XXIII International Seminar
on Interaction
of Neutrons with Nuclei

SOIL CONTAMINATION ASSESSMENT IN VICINITY OF THE VOLGORECHENSK TOWN (KOSTROMA REGION, RUS.)

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Introduction

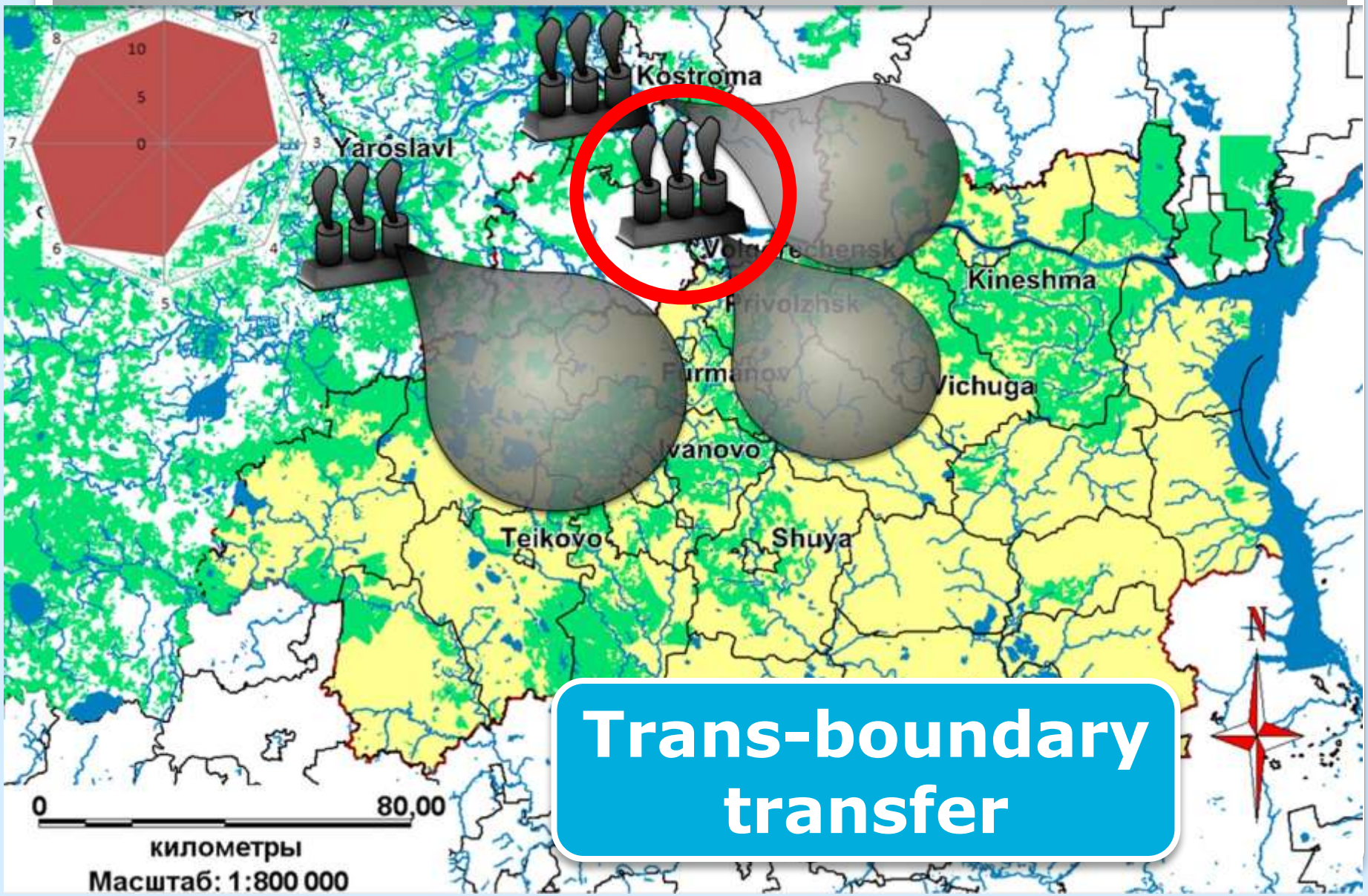
Power industry is one of the leading industries by the level of environmental impact

The monitoring of the effects is an important and urgent problem not only on the local, but also at the regional level

During preparation for the 2010/2011 moss survey, it was found that the area of the Ivanovo region, adjacent to the Kostroma region in the vicinity of the **Volgorechensk** town, characterized by great level of heavy metal content in mosses and soil

This work is devoted to the detailed study of soil contamination on the territory of foresaid area

The main sources of impact



Sampling map

The map legend:

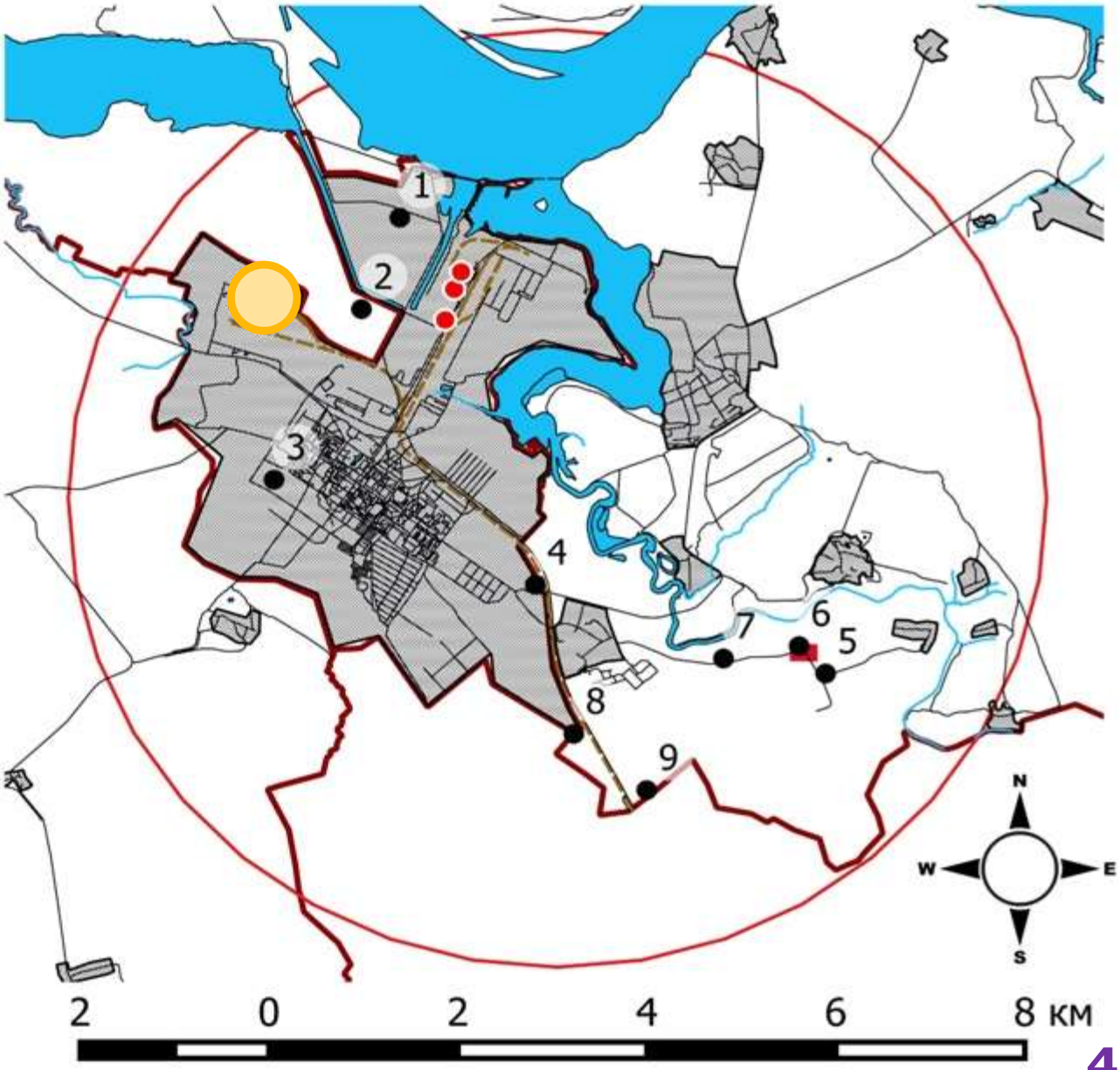
- - Sampling point
- - The power station
- - The town dump
- - Pipe Plant

