	6	22-1050	10-30	30-300	400-1000
Fe	35	0.2-100			
Cr	<0.01	<0.01	-	0.1-0.5	5-30
Co	<0.02	<0.02	-	0.02-1	15-50
Ni	0.92	0.3-22	-	0.1-5	10-100

Average coefficients of metals Bioaccumulation in needles

	CBAbs	CBAcc	CBGCM
Cu	0.020	0.265	0.232
Cd	0.015		
Zn	0.202	2.002	14.555
Mn	0.285	0.928	14.114
Fe	0.008	0.020	0.768
Ni	0.009	0.188	

$$\mathbf{CBAbs} = \mathbf{C_{needle}/C_{lytosphere}}$$

$$\mathbf{CBAcc} = \mathbf{C_{needle}/C_{soil\ (gross)}}$$

$$\mathbf{CBGCM} = \mathbf{C_{needle}/C_{soil\ (mov)}}$$

CB > 10:

1 < CB < 10:

0.1 < CB < 1:

0.01 < CB < 0.1:

0.001 < CB < 0.01:

vigorous accumulation

strong accumulation

weak accumulation, medium absorption

weak absorption

very weak absorption

Factor analysis

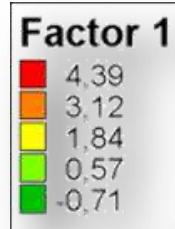
Extraction Method:
Principal Component Analysis.

Rotation Method:
Varimax with Kaiser Normalization.

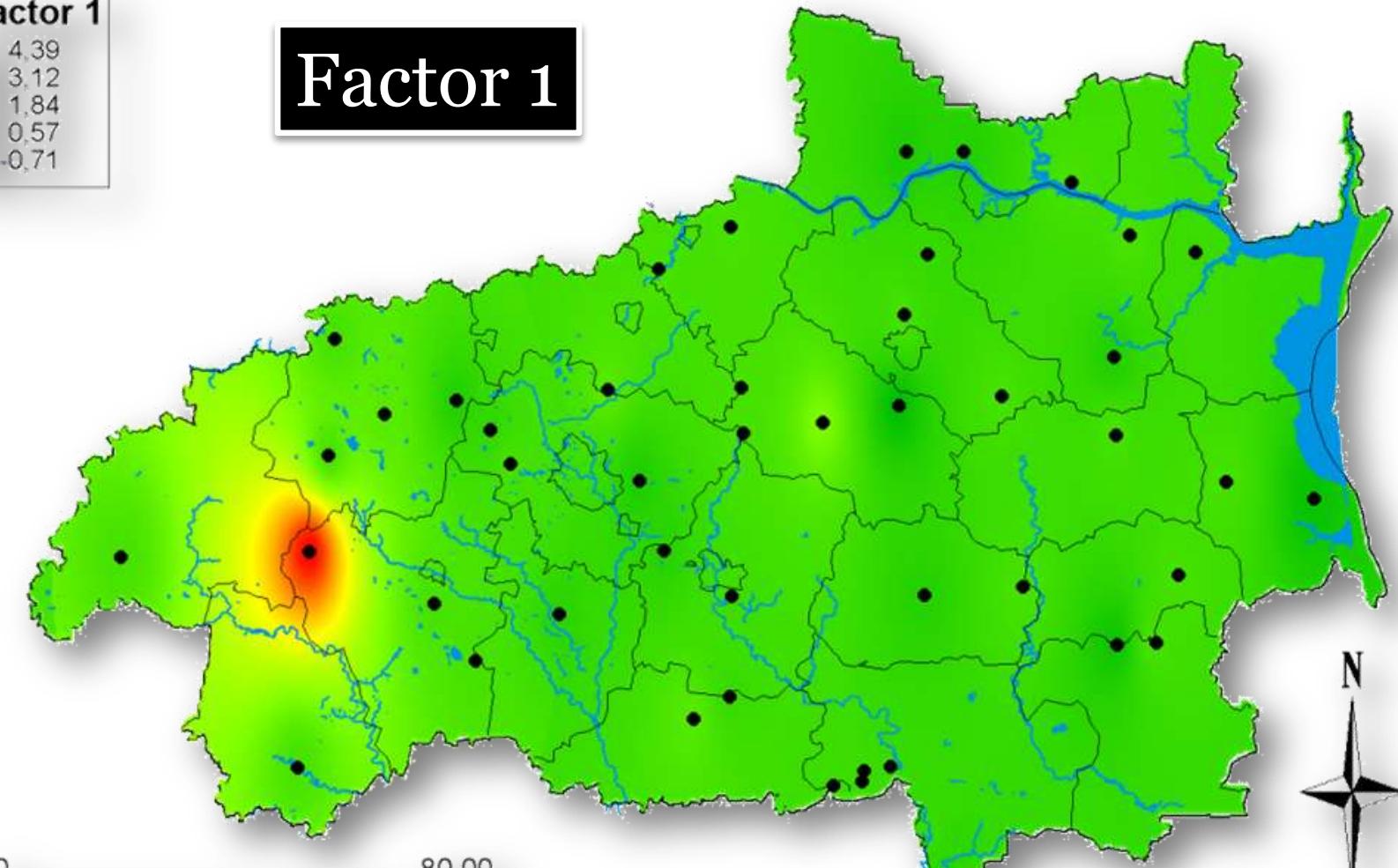
Indexes:

s_g – soil gross; s_m – soil movable; m – moss; n – needles.

