Professional English

Lecture 8

Elemental composition of dust aerosols

(by the example of Tomsk city)

Anna V. Talovskaya

Associate professor

Candidate of geological and mineralogical science

Tomsk Polytechnic University

Institute of natural recourses Department of Geoecology and Geochemistry

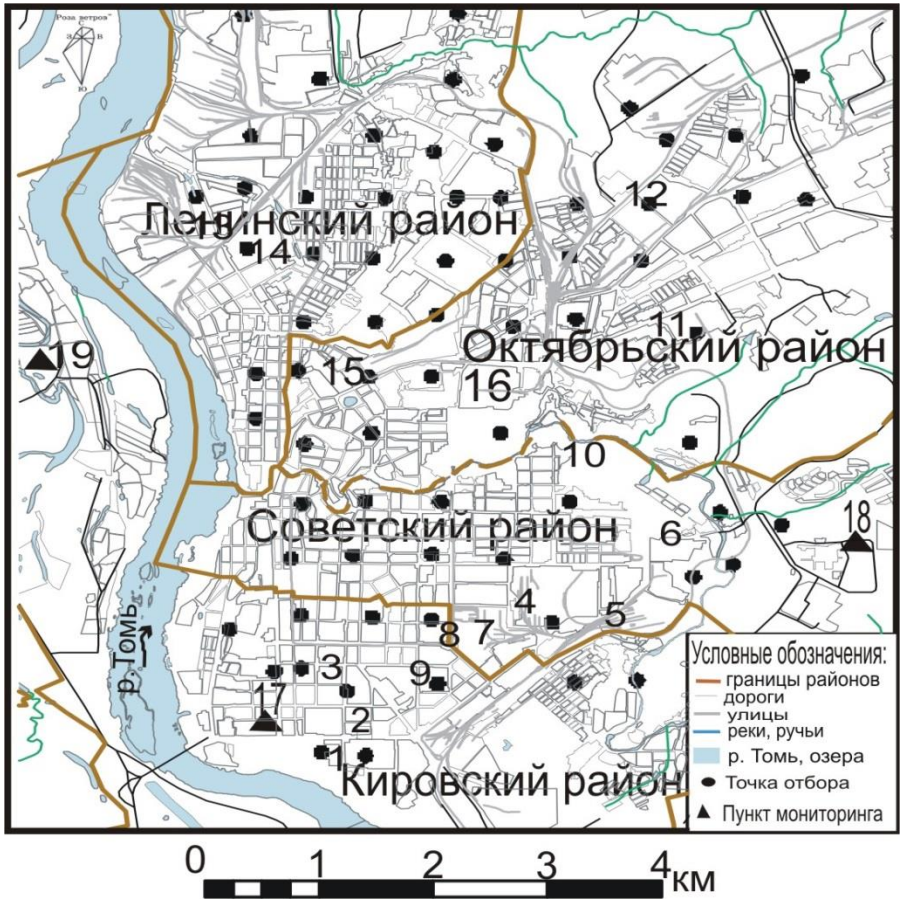
Outline

1. Material and methods.
2. Trace elements concentration in dust aerosol.
3. Radioactive elements concentration in dust aerosol.

1. Material and methods

Map of sampling sites in Tomsk city

Scale of snowgeochemical surveying is 1:50 000



1-16 - plants
17-19 – monitoring points: 17 – campus TPU,
18 – Academgorodok,
19 – village Timiryazevo.

1. ООО «Континентъ».
2. ОАО «Томский инструмент».
3. ОАО «Томский электроламповый завод».
4. Томская «ГРЭС-2».
5. ООО «Завод крупнопанельного домостроения ТДСК».
6. «Эмальпроизводство ЗАО «Сибкабель».
7. ОАО «Манотомь».
8. ОАО «Сибэлектромотор».
9. ФГУП «Томский электротехнический завод» и НПО «Полюс».
10. Золоотвал Томской «ГРЭС-2».
11. ЗАО «Карьероуправление».
12. ОАО «Завод ЖБК-100» и ООО «Керамзит-Т».
13. ОАО «Томский шпалопропиточный завод».
14. ООО «Томский завод резиновой обуви».
15. ЗАО «Сибкабель».
16. ЗАО «Томский подшипник».

The scheme of processing and analysis of snow samples

Snow sampling (pit method)

Snow samples (15-20 kg)

Melting (18-22^{0}C)

Desilting

Filtering

Drying the filter

Sifting

Weighting

Фото: Таловской А.В., Филимоненко Е.А.

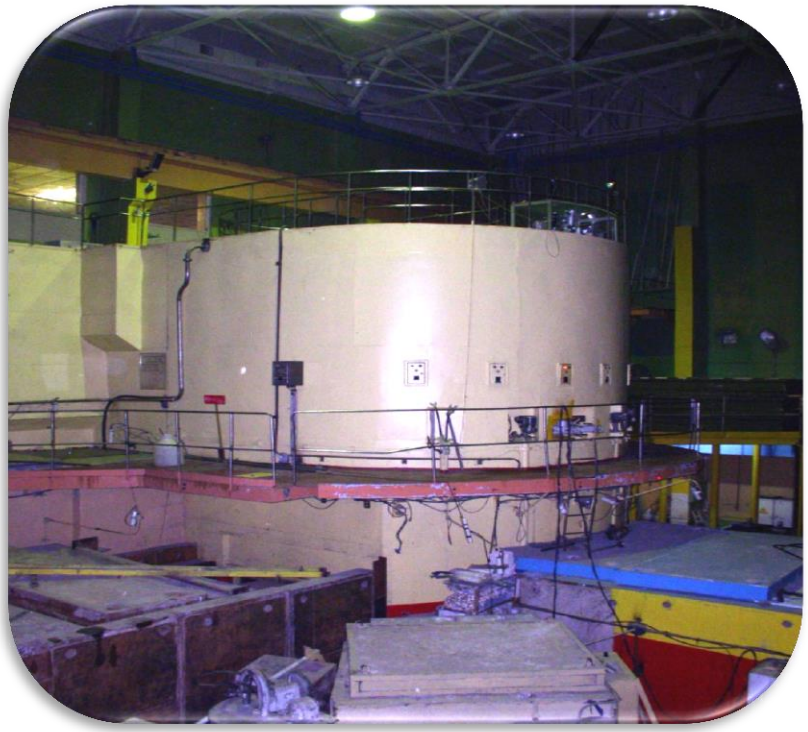
Innovation Scientific-Education Centre “Uranium Geology” (TPU, Department of geoecology and geochemistry)

Laboratories:

- Nuclear-geochemical laboratory
- Electron-optic laboratory
- Isotope spectrometry laboratory
- Microelement Analysis Laboratory
- Geotechnology

Nuclear-geochemical laboratory

Neutron activation analysis is used to determine the concentration of heavy metals (As, Cr, Zn, Co, Sb, Br, Ba, Sr), macro elements (Ca, Na, Fe), rare, rare earth elements (Rb, Cs, Hf, Ta, Sc, Tb, Sm, Eu, La, Ce, Yb, Lu, Nb), radioactive elements (U, Th) and Br, Au, Ag.



research nuclear reactor of TPU

Power of reactor is 6 MWt

Flow of thermal neutron is $1.2*10^{14}$ $n*sm^2/sec$

Quantity of canals is 24, including 10 horizontal, 14 vertical ones

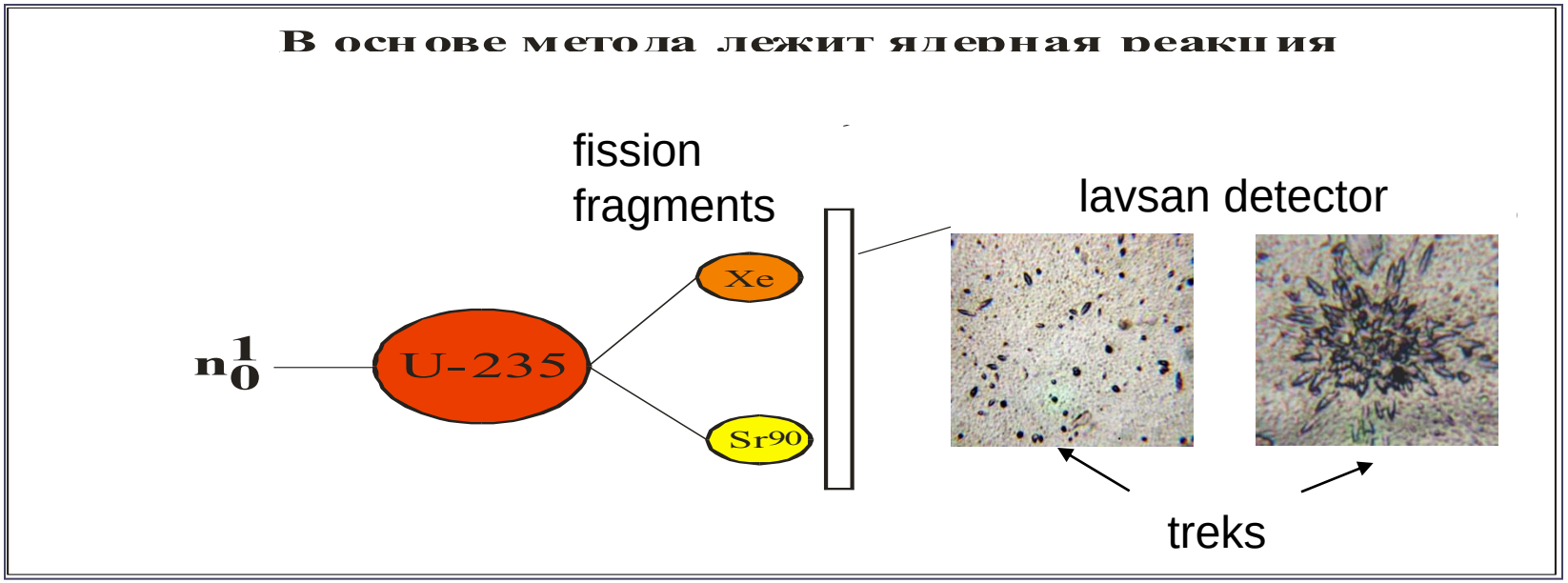
Wight of samples for analysis – 100 mg

Analysts – Sudyko A.F., Bogutskaya L.F.

The lower detection limits of element concentration in natural environments using INAA method

Element	Detection limit, mg/kg	Element	Detection limit, mg/kg
Na	20	Ta	0,05
Ca	300	Sc	0,02
Fe	100	Tb	0,05
As	1	Sm	0,01
Co	0,1	Eu	0,01
Cr	0,2	La	0,03
Sb	0,2	Ce	0,05
Ba	8	Yb	0,1
Br	0,3	Lu	0,01
Rb	0,6	U	0,1
Cs	0,3	Th	0,2
Sr	7	Au	0,01
Hf	0,01	Ag	0,5

The ***f- radiography*** method is a unique method of the fissionable radionuclides (^{235}U, ^{239}Pu, ^{241}Am) analysis.