Population: 16768

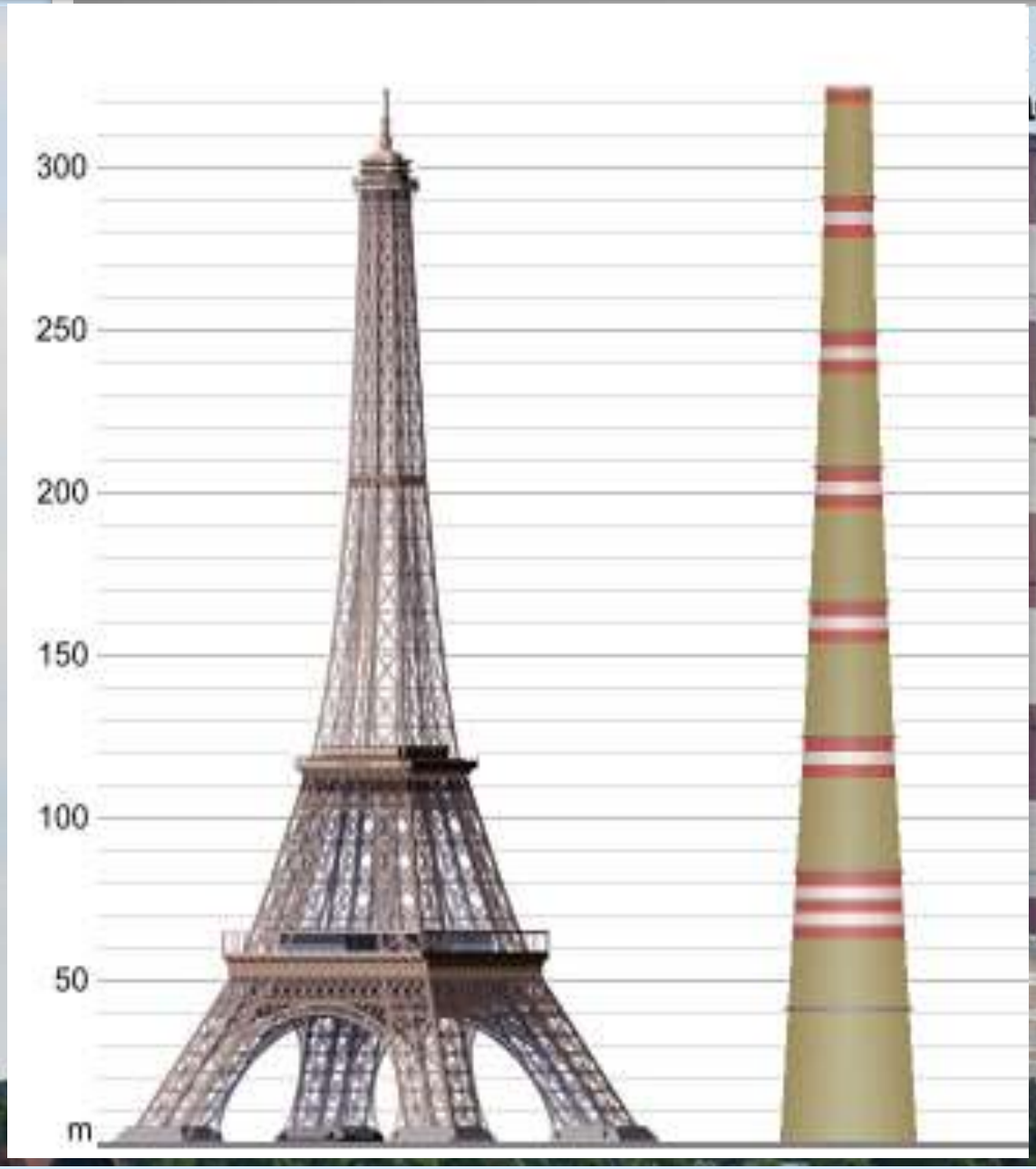
Men	7498
Women	9275
Children	2515

District Square:
17,8 km²

9 sampling point



Kostroma's power station characteristics



Electric power: 3600 MW

ermal power: 450 Gcal / h

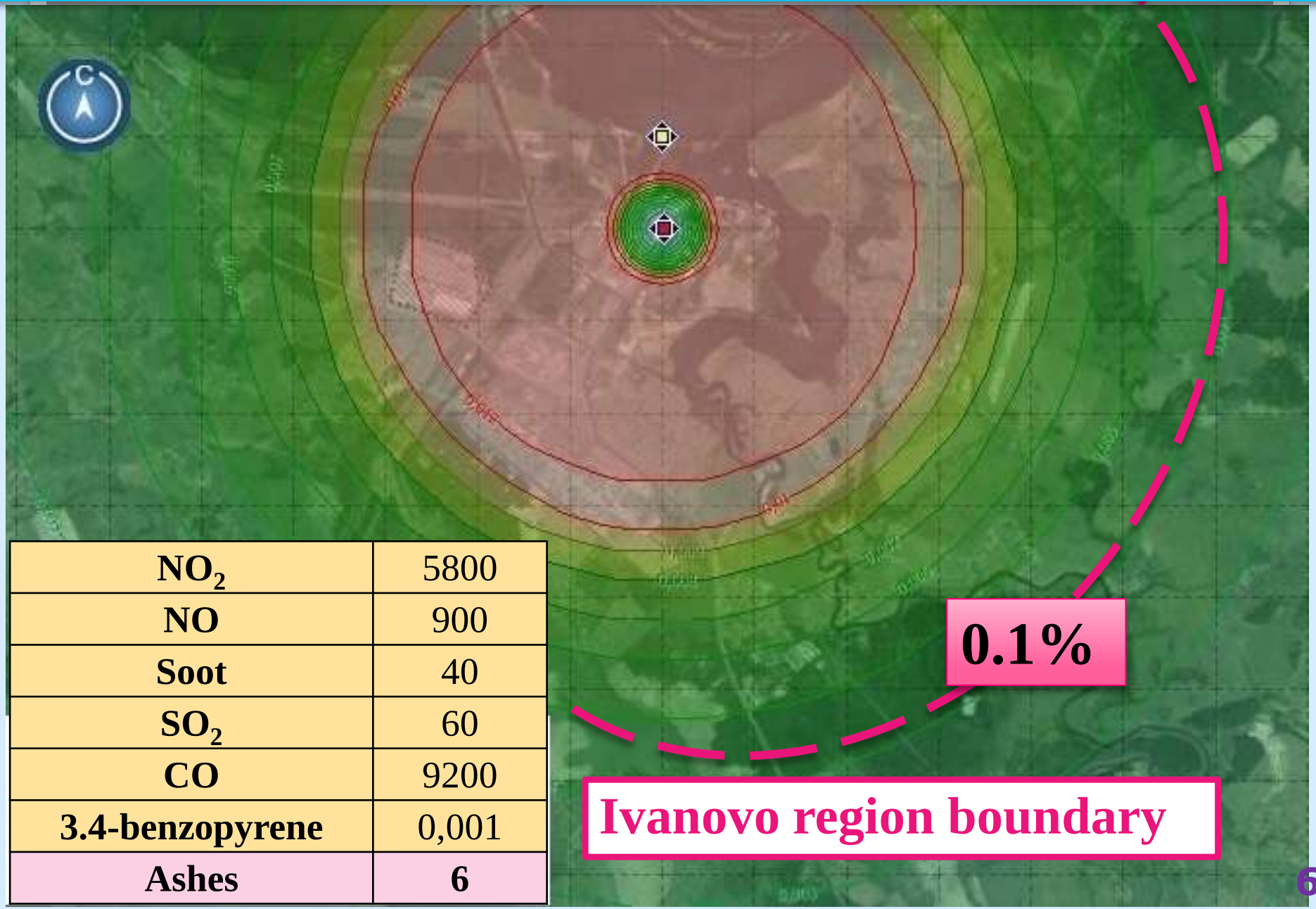
Fuel: natural gas
fuel oil

Total emissions:
16000 tons per year

Tgas.=150 C

V=0.3m3/sec

Total emissions from power station, (ton per year)

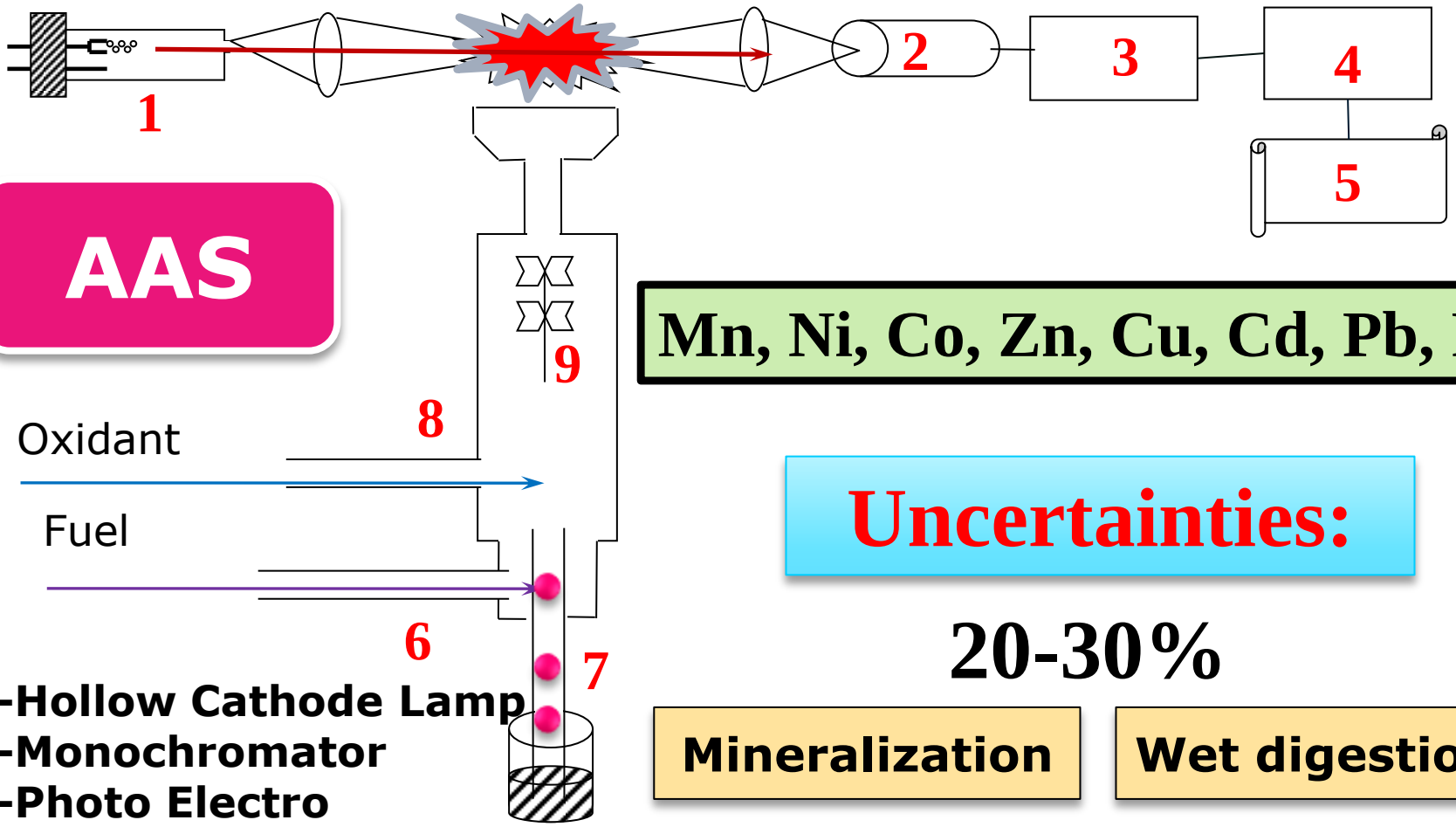


NO_2	5800
NO	900
Soot	40
SO_2	60
CO	9200
3.4-benzopyrene	0,001
Ashes	**6**

0.1%

Ivanovo region boundary

Atomic absorption spectroscopy (AAS)



AAS

Mn, Ni, Co, Zn, Cu, Cd, Pb, Fe

1-Hollow Cathode Lamp
2-Monochromator
3-Photo Electro Multiplier
4-Amplifier
5-Selfrecorder
7- Sprayer
9-Spraying chamber

Uncertainties:

20-30%

Mineralization

Wet digestion

Extraction

1M HNO_3

Buffer pH = 4,8

Metals content in soils of Volgorechensk town (mg/kg)