	Factors						
	1	2	3	4	5	6	7
Cd_s_m	0,957		-0,124			-0,105	
Cr_s_m	0,957		-0,124			-0,105	
Cr_m	0,853		0,424				
Cu_m	0,834		0,487				
Cd_m	0,661	-0,100	-0,163	0,580			-0,168
Ni_s_m	0,637	0,394	-0,296			-0,102	
Mn_s_m		0,932	0,227				
Ni_s_g		0,915			0,154		
Pb_s_g		0,768	0,352		0,390	-0,164	
Fe_s_m	-0,184	0,756	0,150	-0,131	-0,250		
Fe_s_g	-0,115	0,734	-0,210		-0,122	0,298	
Cu_s_g	0,184	0,638		-0,126	0,400	0,135	
Pb_m			0,902		0,207		
Zn_m			0,868				0,191
Cd_s_g		0,370	0,636		0,589	-0,127	
Fe_n	-0,174	-0,292		0,807			0,167
Zn_n		0,251	-0,188	0,785		0,393	-0,187
Fe_m	0,218		0,269	0,779			0,197
Cr_s_g			0,170		0,875		
Co_s_g		0,228	0,452		0,484		
Cu_n				0,175		0,887	
Mn_s_g	-0,150	0,135			-0,108	0,878	-0,106
Ni_n							0,928
Zn_s_g		0,122	0,345				0,795



Factor 1

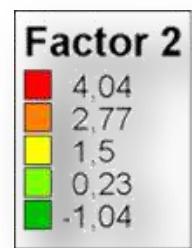


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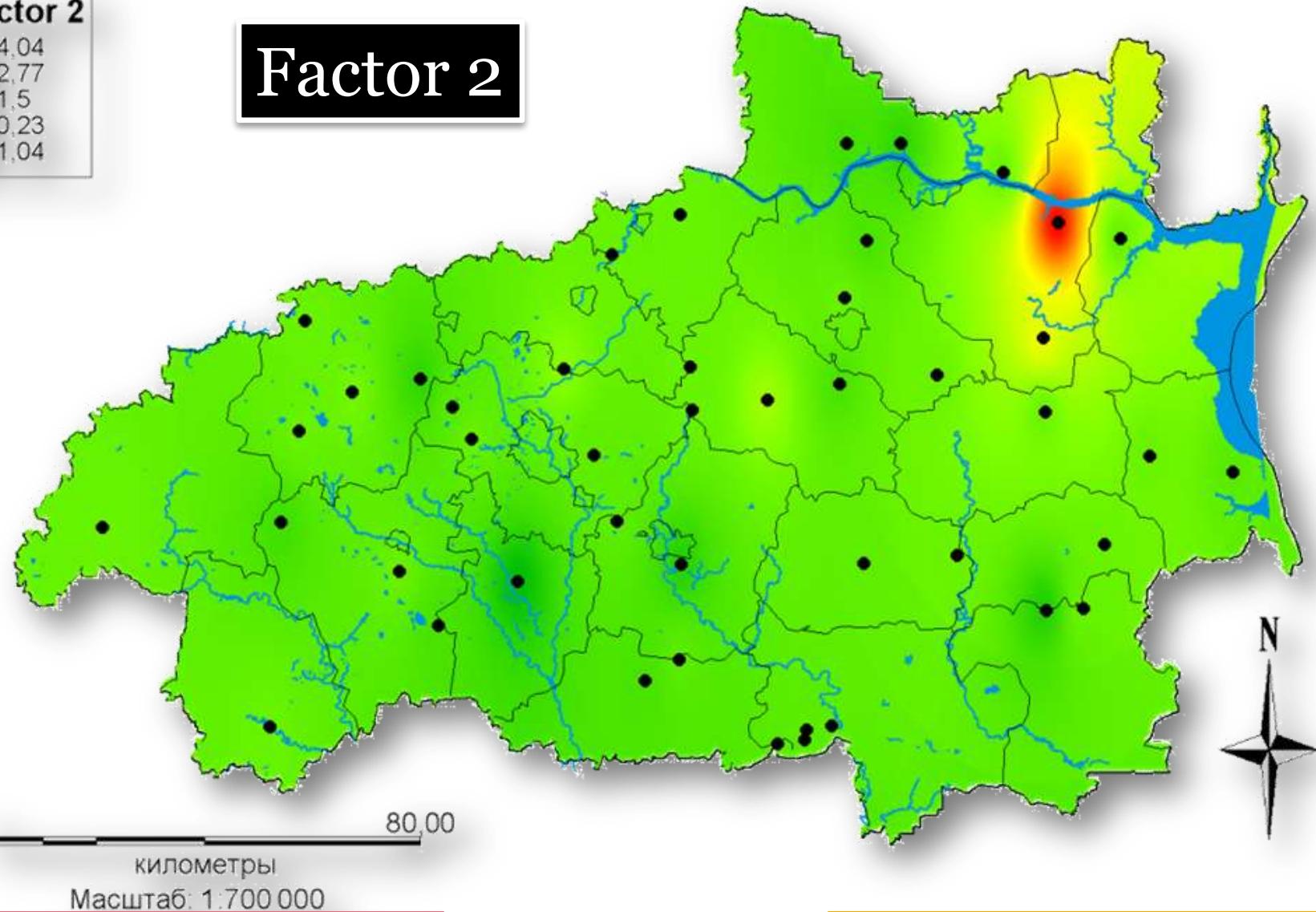
километры
Масштаб: 1:700 000