The method allows to determine with high accuracy the quantitative contents of fissionable radionuclides, their modes of occurrence (dispersed or concentrated) in researched object.

Microelement Analysis Laboratory

Atomic absorption method is used to determine mercury concentration.

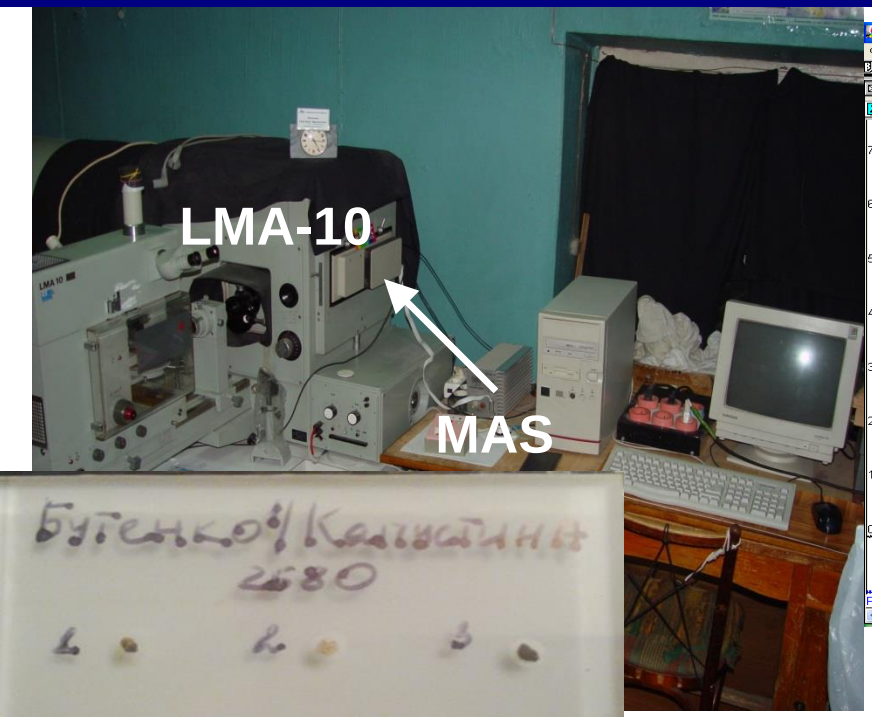
mercury analyzer RA-915+

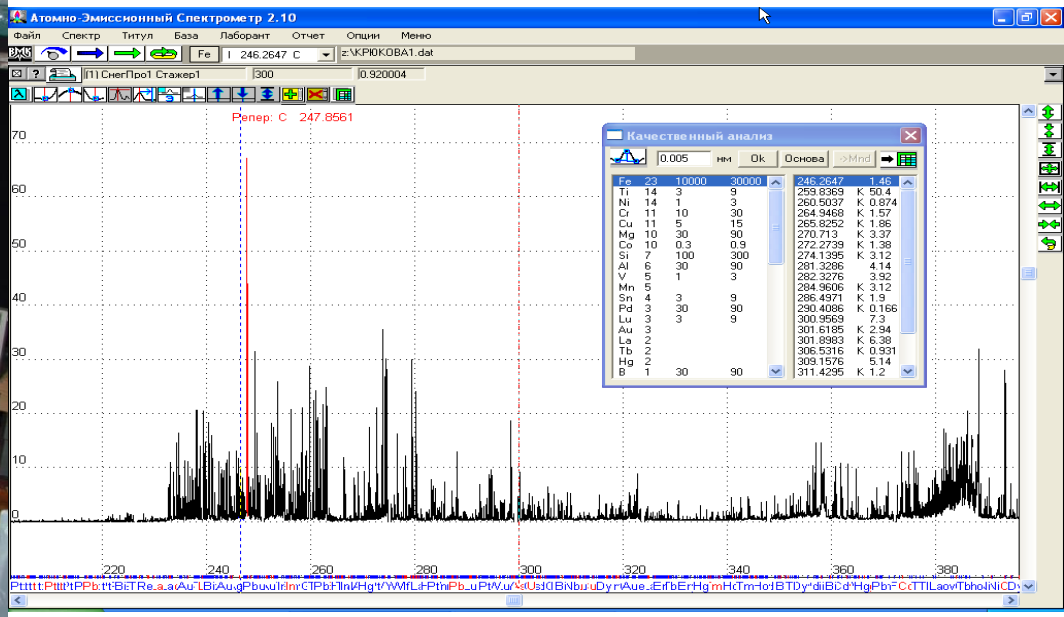
- ultra low detection limit;
- high selectivity of analysis;
- direct continuous mercury detection (without preliminary mercury concentration on a sorbent);
- capability of the operation in the field using a built-in battery;
- user-friendly computer interface;
- background monitoring of mercury vapour;
- direct analysis of complex gas mixtures;
- on-line measurements;
- wide dynamic range of the direct measurements;
- measurements from moving objects;
- data logger.

Microelement Analysis Laboratory

Laser spectral analysis on installation LMA-10

Allows to investigate the chemical composition of the particles in samples.

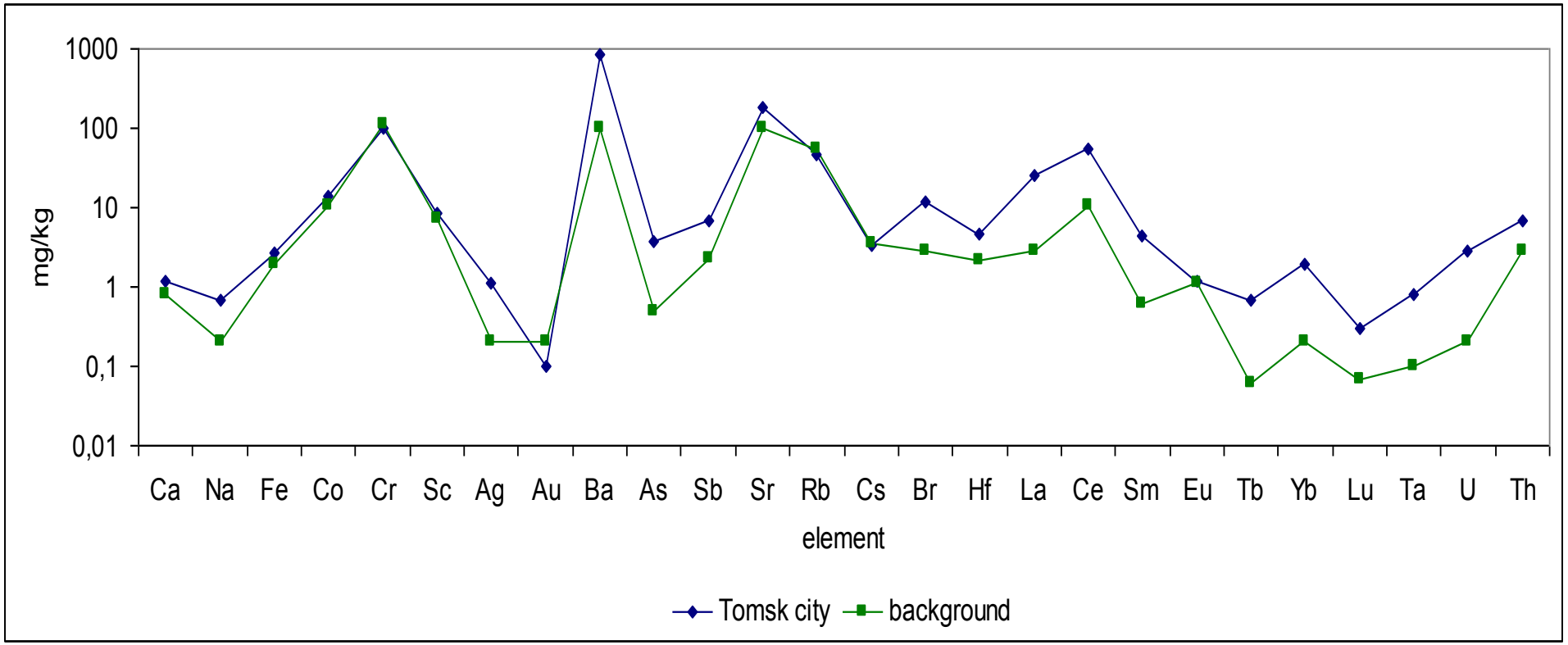




the specimen for LMA analysis

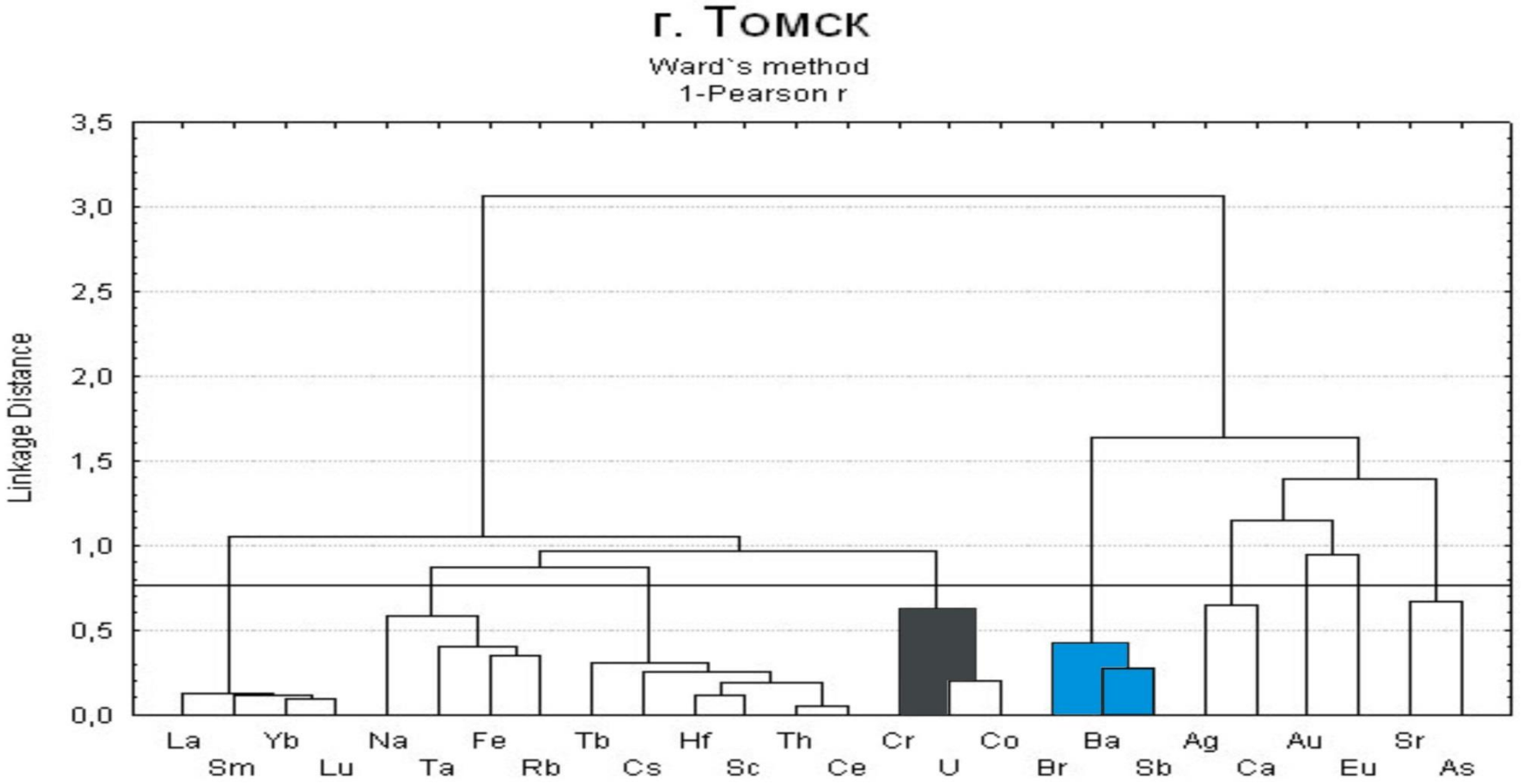
2. Trace elements concentration in dust aerosol