M	Mean		Min-Max		MPC_S (Gross)
	Gross	Mov.	Gross	Mov.	
Mn	207±62	101.4±30	98.6-296	63-140	**1500**
Ni	14.6±4.3	7.1±2.1	5.1-19.6	1-14	**80**
Co	15.6±4.7	7.1±2.1	3.5-35.2	0.7-22.5	**-**
Zn	57.2±17	11±3.3	15.3-134	2-19.6	**220**
Cu	4.9±1.4	1.6±0.5	2.7-7.1	0.1 -3.9	**132**
Cd	1.1±0.33	0.9±0.26	1.02-1.3	0.53-1.2	**2**
Pb	6.4±1.9	2.4±0.7	1.7-13.4	0.14-7.3	**32**
Fe	5840±1752	55±16	3086-9600	20-115	**-**

Metals content in soil of Back Ground areas in Russia (mg/kg)

Metals	Mn	Ni	Co	Zn	Cu	Cd	Pb
Volgorechensk	207	14.6	15.6	57.2	4.9	1.1	6.4
BG [1]	650	5					
BG [2]	270						
	-	3					
BG [3]	311	4					

The possible source of these elements **-the power station activity**

[1]-Methodical instructions for hea
Approved by the Deputy Minister o
[2] SP 11-102-97. Engineering and
enacted on 15 August 1997;
[3]-Yearbook. Soil contamination of the Russian Federation toxicants of industrial origin in 2013. Obninsk: FGBI "VNIIGMI-" CD "2014g.112 p.

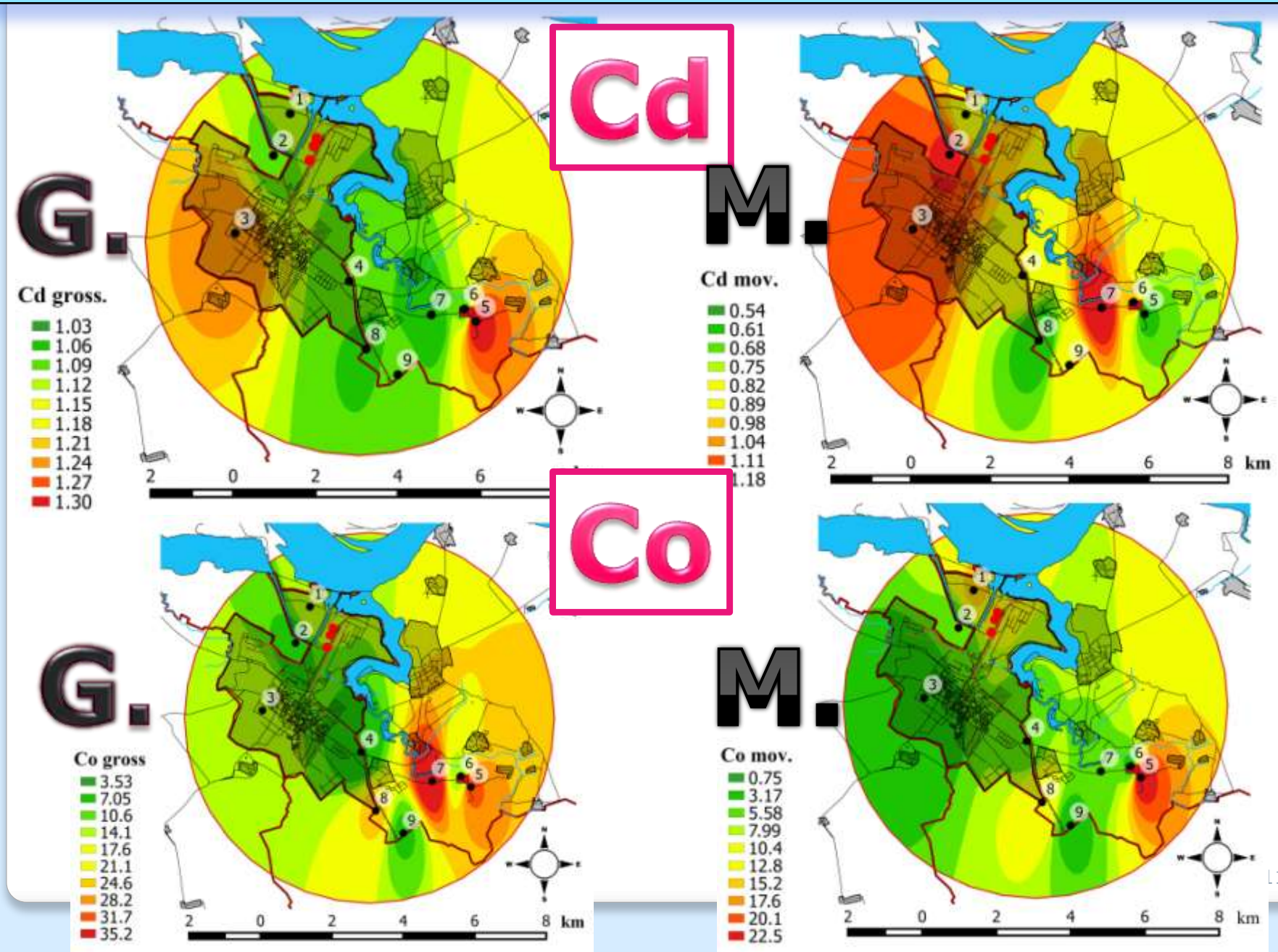
The metals content in soil of Ivanovo and neighboring areas in Russia, (mg/kg)

Metals	Volgorechensk	Ivanovo region	Vladimir region	Nizhny Novgorod region	RF
Mn	207	260			
Fe	5840	3060			
Co	15.6	34.7			
Ni	**14.6**	12.4			
Cu	4.9	5.9			
Cr	-	56.8			
Pb	6.4	5.7			
Zn	**57.2**	43.7			
Cd	**1.1**	0.5	-	0.4	0.3

The possible sources of these elements:

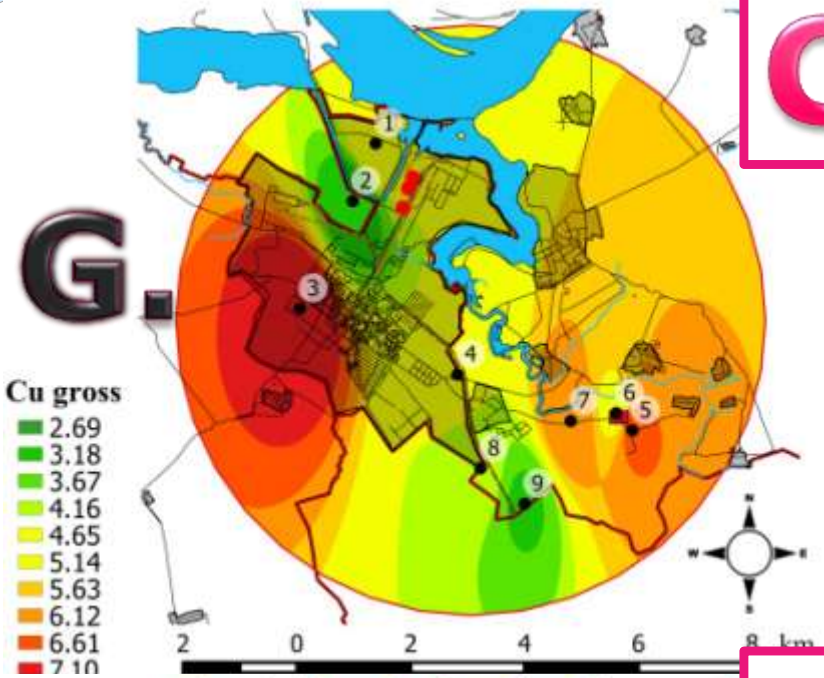
-influence from the power station
-emission from the pipe plant