Cr, Cd, Ni

Cr, Cd, Cu

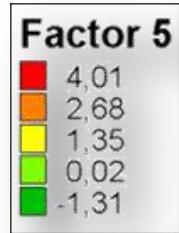


Factor 2

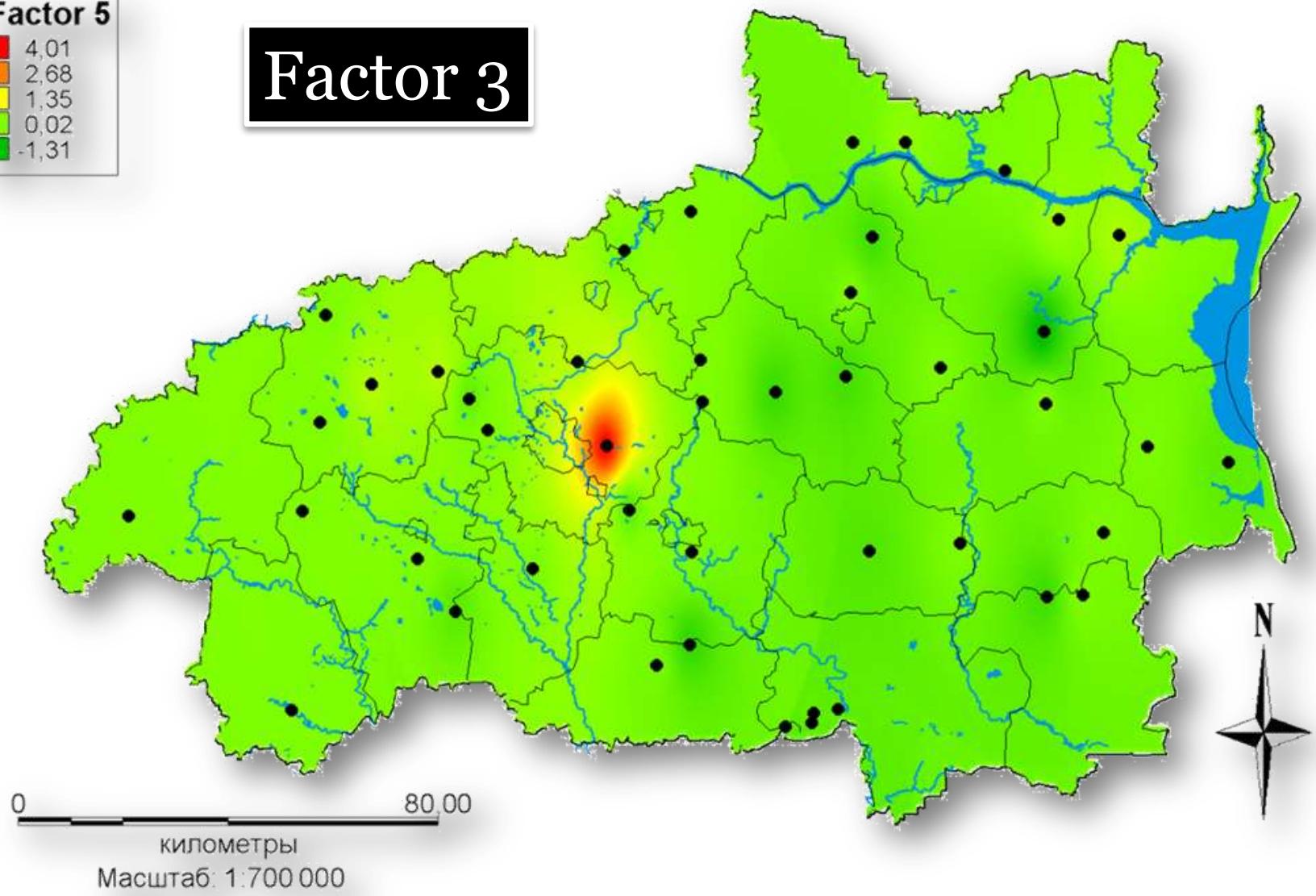


Fe, Ni, Pb, Cu

Fe, Mn



Factor 3

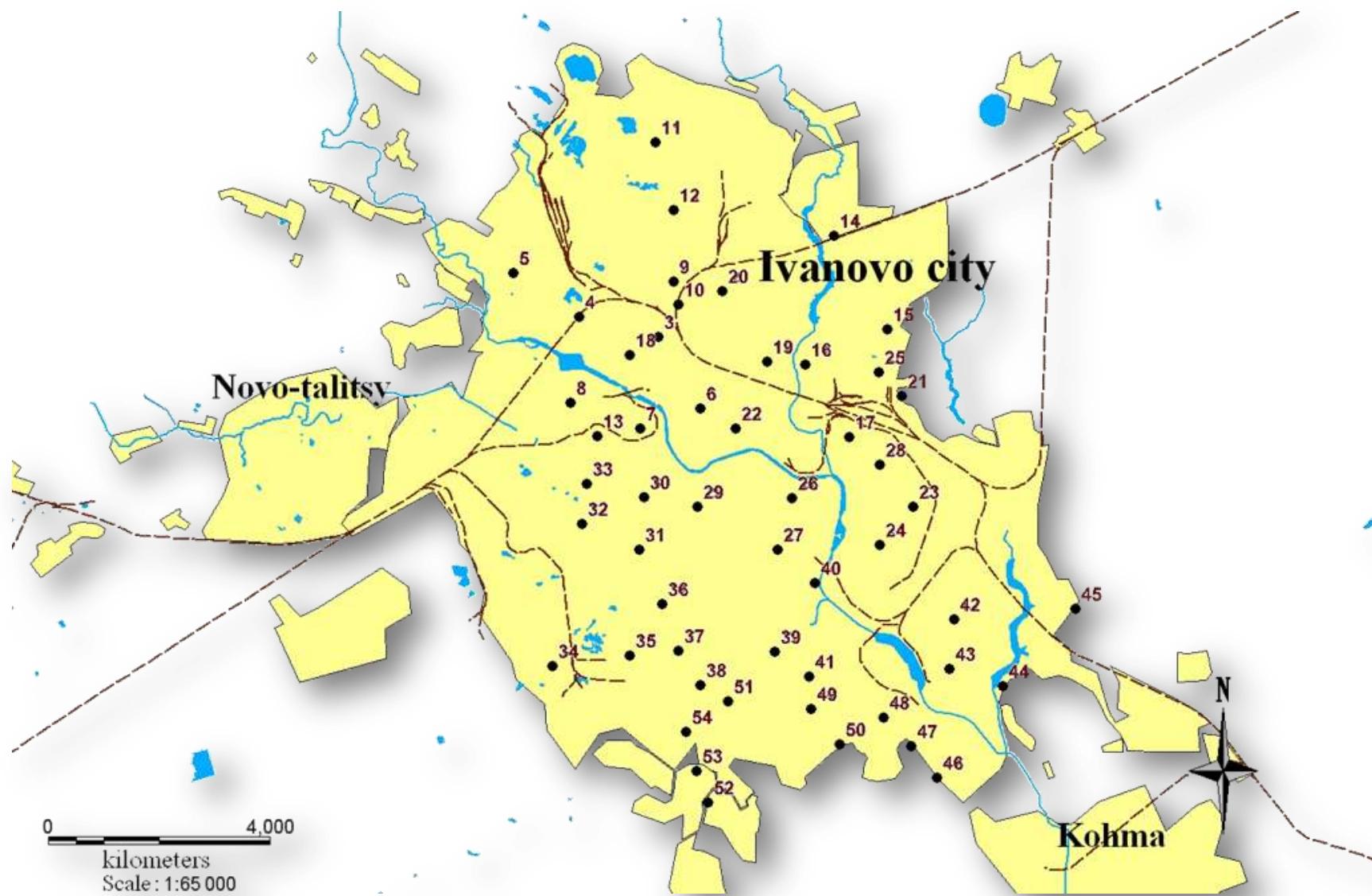


Co, Cd

Pb, Zn

	Cu	Zn	Mn	Fe	Ni	IWP	Water quality
MPC _w	1	10	10	100	10		
This work, 2010 г.							
1. r. Matnya	-	2	5	1	13	0.41	2-pure
2. r. Lulekh	-	2	0.3	6	-	0.06	1-very pure
3. r. Kuromza	-	1	2	5	-	0.06	1-very pure
4. r. Tulekh	5	-	9	14	-	1.24	3-moderately impure
5. r. Yachmenka	2	1	0.3	1	-	0.48	2-pure
6. r. Uhtoma	2	1	0.2	0.5	-	0.41	2-pure
7. r. Shacha	8	-	7	15	17	2.18	3-moderately impure
8. r. Teza (source)	-	1	0.2	1	-	0.02	1-very pure
9. r. Sunzha	-	-	5	9	-	0.12	1-very pure
10. r. Mera	17	-	2	61	-	3.49	4-impure
11. r. Yolnat'	-	-	0.3	8	-	0.02	1-very pure
12. r. Teza (near Bobrokovo)	7	-	4	18	-	1.51	3-moderately impure
13. r. Lukh	-	-	6	11	-	0.14	1-very pure
14. r. Dobritsa	4	3	10	32	-	0.16	1-very pure
State monitoring, 2009 г.							