The average contents of element in dust aerosols of Tomsk city



According to data of neutron activation analysis. Ca, Ne, Fe - %

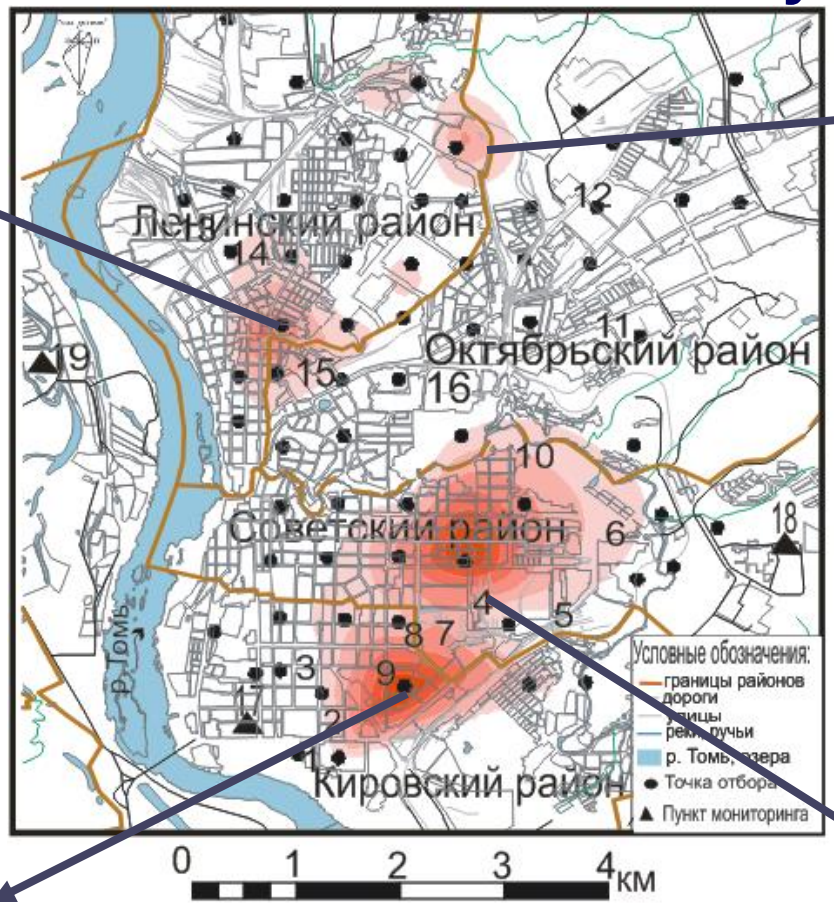
Association links of trace elements in dust aerosols of Tomsk-city



(1-$r_{0,05}$ = 0,77, n = 69)

The scheme of Hg concentration distribution in dust-aerosols of Tomsk city

Local boiler plant



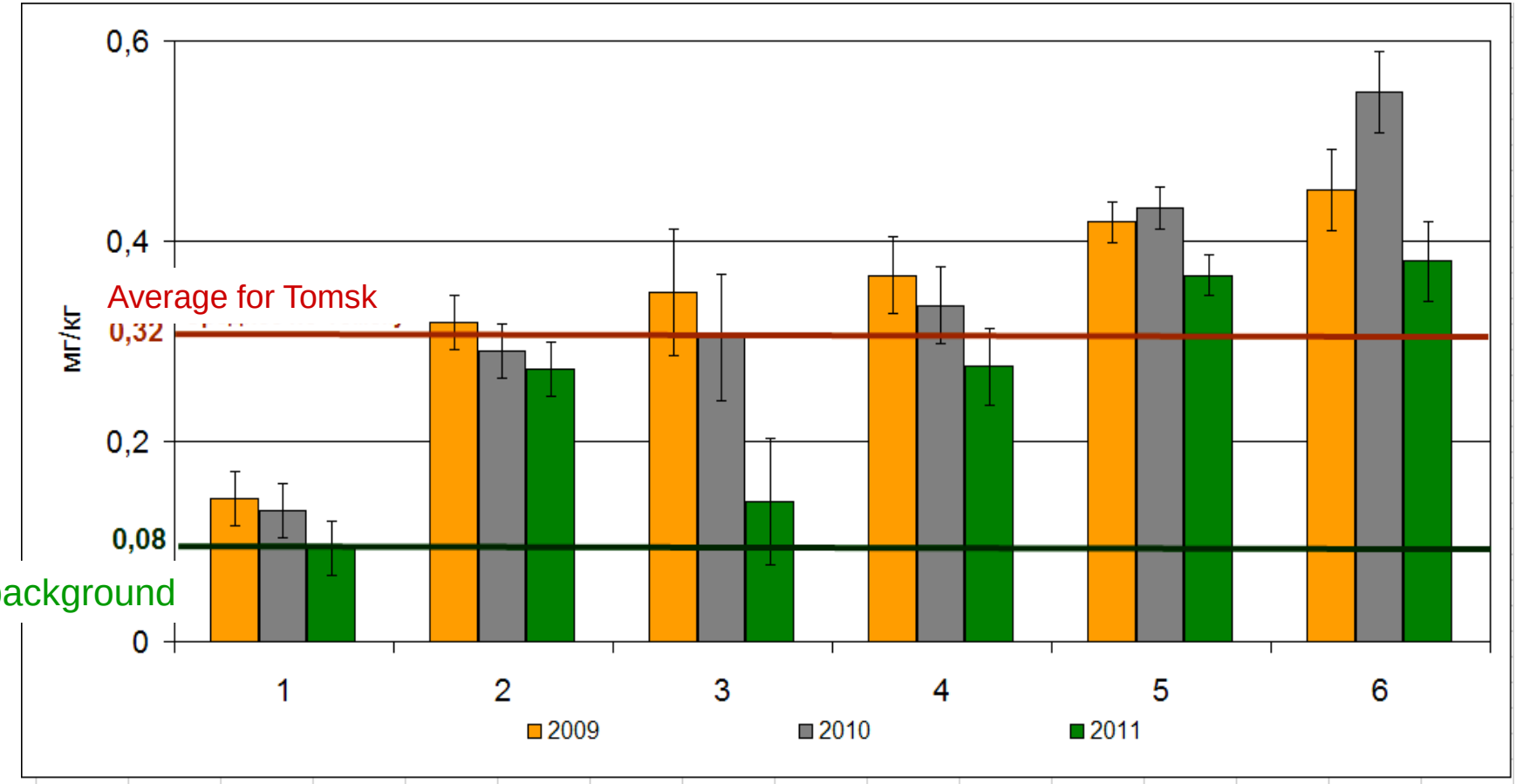
reinforced concrete plant

mechanical engineering plants with foundry and plants produsing manometers

power thermo electrical stationГРЭС-2

Background value 0.08 мг/кг, п. Киреевск

Hg concentration in dust aerosols plants impact zone in Tomsk city, mg/kg



1 –construction plants, **2** – v. Kaltai, **3** – power thermo electrical stationГРЭС-2, **4** – reinforced concrete plant , **5** – campus TPU, **6** – petrochemical plant ООО «Томскнефтехим»

Concentration coefficient (KK)

$$KK = C / C_b$$

C – element concentration, mg/kg;

Cb – background value of element concentration, mg/kg.

Geochemical row of element association from the highest value to the lowest value

Impact zone	*concentration coefficient*			
	More than 10	10..5	5..3	3..1
Construction plants	$Tb_{16.2}$ - $U_{16.1}$ - Yb15.2 - As12.7 - La11.5	Sm9.9 - Ta9.7 - Na7.9 - Ce6.9 - Ba6.4 - Lu5.9	Hf3.5 - Th3.1	Sc1.8 - Fe1.5 - Ca1.5 - Hg1.2
reinforced concrete plants	U22 - As16.8 - Tb13.1 - Yb12.5 - La12.1	Ta9.6 - Sm9.1 - Ba7.5 - Ce6.7 - Na5.1	Lu4.6 - Hg3.9 - Sr3.8 - Ca3.1 - Sb3.1 - Th3	Hf2.6 - Co1.9 - Fe1.5
Power station Tomskaya GRES-2	U21.2 - Tb13.9 - As13.8 - Yb13 - La11.6	Ta9.5 - Sm9.3 - Ba7.4 - Ce6	Lu4.7 - Sr4 - Hg3.5 - Na3.4 - Th3	Sb2.1 - Hf1.9 - Co1.8 - Ca1.7 - Fe1.6 - Br1.5
Petrochemical plant	U26.2 - Tb16.6 - Yb16.2 - La15.3 - Ta13 - Sm11.3	As9.7 - Ba8.5 - Ce8.3 - Lu5.9 - Hg5.1	Th4.7 - Na4.1 - Hf3.3 - Br3	Sr2.1 - Fe1.9 - Sb1.6 - Cs1.4
Tomsk city	U13,8–Tb11,5	Yb9,5–La9–Ba8,6–Ta8,1–As7,6–Sm7,6–Ce5,2	Na4,5–Ag4,3–Br4,2–Lu4,1–Hg4,2-Sb3	Th2,3–Hf2,1–Sr1,8–Ca1,5–Fe1,4–Co1,3–Sc1,2–Eu1,1–Cs1–Cr0,9–Rb0,8–Au0,3