Maps of the spatial distribution

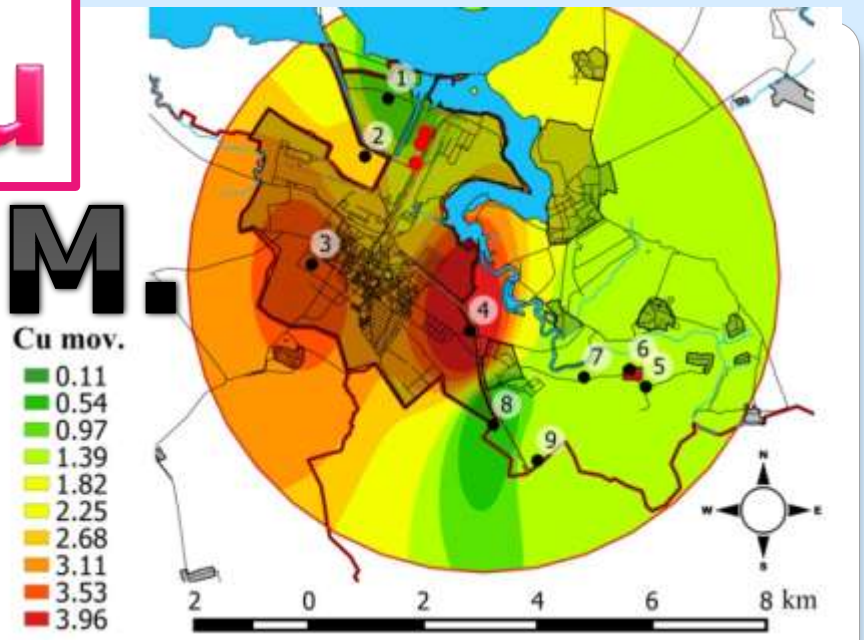


Cu

G.

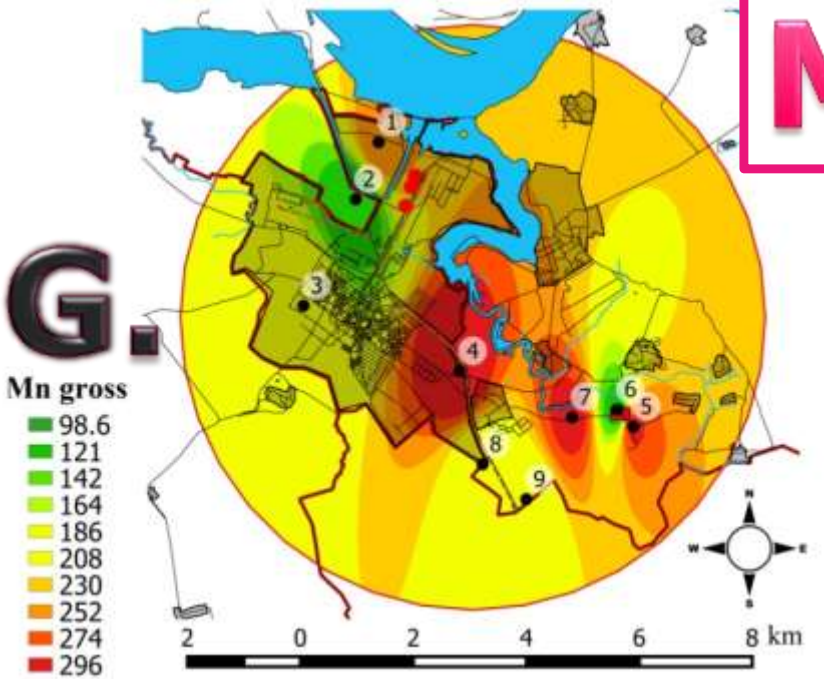

Cu gross
2.69
3.18
3.67
4.16
4.65
5.14
5.63
6.12
6.61
7.10
1
2
3
4
5
6
7
8
9
2 0 2 4 6 8 km

M.

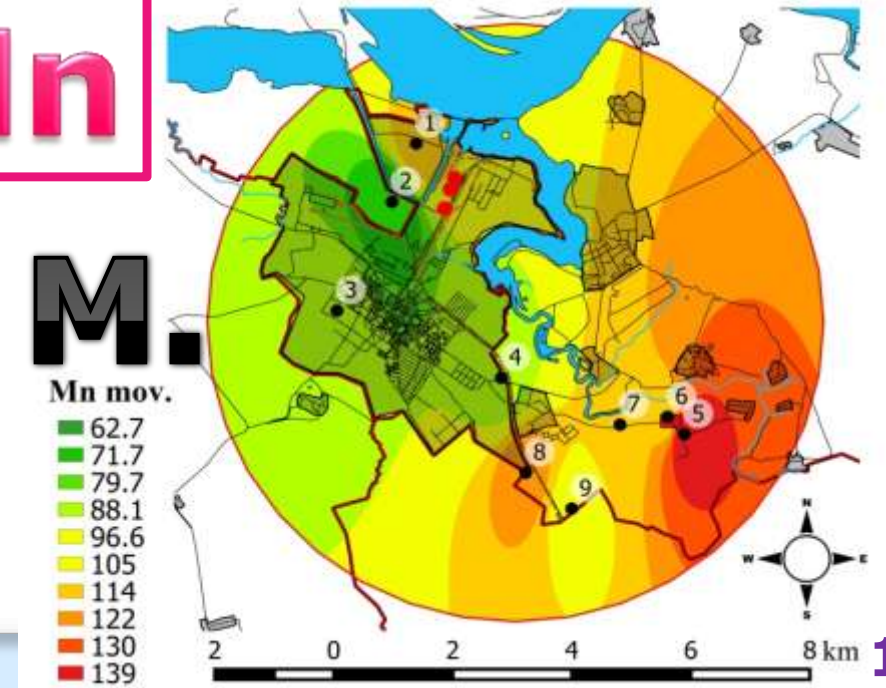

Cu mov.
0.11
0.54
0.97
1.39
1.82
2.25
2.68
3.11
3.53
3.96
1
2
3
4
5
6
7
8
9
2 0 2 4 6 8 km

Mn

G.