9. r. Sunzha	4.2	-	18	630	-	3.38	4-impure
11. r. Yolnat'	1.4	-	48	480	-	2.22	3-moderately impure
12. r. Teza (near Sergeevo)	25.7	11	56	530	-	2.57	4-impure
State monitoring, 2010 г.							
9. r. Sunzha	2.9	-	37	590	-	2.07	3-moderately impure
10. r. Mera	5.1	-	20	660	-	1.88	3-moderately impure
11. r. Yolnat'	1.9	-	19	610	-	2.00	3-moderately impure

Sampling map



Metal content and some physicochemical soils characteristics of Ivanovo city

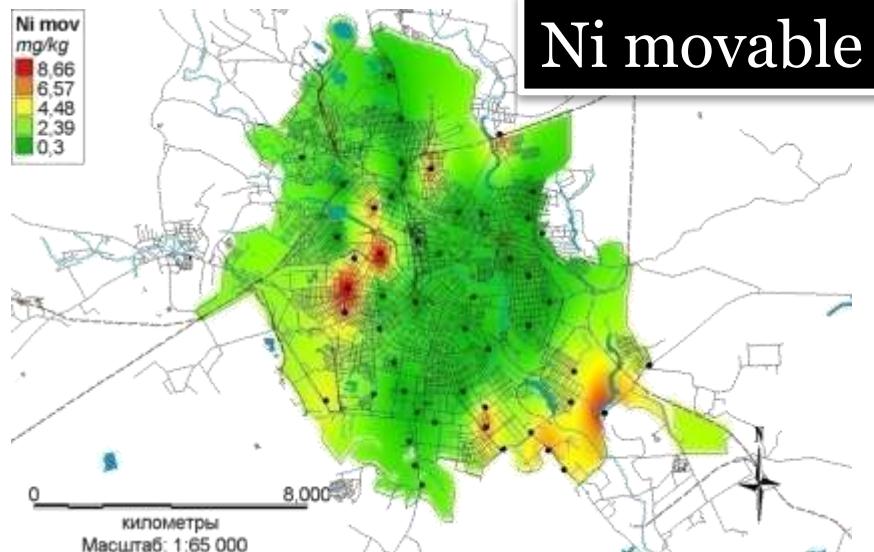
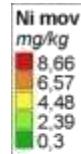
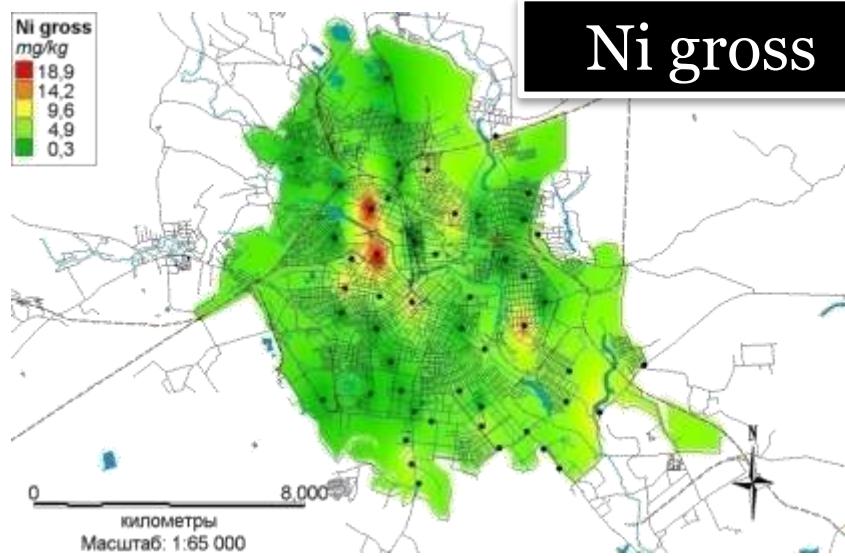
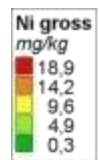
Metal	Mean	Min	Max	MPC_s (APC_s)
Cu (mg/kg)	10.2	0.2	23.3	(132) 3
	1.64	0.05	10.0	
Mn (mg/kg)	208	43	545	1500 500
	66	2.5	250	
Fe (mg/kg)	7120	100	17500	-
	257	8.0	4170	
Zn (mg/kg)	135	23.4	800	(220) 23
	38.5	10	139	
Ni (mg/kg)	3.93	0.3	18.9	(80) 4
	1.62	0.3	8.66	
pH	7.0	5.8	7.6	6-8
Cation-exchange capacity (mg·eq/100g)	30.6	7.0	77.6	>50