Total pollution environment factor (Zc)

$$Z_c = \sum KK - (n-1)$$

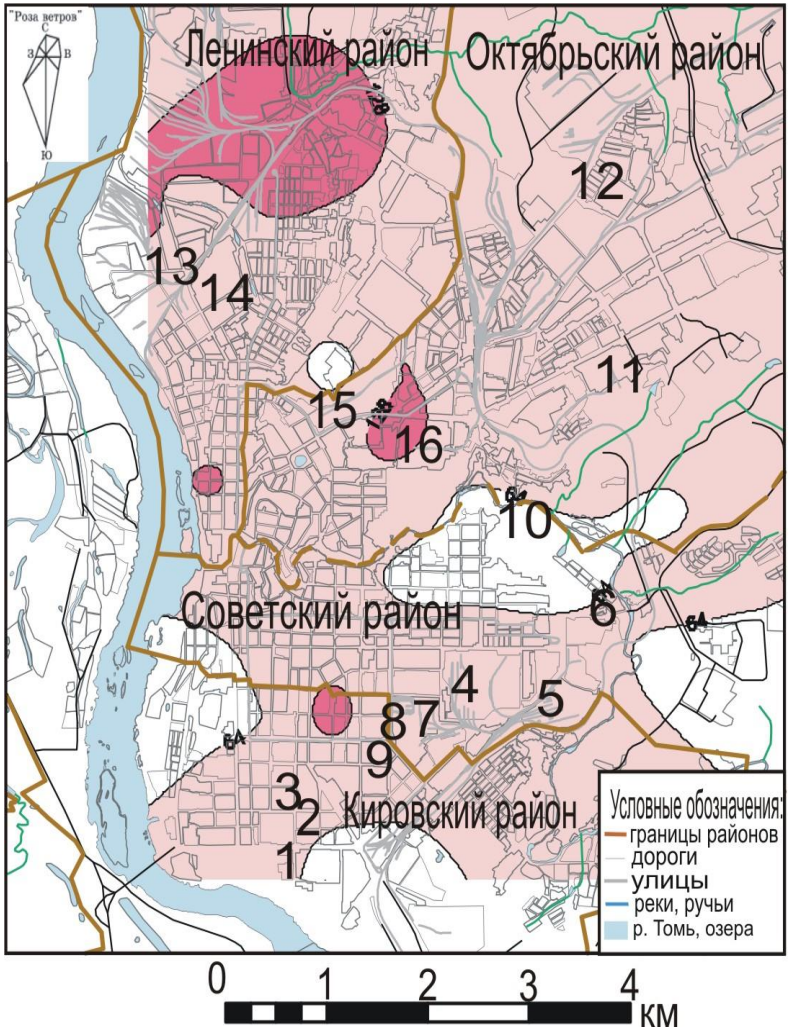
KK – factor of element concentration

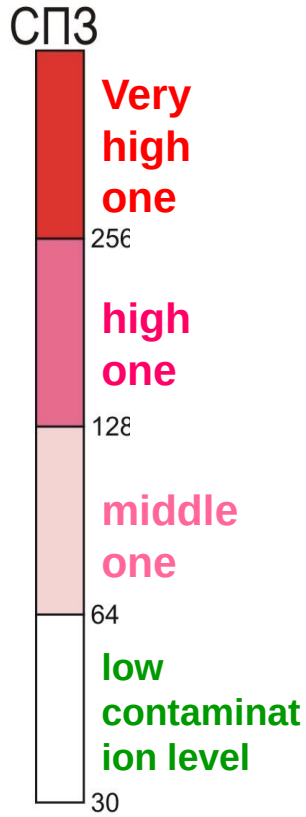
n – a number of elements having the KK values more than 1

contamination levels of total pollution factor

- less than 64 – low contamination level;
- 64-128 – middle one;
- 128-256 – high one;
- more than 256 – very high one

The scheme of total pollution environment factor value distribution in Tomsk city

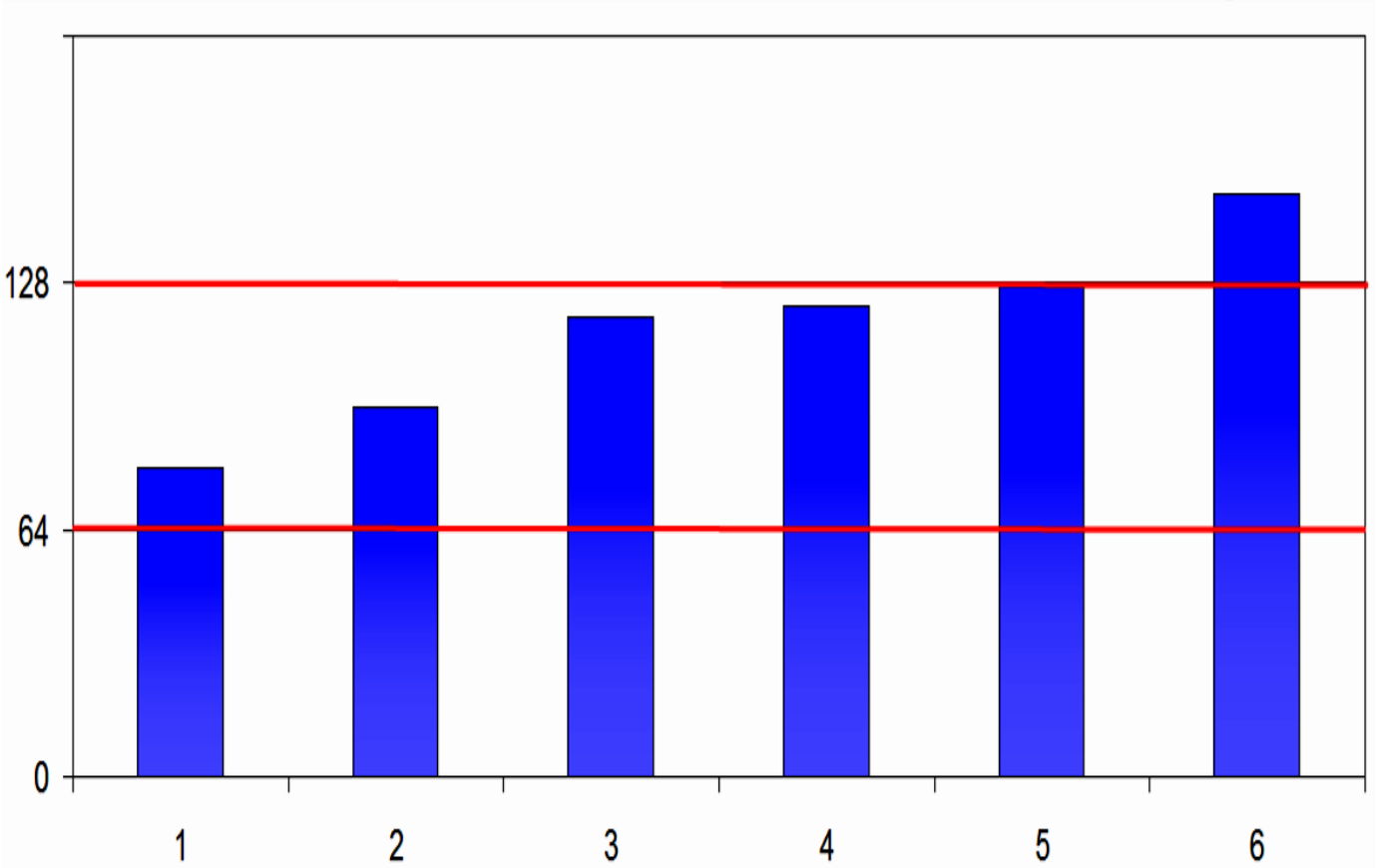




1. ООО «Континентъ».
2. ОАО «Томский инструмент».
3. ОАО «Томский электроламповый завод».
4. Томская «ГРЭС-2»
5. ООО «Завод крупнопанельного домостроения ТДСК».
6. «Эмальпроизводство ЗАО «Сибкабель».
7. ОАО «Манотомь».
8. ОАО «Сибэлектромотор».
9. ФГУП «Томский электротехнический завод» и НПО «Полюс».
10. Золоотвал Томской «ГРЭС-2»
11. ЗАО «Карьероуправление».
12. ОАО «Завод ЖБК-100» и ООО «Керамзит-Т».
13. ОАО «Томский шпалопропиточный завод».
14. ООО «Томский завод резиновой обуви».
15. ЗАО «Сибкабель».
16. ЗАО «Томский подшипник».

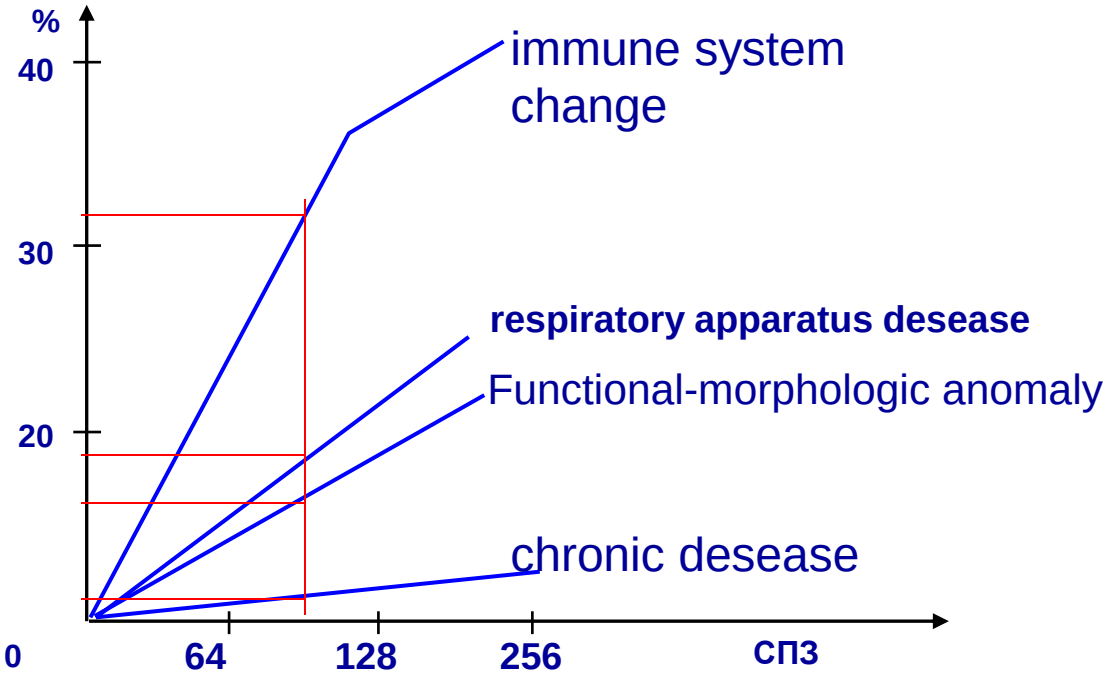
Average - 93

Total pollution factor value in plants impact zone in Tomsk city



1 – south part of Tomsk region, **2** – Tomsk city, **3** – Construction plants, **4** – power thermo electrical station ГРЭС-2, **5** – reinforced concrete plants, **6** – petrochemical plant ООО «Томскнефтехим»

Forecast children morbidity according to the value of total pollution factor



total pollution factor in Tomsk city - 93.