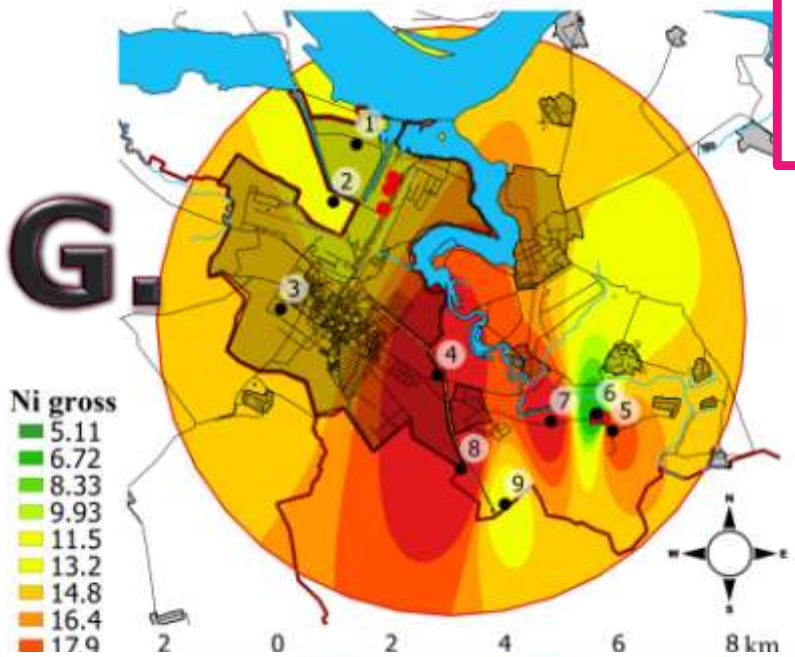

Mn gross
98.6
121
142
164
186
208
230
252
274
296
1
2
3
4
5
6
7
8
9
2 0 2 4 6 8 km

M.

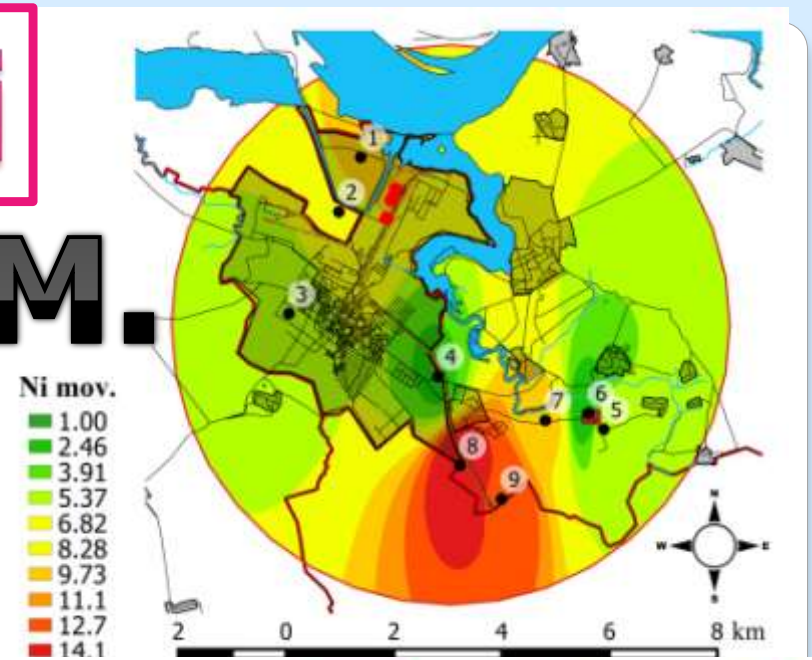

Mn mov.
62.7
71.7
79.7
88.1
96.6
105
114
122
130
139
1
2
3
4
5
6
7
8
9
2 0 2 4 6 8 km

Ni

G.

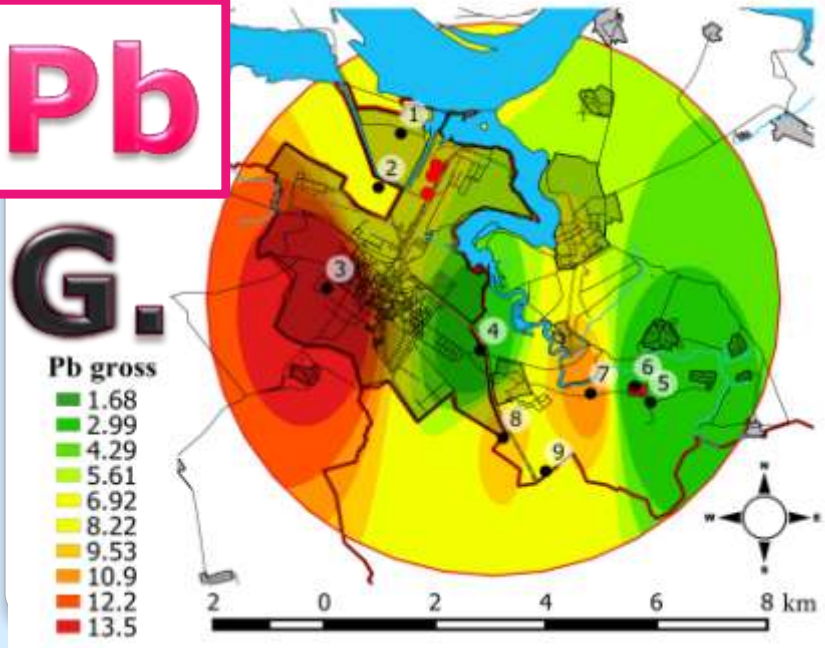

Ni gross
5.11
6.72
8.33
9.93
11.5
13.2
14.8
16.4
17.9
1
2
3
4
5
6
7
8
9
2 0 2 4 6 8 km

M.


Ni mov.
1.00
2.46
3.91
5.37
6.82
8.28
9.73
11.1
12.7
14.1
1
2
3
4
5
6
7
8
9
2 0 2 4 6 8 km

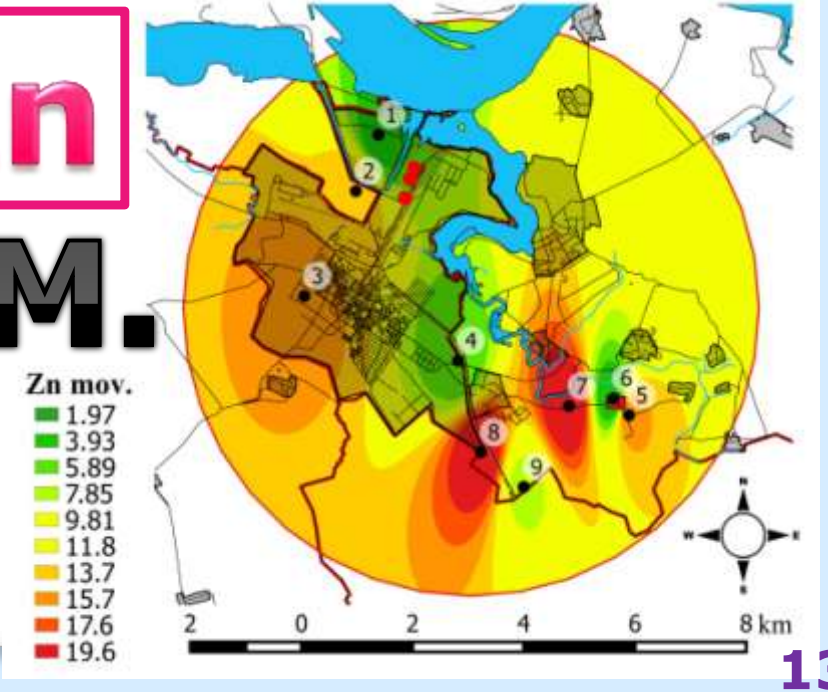
Pb

G.