Upper row contains data for gross form of metal, lower row – for movable forms

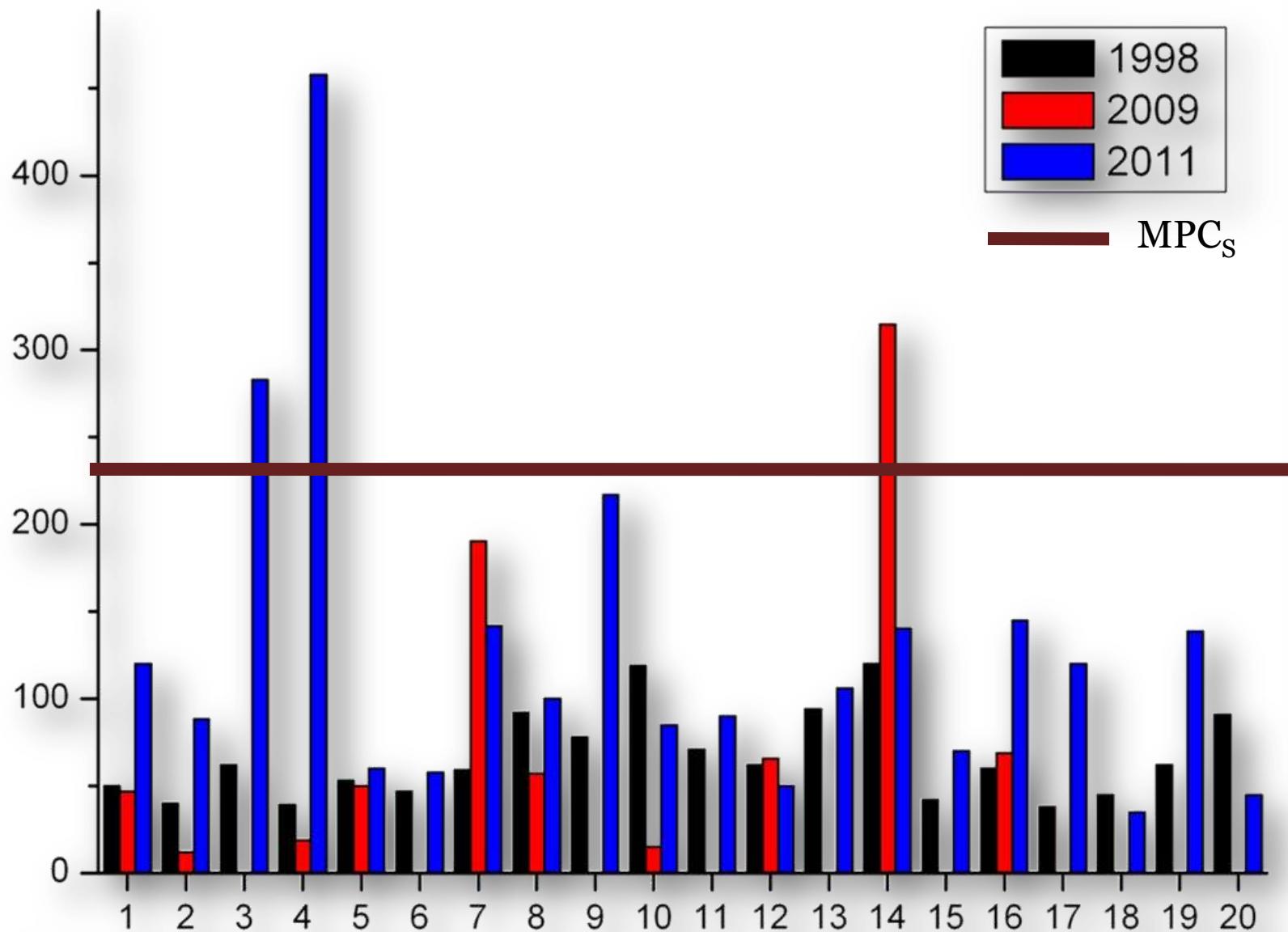
Factor analysis

	Factors				
	1	2	3	4	5
Ni_mov	,880	-,115		-,113	
Ni_gross	,870			,135	-,107
Mn_mov	-,125	,751	-,157		-,411
Mn_gross		,716	-,251	,174	,310
Fe_mov	-,172	,702	,213		
Zn_mov		,176	,789	-,158	
Fe_gross		,206	-,657	-,174	,124
Zn_gross				,913	
Cu_gross	-,292				,795
Cu_mov	,516		-,111	-,423	,530