In the impact zone of
-construction plants – 115
-petrochemical plant – 140
-power station - 115

- less than 64 – safety morbidity level; lower change of children's health;
- 64-128 – mildly unsafe one; increase in total morbidity;
- 128-256 – unsafe one; increase in total morbidity and number of illness children;
- more than 256 – immensely unsafe one; very high level of morbidity, there are many children with chronic diseases and abnormalities in physical abilities.

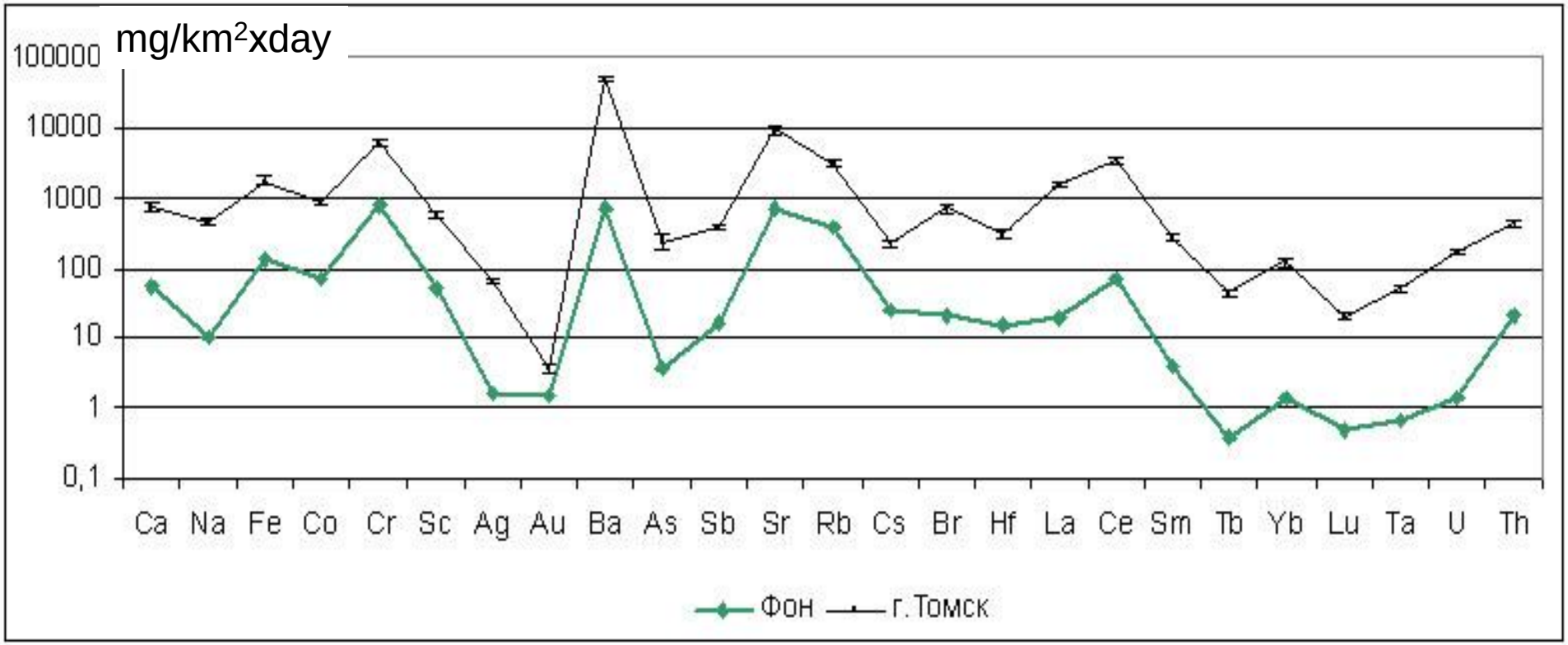
Factor of pollutant (element) load on the environment (P_{total}) (average daily fallout of elements on the city territory)

$$P_{total} = C \times P_n$$ mg/km^2 per day

C – element concentration, mg/kg;

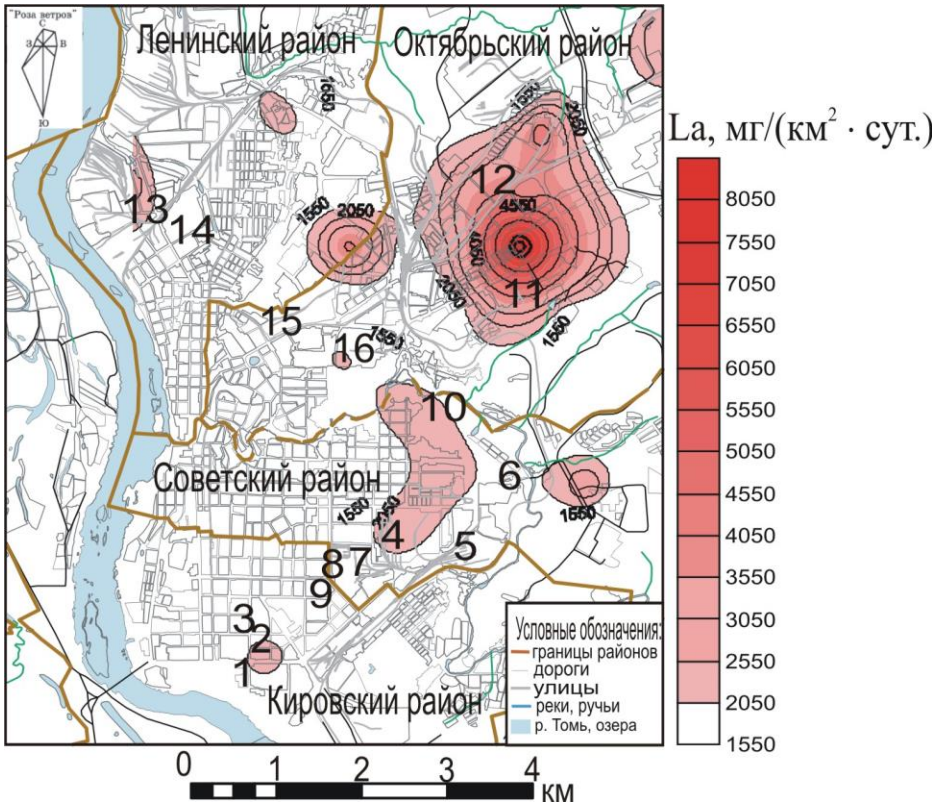
Pn – dust load, mg/m^2 per day

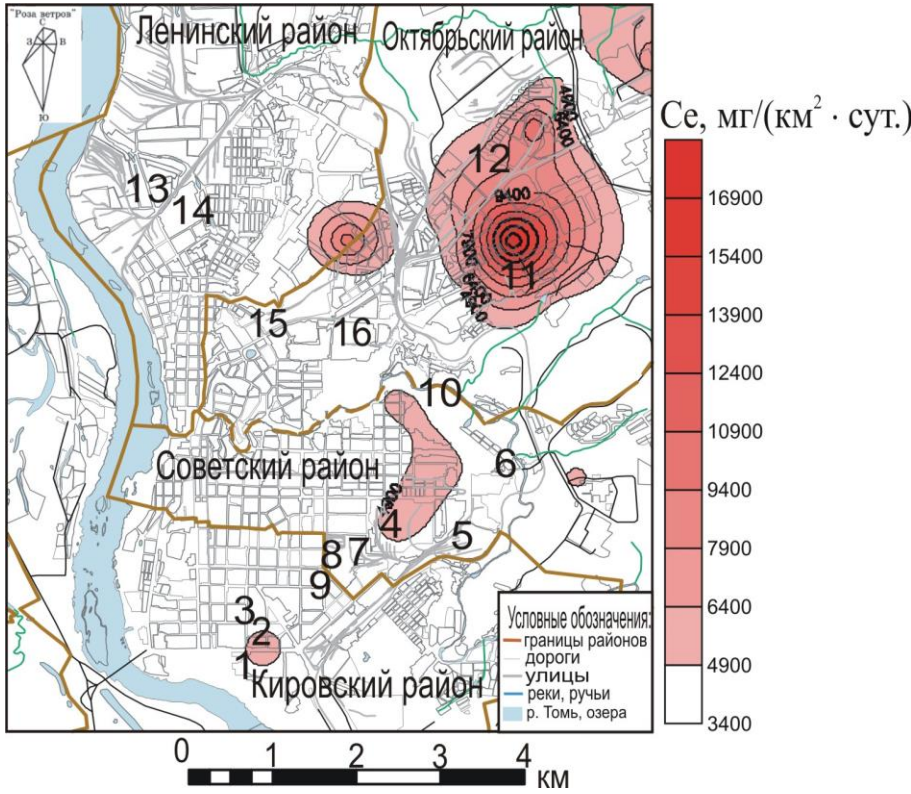
The value of mean daily fallouts of elements on snow in Tomsk city