Pb gross
1.68
2.99
4.29
5.61
6.92
8.22
9.53
10.9
12.2
13.5
1
2
3
4
5
6
7
8
9
2 0 2 4 6 8 km

Zn

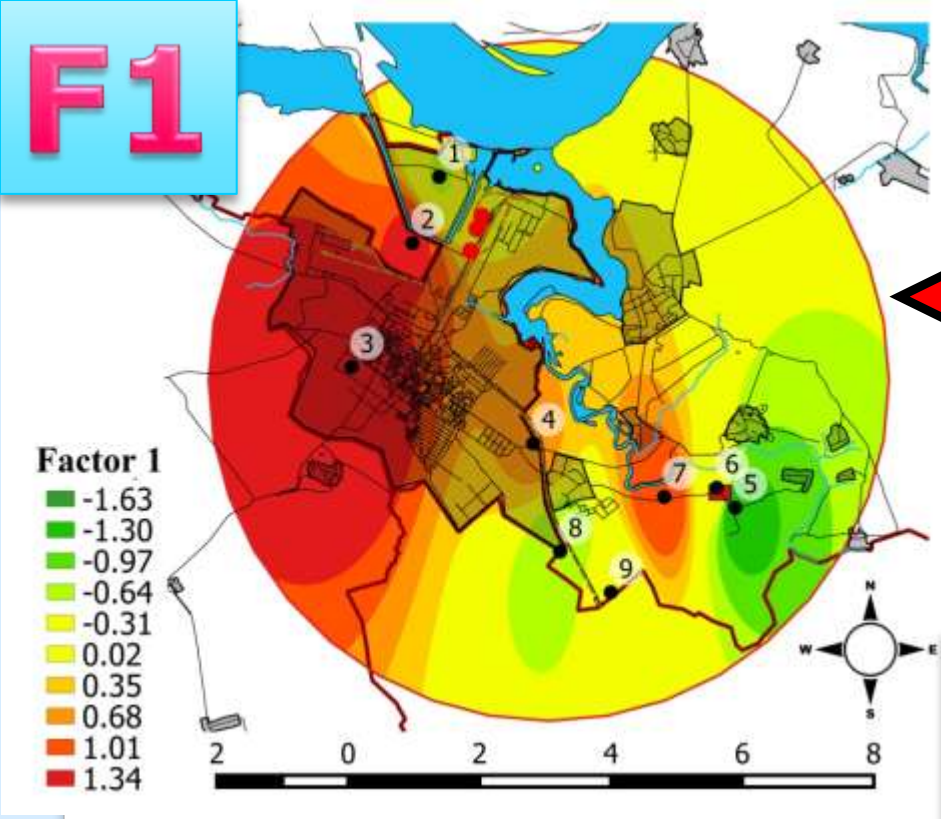
M.


Zn mov.
1.97
3.93
5.89
7.85
9.81
11.8
13.7
15.7
17.6
19.6
1
2
3
4
5
6
7
8
9
2 0 2 4 6 8 km

Results of Factor Analysis

	1	2	3	4
Cd_mov	0.900		0.195	-0.201
Mn_mov	-0.850	0.142	0.321	
Co_mov	-0.819		0.264	0.246
Pb_mov	0.726	0.176	0.630	
Cu_mov	0.679	-0.445	-0.355	0.261
Zn_gross	0.259	-0.911	-0.126	
Pb_gross	0.508	0.841		
Ni_mov	-0.322	0.758		0.153
Fe_gross	0.416	0.538	0.315	0.523
Co_gross	-0.268	0.263	0.809	0.292
Fe_mov	-0.125		0.783	
Zn_mov		0.446	0.667	0.339
Ni_gross		0.169	0.224	0.915
Mn_gross	-0.238			0.834
Cd_gross	-0.249			
Cu_gross		0.110	0.300	0.208

F1



Cd (Mov)

Pb (Mov+Gross)

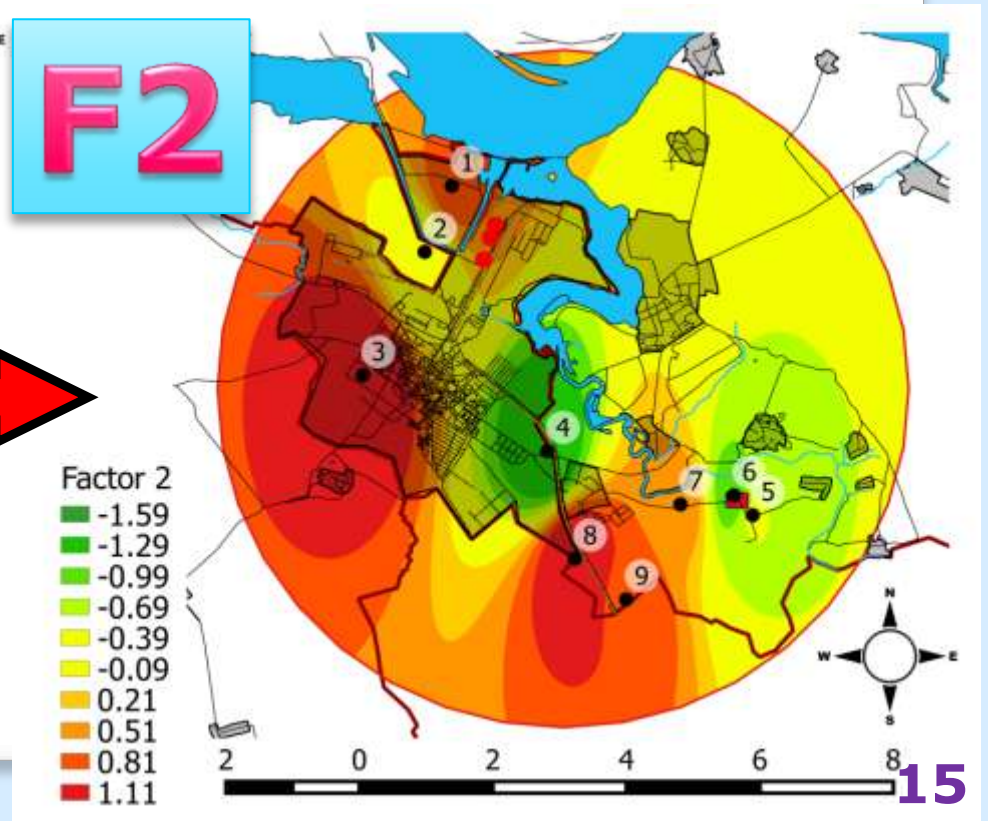
Cu (Mov)

Pb (Gross)