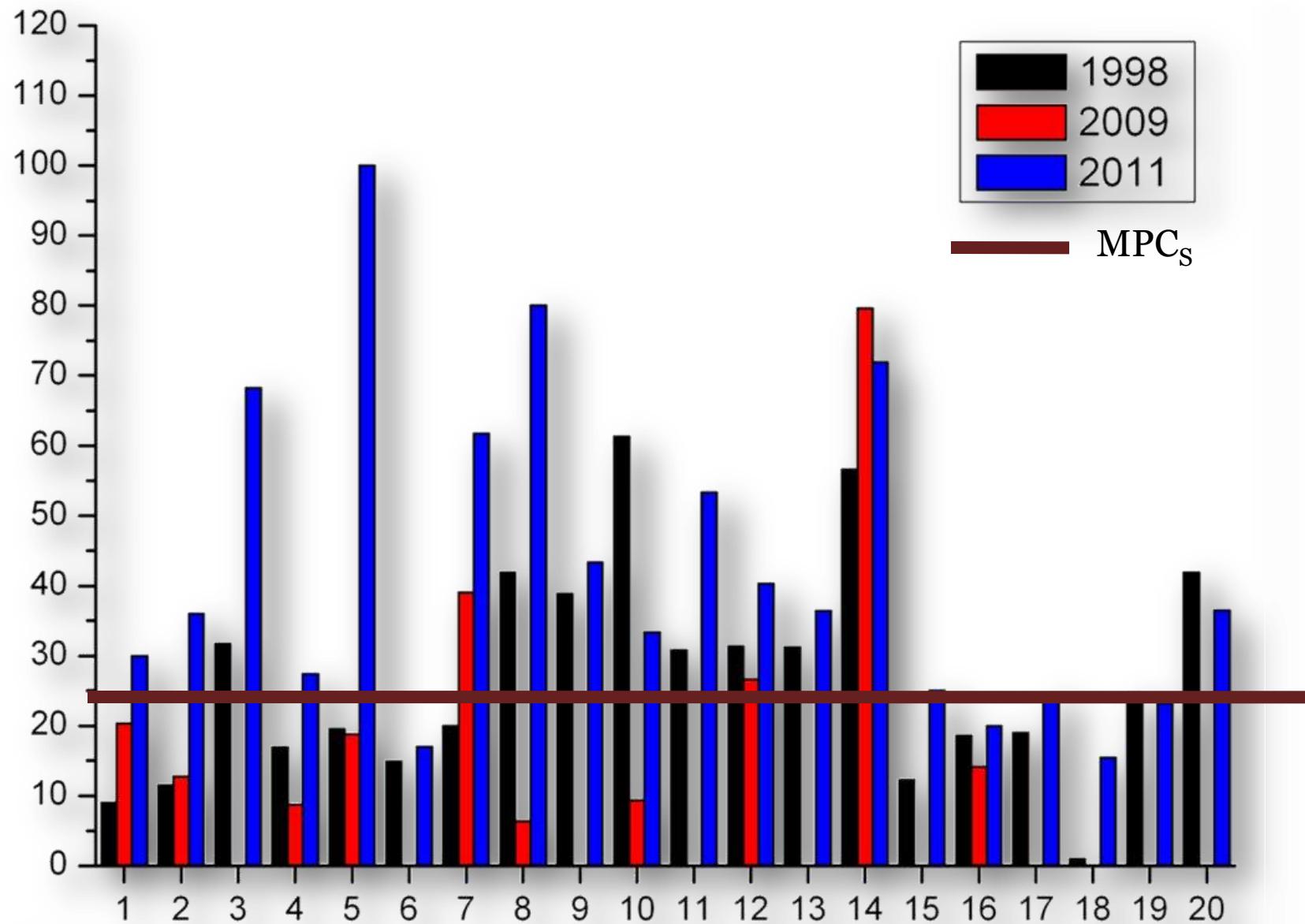
Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser
 Normalization.