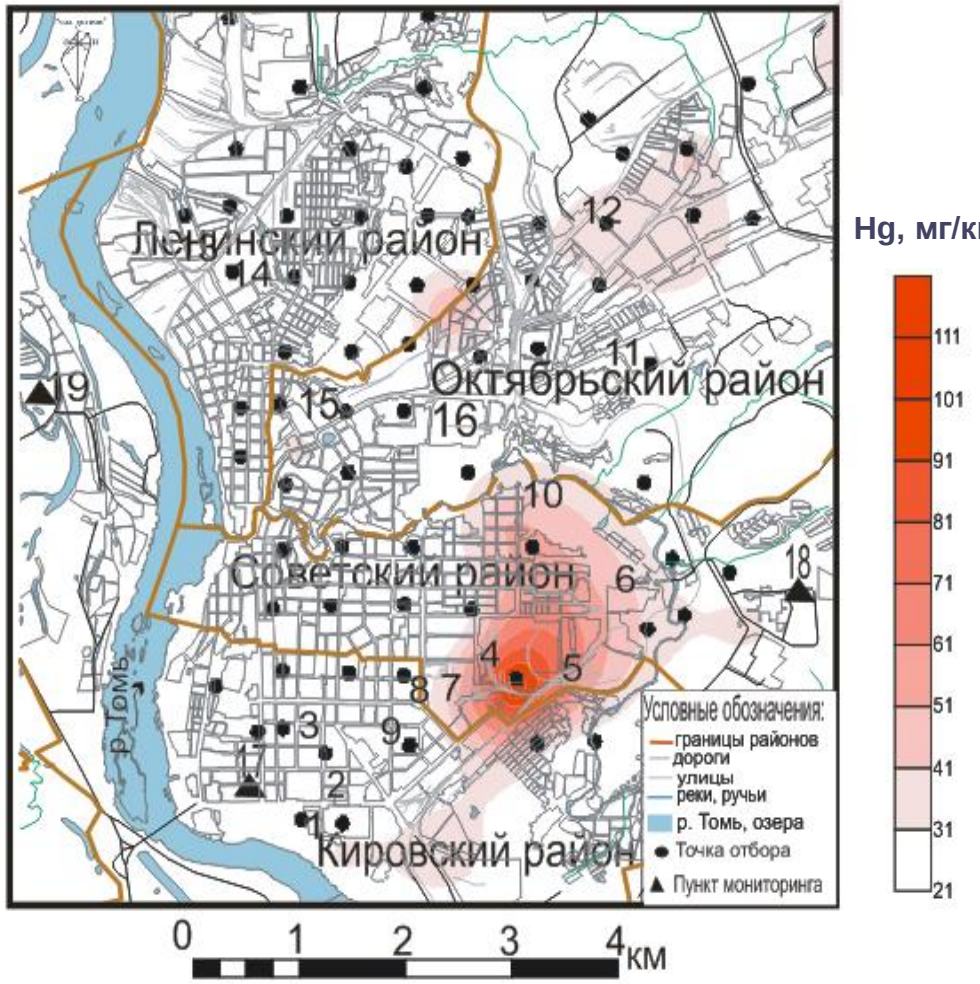
Background value according to А.Ю. Шатилова (2001 г.) с доп. Е.Г. Язикова (2006 г.), Ca, Na, Fe g/km^{2}xday.

The scheme of the value of mean daily fallouts of some elements distribution, mg/km²xday





The scheme of value of mean daily fallouts of mercury distribution



1. ООО «Континентъ».
2. ОАО «Томский инструмент».
3. ОАО «Томский электроламповый завод».
4. ***Томская «ГРЭС-2».***
5. ООО «Завод крупнопанельного домостроения ТДСК».
6. «Эмальпроизводство ЗАО «Сибкабель».
7. ОАО «Манотомь».
8. ОАО «Сибэлектромотор».
9. ФГУП «Томский электротехнический завод» и НПО «Полюс».
10. Золоотвал Томской «ГРЭС-2».
11. ЗАО «Карьероуправление».
12. Асфальтобетонный завод ЗАО «Томский цемент».
13. ОАО «Томский шпалопропиточный завод».
14. ООО «Томский завод резиновой обуви».
15. ЗАО «Сибкабель».
16. ЗАО «Томский подшипник».

Factor of relative increase in total elements load (Kp)

$$K_p = P_{total} / P_b$$

Pb – background value of total element load. It is calculated by the formula:

$$P_b = C_b \times P_{nb}$$

Pnb – background value of dust load, it is 7 kg/km^2 per day for the Tomsk region

Factor of total element load (Zp)

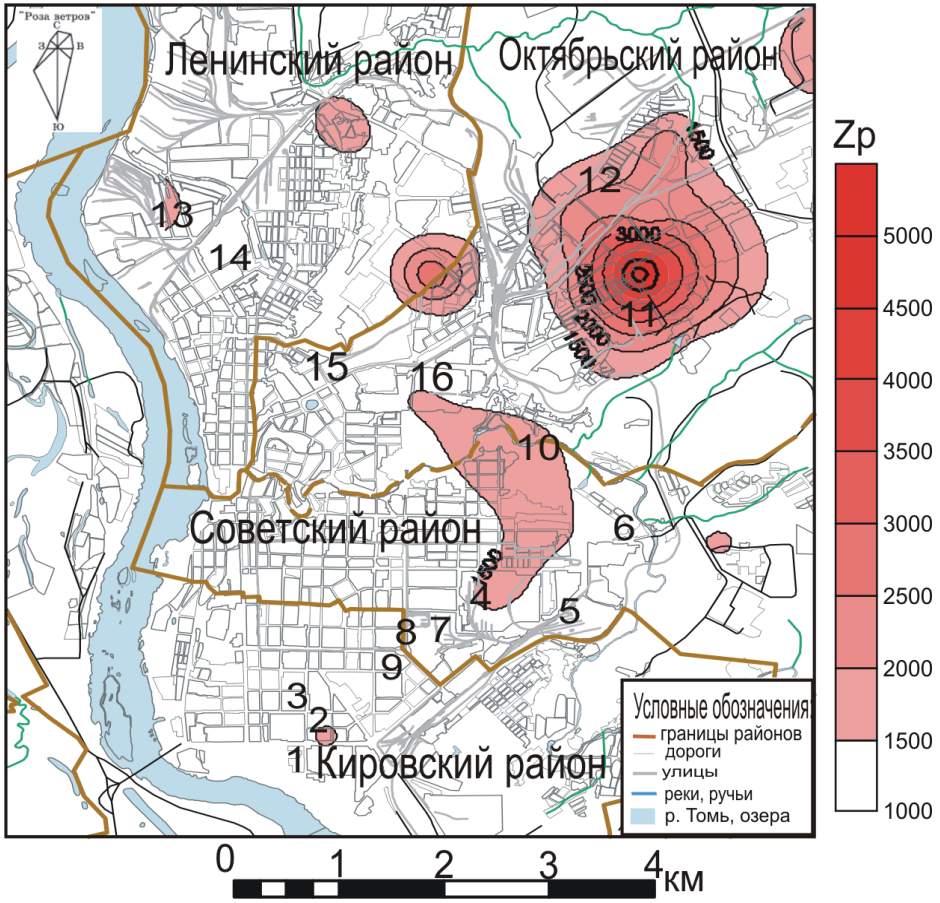
$$Z_p = \sum K_p - (n-1)$$

n – a number of elements having Kp values more than 1.

contamination levels of factor of total element load

- less than 1000 – low contamination level;
- 1000-5000 – middle one;
- 5000-10000 – high one;
- more than 10000 – very high one.

The scheme of factor of total element load value distribution in Tomsk city

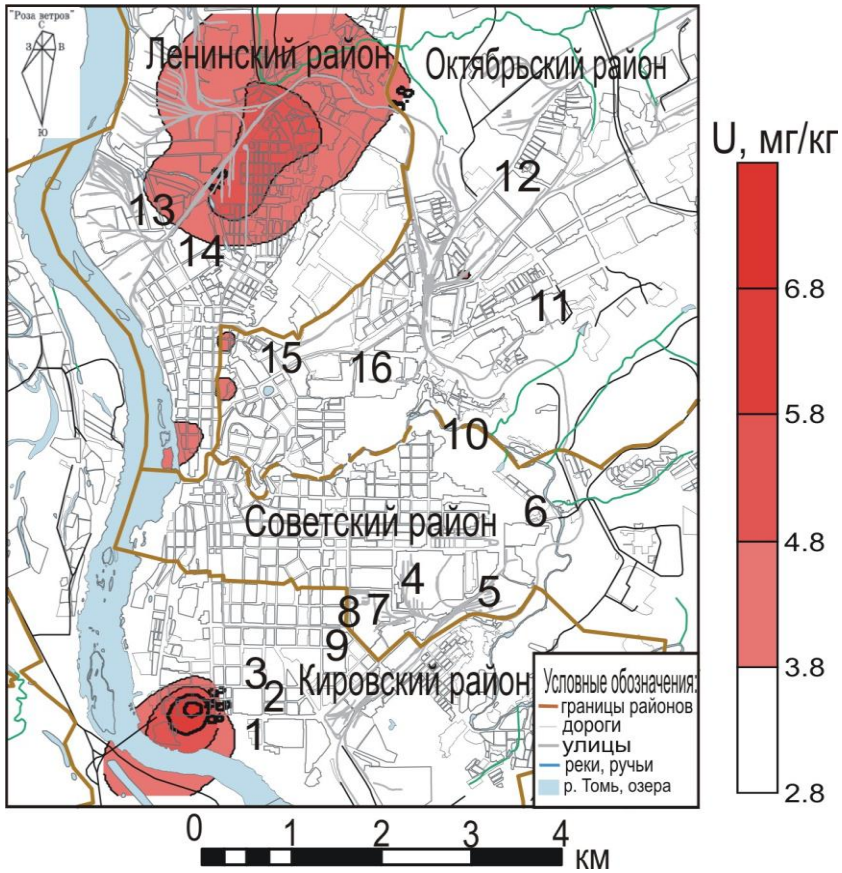


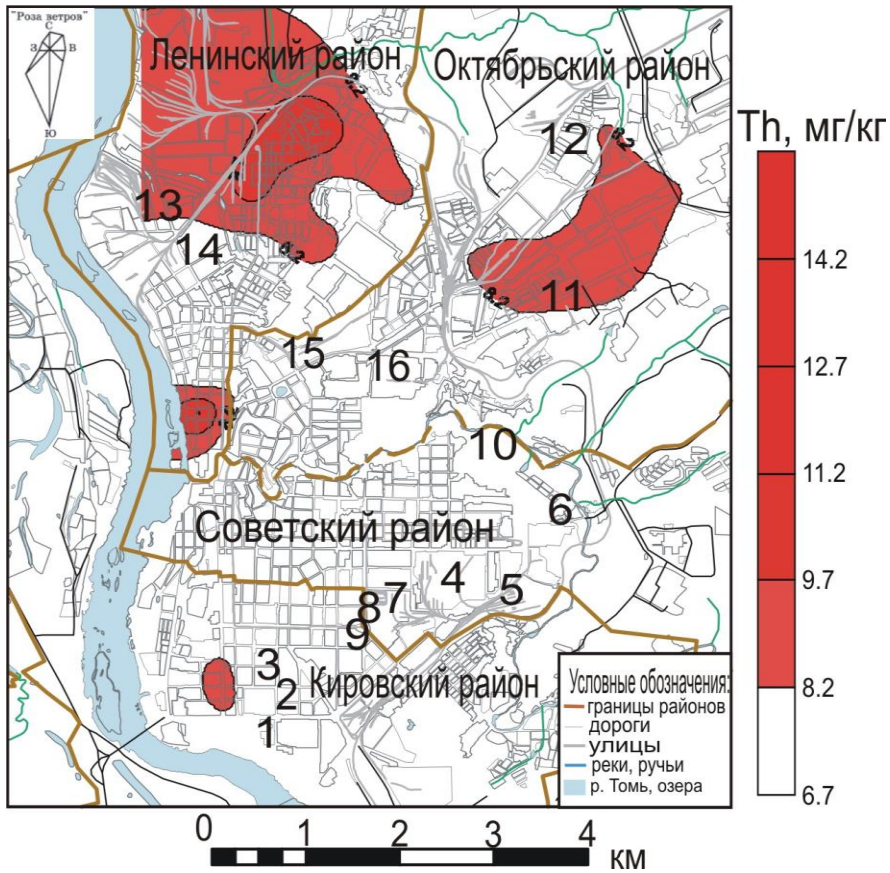
Background value 28 (Шатилов, 2001 с доп. Язикова, 2006), average value is 1005 .