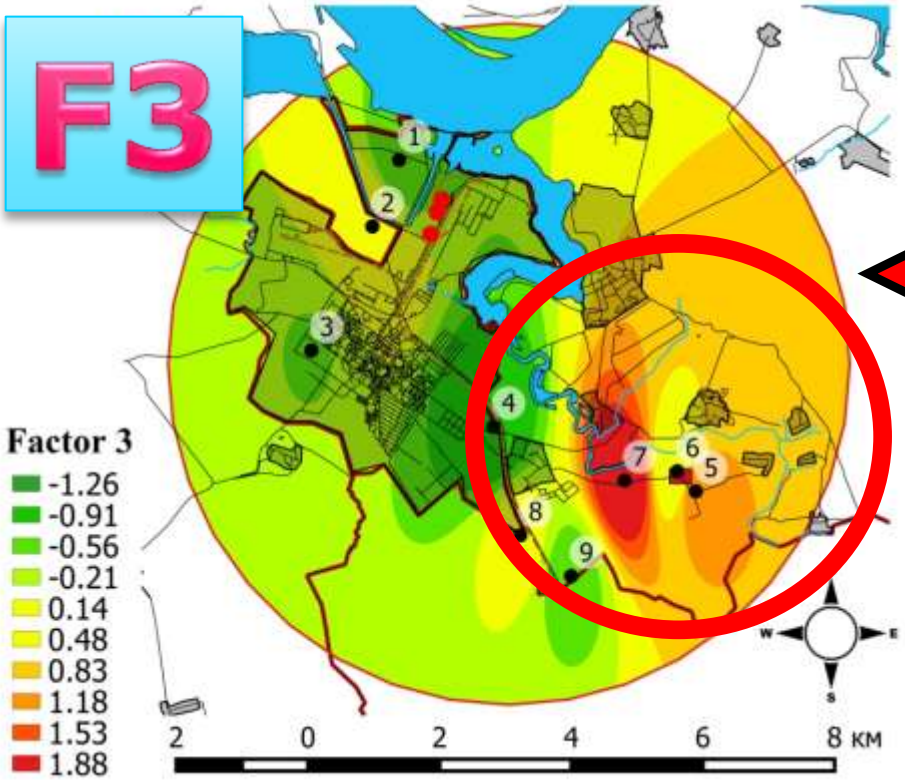
Fe (Gross)

Ni (Mov)

F2



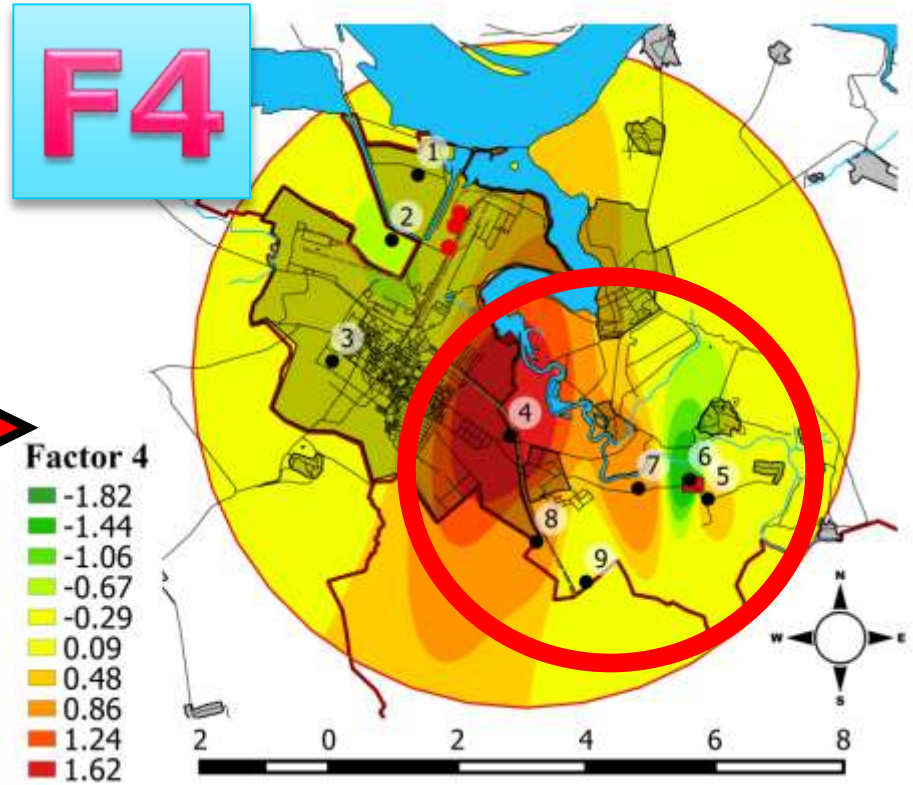
F3



Zn (Mov)
Co (Gross)
Fe (Mov)

Ni (Gross)
Mn (Gross)

F4



Estimation of the environmental risk parameters

Public health risk

- Probability of unfavorable events occurrence (HQ, CR)
- Economic Damage to Health (risks and average cost of living)
- Loss in Life Expectancy (LLE)

HM contained in the soil are able to act on the human health in 2 ways:
on skin (in direct contact with the dust), orally (with dust swallowing)

The calculation was made for 4 groups:
men, women, children and all adult population

Public health risk

Calculation was carried out using standard technique *

(*Human Health Risk Assessment from Environmental Chemicals. Russian Ministry of Public Health, Moscow, RMPH. 2004. R 2.1.10.1920-04)

Calculation of individual carcinogenic risk (**CR**) :

$$CR = LADD \cdot SF;$$

(SF_a) – factors of the carcinogenic potential

LADD – average daily lifetime dose

The risk of non-carcinogenic effects (**HQ**)

$$HQ = AD / RfD;$$

AD - average daily lifetime dose, RfD – reference dose

SF and RfD values are advisory and depend only on the nature of the toxicant and the method of its receipt

Public health risk

Calculation was based on the results of research and census statistical data

Loss in Life Expectancy (LLE).

$$LLE = (T_{cp} - A_{cp}) \cdot (HQ + CR)$$

T_{mean} – average life expectancy of the target population, years;

A_{mean} – the average age of the target group, years;

Economic Damage to Health (risks and average cost of living):

$$R_{MO} = LLE \cdot N \cdot ALC$$

N – the number of people in the group;

ALC – the average living costs, Eur.

$$ALC = GDP_{RUS} / N_{RUS} \cdot T_{Mean}$$

The total average risks of carcinogenic CR and non-carcinogenic effects HQ (Probability)

	HQ	CR	P_{summ}
Adults	$2{,}69 \cdot 10^{-4}$	$2{,}50 \cdot 10^{-5}$	$\mathbf{2{,}94 \cdot 10^{-4}}$
Men	$2{,}69 \cdot 10^{-4}$	$2{,}46 \cdot 10^{-5}$	$\mathbf{2{,}93 \cdot 10^{-4}}$
Women	$3{,}06 \cdot 10^{-4}$	$2{,}91 \cdot 10^{-5}$	$\mathbf{3{,}35 \cdot 10^{-4}}$
Children	$1{,}45 \cdot 10^{-3}$	$8{,}42 \cdot 10^{-5}$	$\mathbf{1{,}54 \cdot 10^{-3}}$

10^{-4}-10^{-3}-Unacceptable risk

Loss in Life Expectancy and Economic Damage to Health

	LLE, days	R, €
Adults	2,8	4386
Men	2,5	3510
Women	3,6	6140
Children	33	52632

Conclusions:

-The average metals content in soils practically unchanged at border areas and did not reach the established normative values MPCs, nevertheless it was noted the exceeding of regional background values indicating a increased level of pollution in the area;

-Analysis of obtained data confirms the contribution of power plant activities to the anthropogenic load, and taking into account the wind rose it explains the high content of toxic substances **(Zn, Ni, Co)** in soils of surrounding areas of the Ivanovo region;

-Analysis of the main parameters of the environmental risk from soil contamination in the Volgorechensk town has revealed a significant level of risk to human health .

Thank you for attention