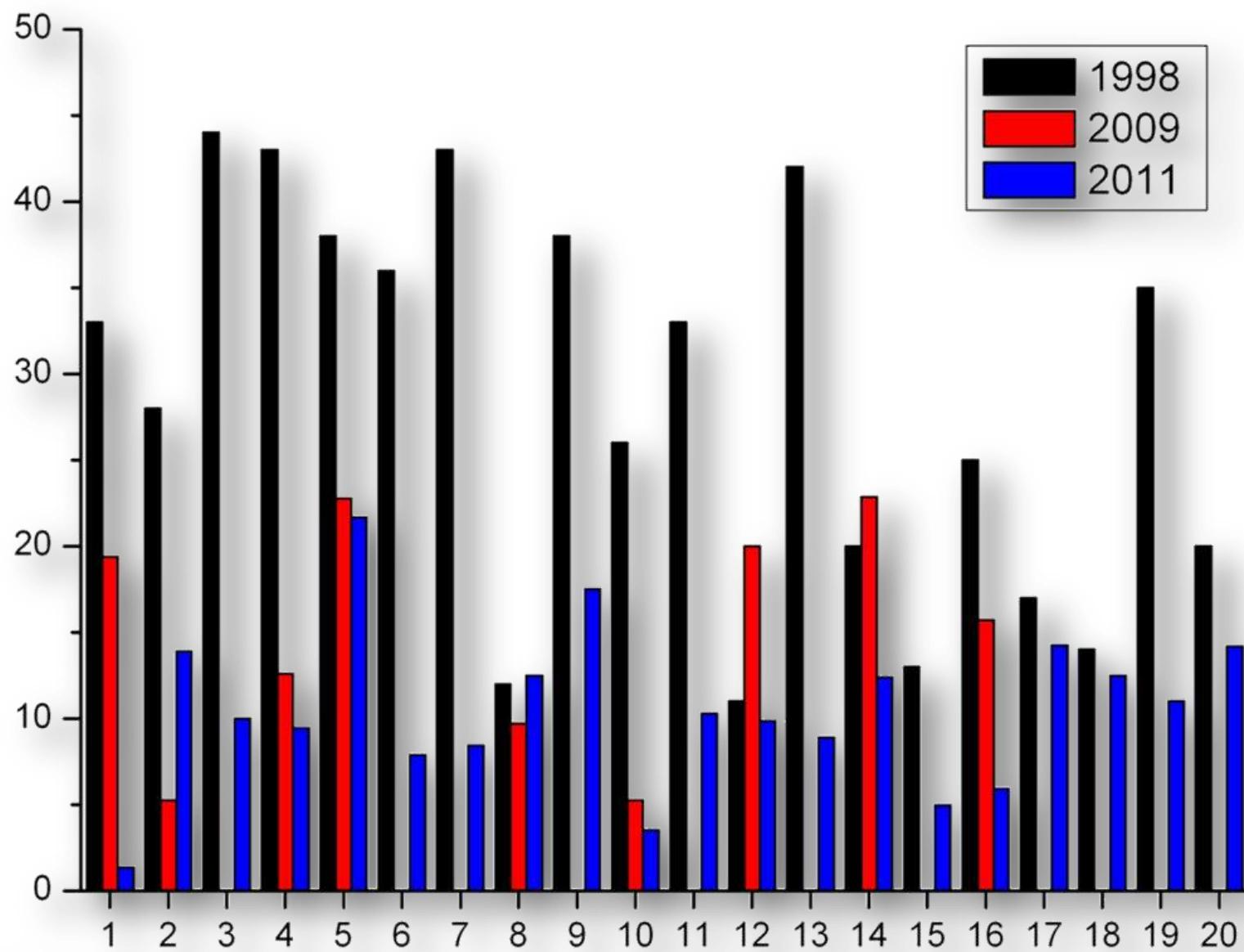
Zn gross



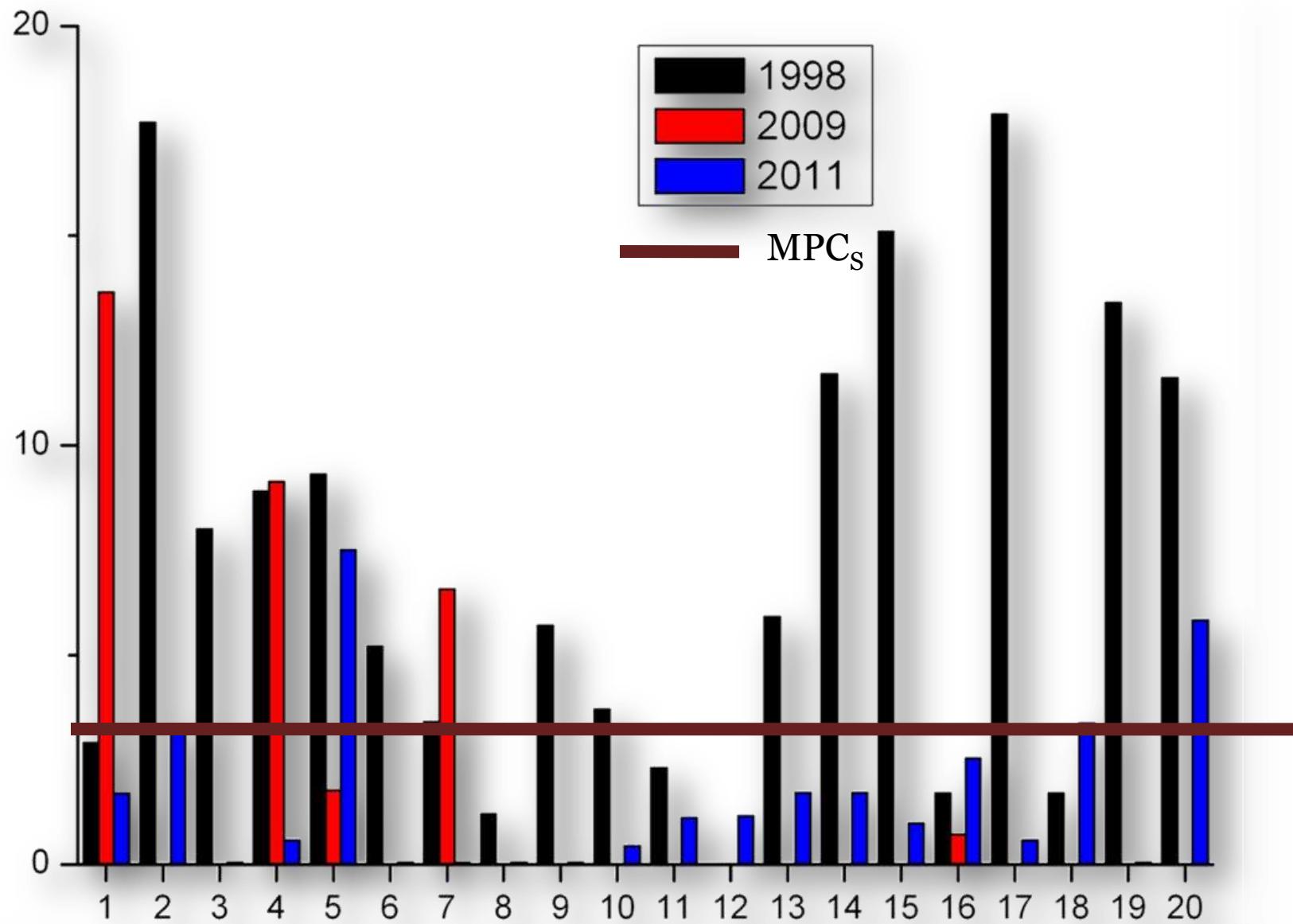
Zn movable



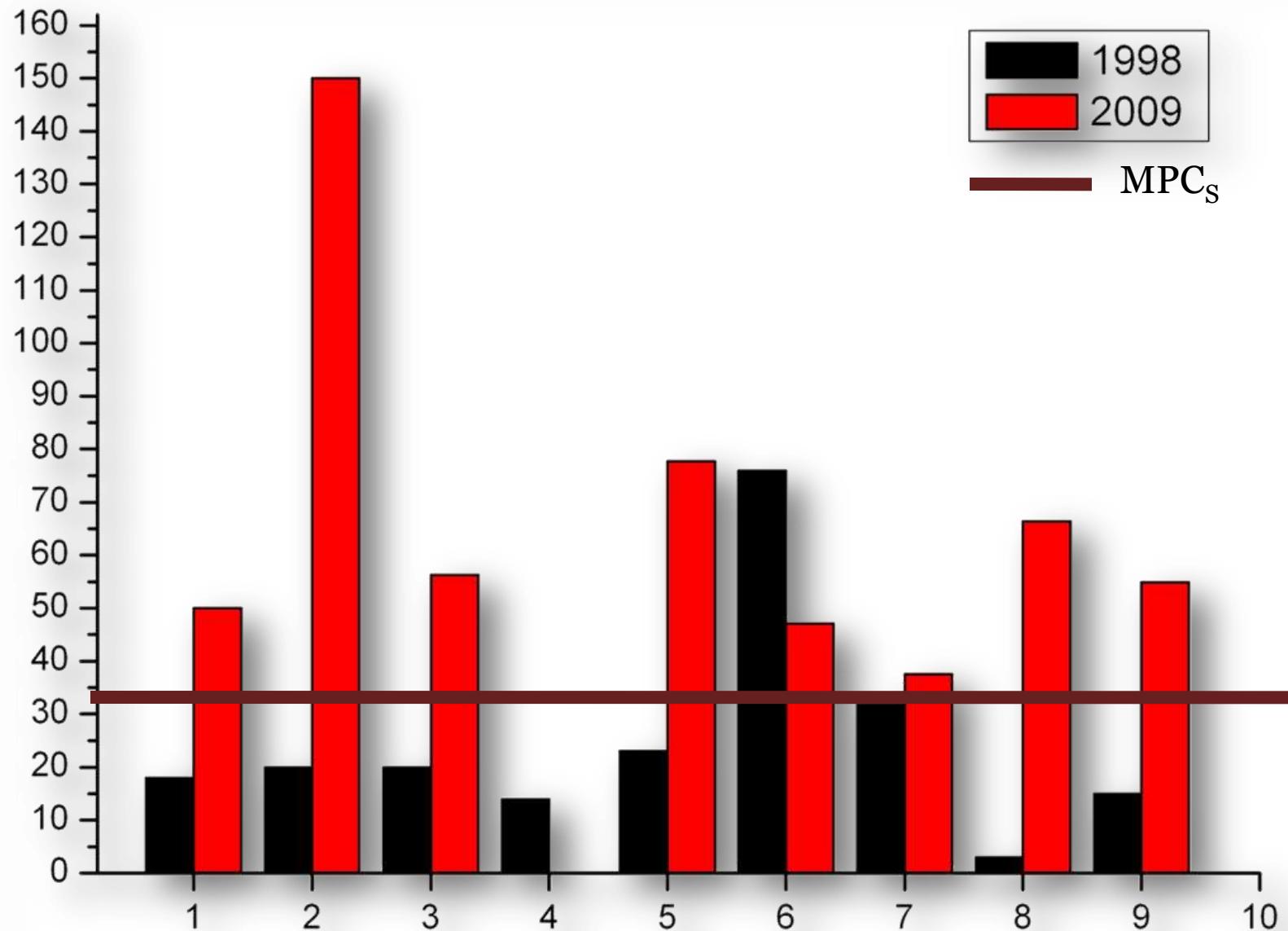
Cu gross



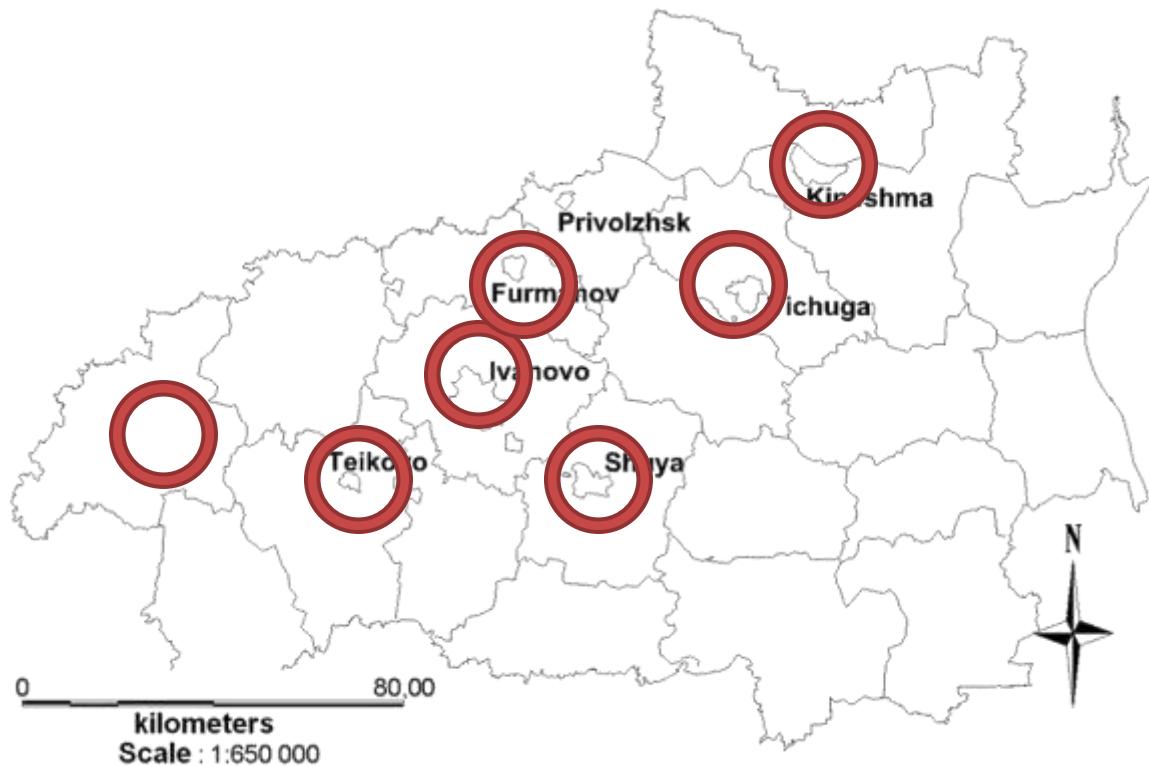
Cu movable



Pb gross



Future planning



Our collaboration

Ivanovo Community
Ecological Council



Ivanovo State University of
Chemistry and Technology



Ivanovo State
Medical Academy

Joint Institute of
Nuclear Research





Thank you for attention!