1. ООО «Континентъ».
2. ОАО «Томский инструмент».
3. ОАО «Томский электроламповый завод».
4. Томская «ГРЭС-2»
5. ООО «Завод крупнопанельного домостроения ТДСК».
6. «Эмальпроизводство ЗАО «Сибкабель».
7. ОАО «Манотомь».
8. ОАО «Сибэлектромотор».
9. ФГУП «Томский электротехнический завод» и НПО «Полюс».
10. Золоотвал Томской «ГРЭС-2»
11. ЗАО «Карьероуправление».
12. ОАО «Завод ЖБК-100» и ООО «Керамзит-Т».
13. ОАО «Томский шпалопропиточный завод».
14. ООО «Томский завод резиновой обуви».
15. ЗАО «Сибкабель».
16. ЗАО «Томский подшипник».

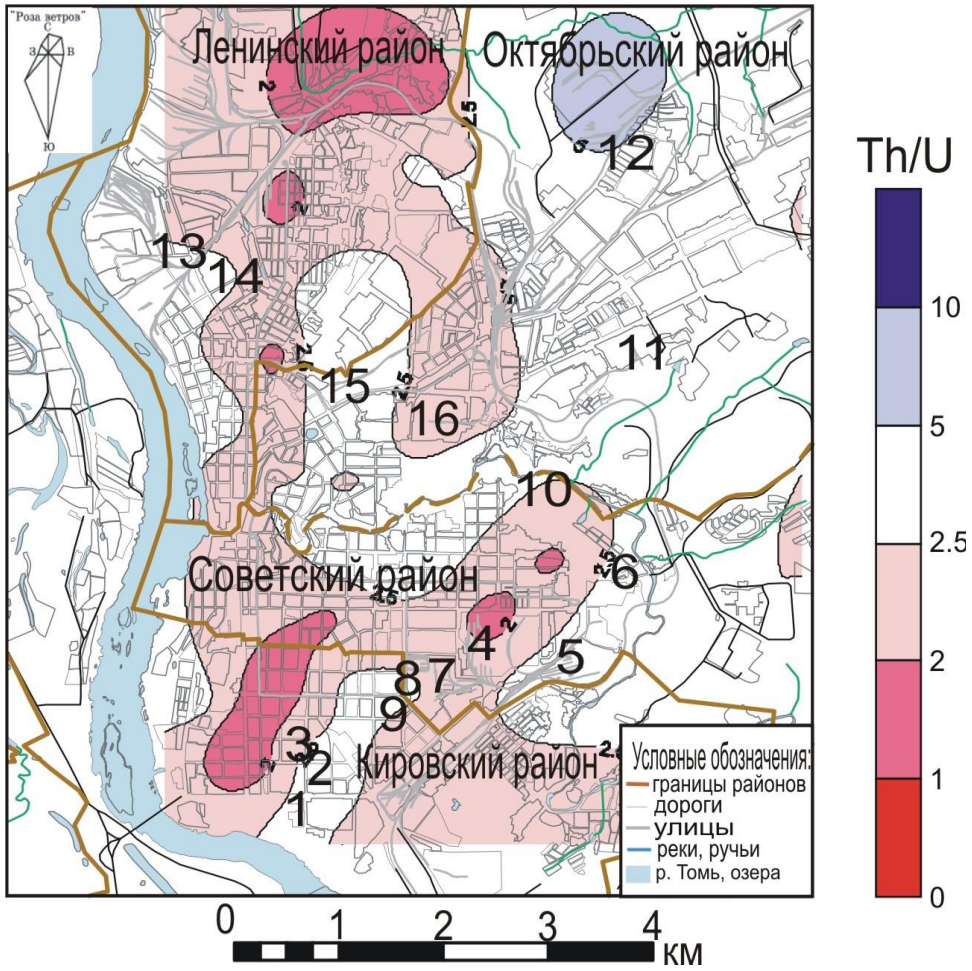
3. Radioactive elements concentration in dust aerosol

The scheme of U and Th concentration distribution in dust aerosols of Tomsk city





Distribution of ratio Th/U in dust aerosols of Tomsk city



According to the data of ratio Th/U aerosols origin is identified (Язиков, 2006):

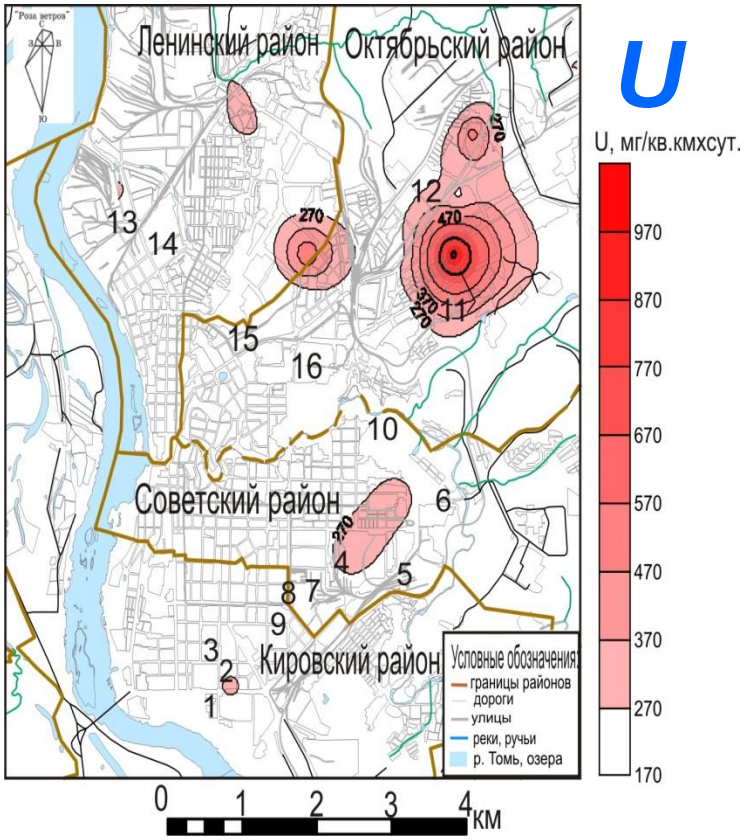
Less 2 – uranium origin (mostly anthropogenic origin)

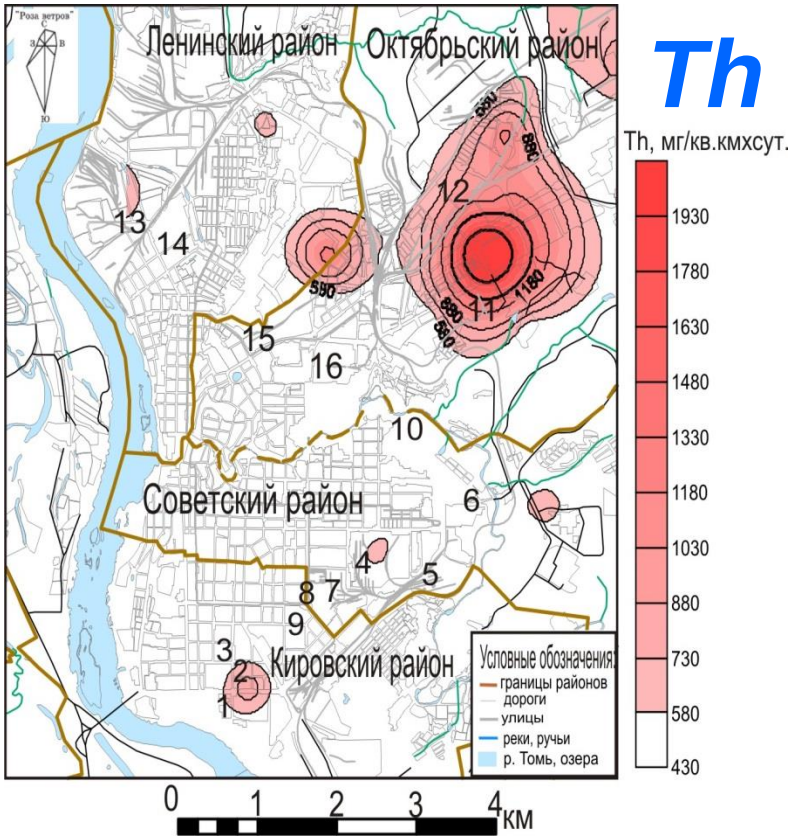
From 2 to 5 – mixture origin

More than 5 - thorium origin (mostly natural origin)

Background value – 14.2

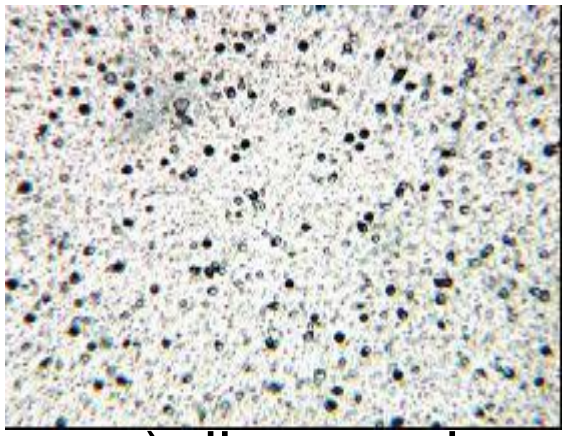
The scheme of value of mean daily fallouts of U and Th distribution



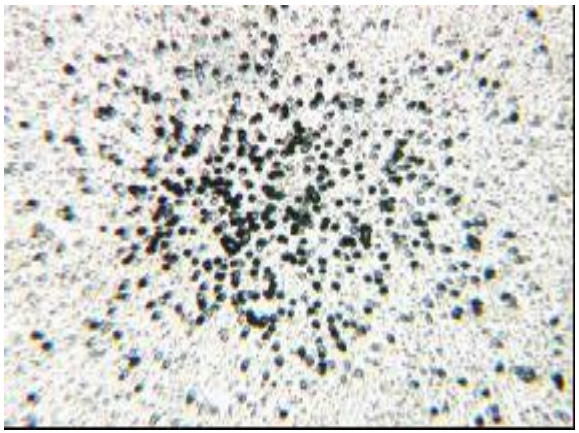


1. ООО «Континентъ», 2. ОАО «Томский инструмент», 3. ОАО «Томский электроламповый завод», 4.Томская ГРЭС-2, 5. ООО «Завод крупнопанельного домостроения ТДСК», 6. «Эмальпроизводство ЗАО «Сибкабель», 7. ОАО «Манотомь», 8. ОАО «Сибэлектромотор», 9. ФГУП «Томский электротехнический завод» и НПО «Полюс», 10. золоотвал Томской ГРЭС-2, 11. ЗАО «Карьероуправление», 12. ОАО «Завод ЖБК-100» и ООО «Керамзит-Т», 13. ОАО ТрансВудсервис «Томский шпалопропиточный завод», 14. ООО «Томский завод резиновой обуви», 15. ЗАО «Сибкабель»; 16. ЗАО «Томский подшипник».

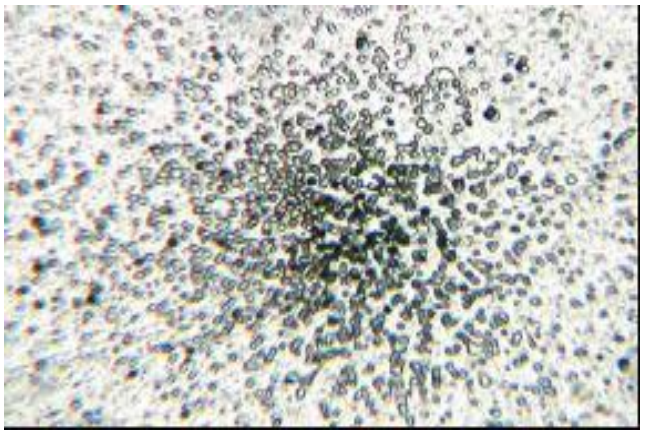
The modes of occurrence of radioactive fissionable elements in the snow residue



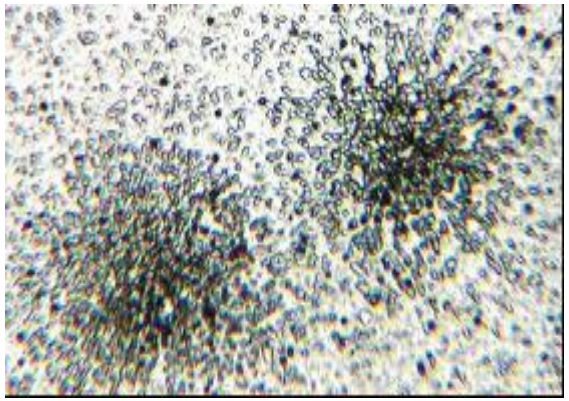
a) dispersed



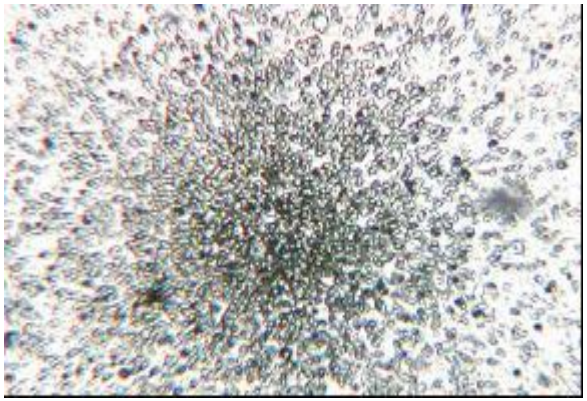
b) accumulations



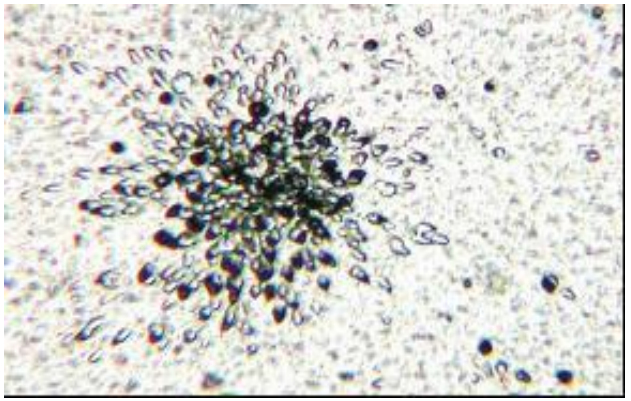
c) micro-inclusions



d) micro-inclusions



e) micro-inclusions

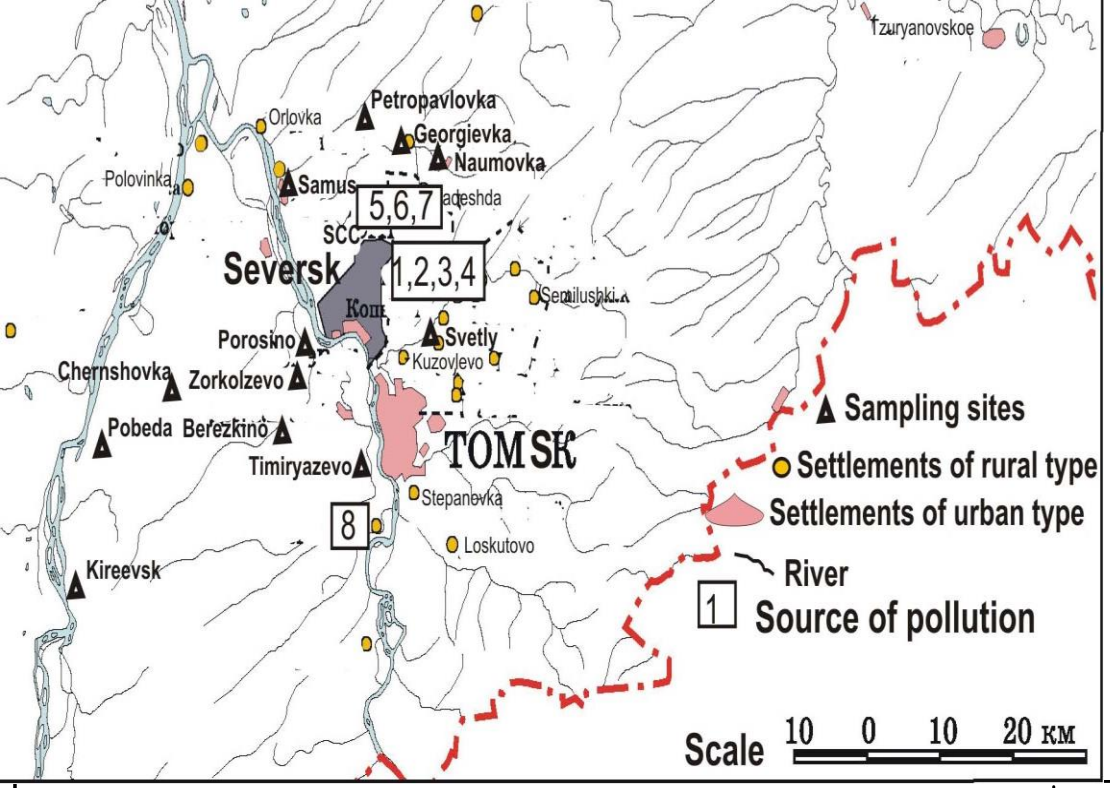


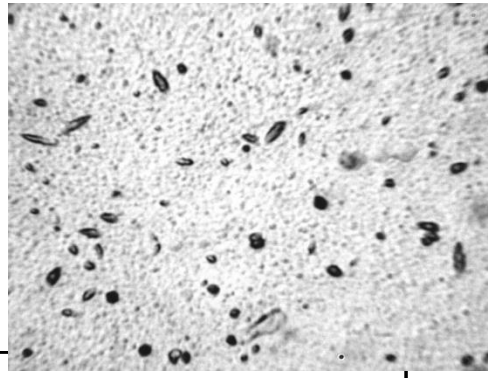
f) micro-inclusions

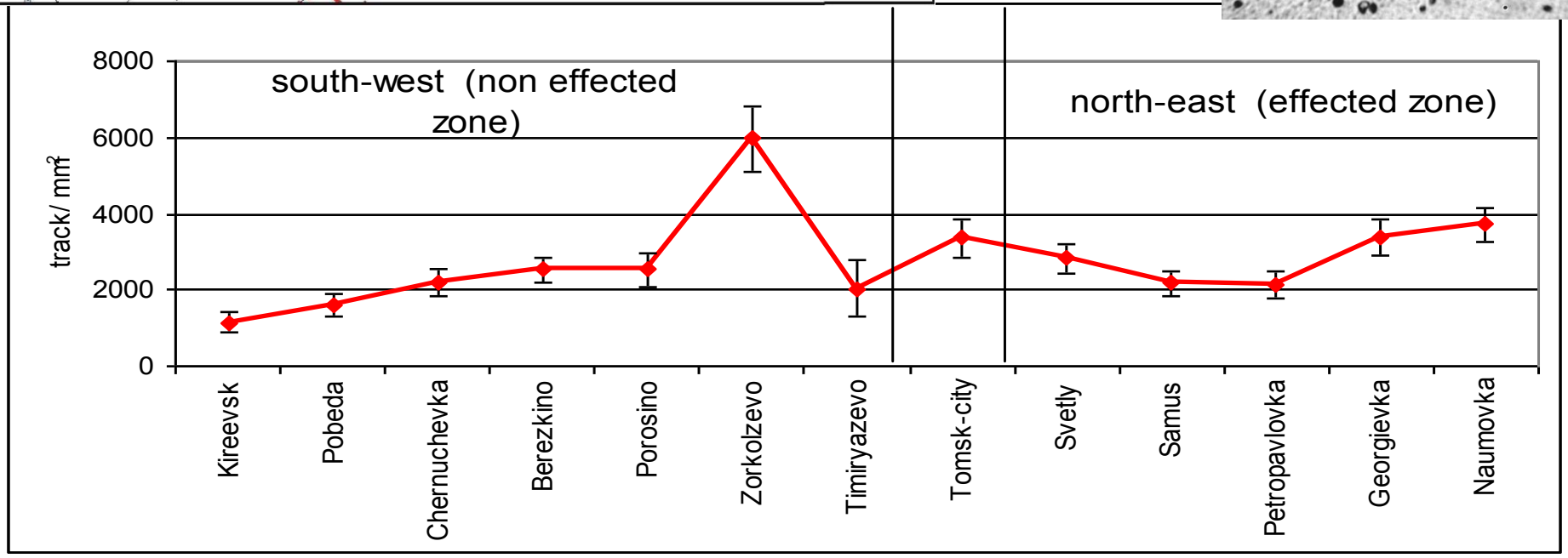
Detector: lavsan. Magnification X160-180

micro-inclusions are called “stars”

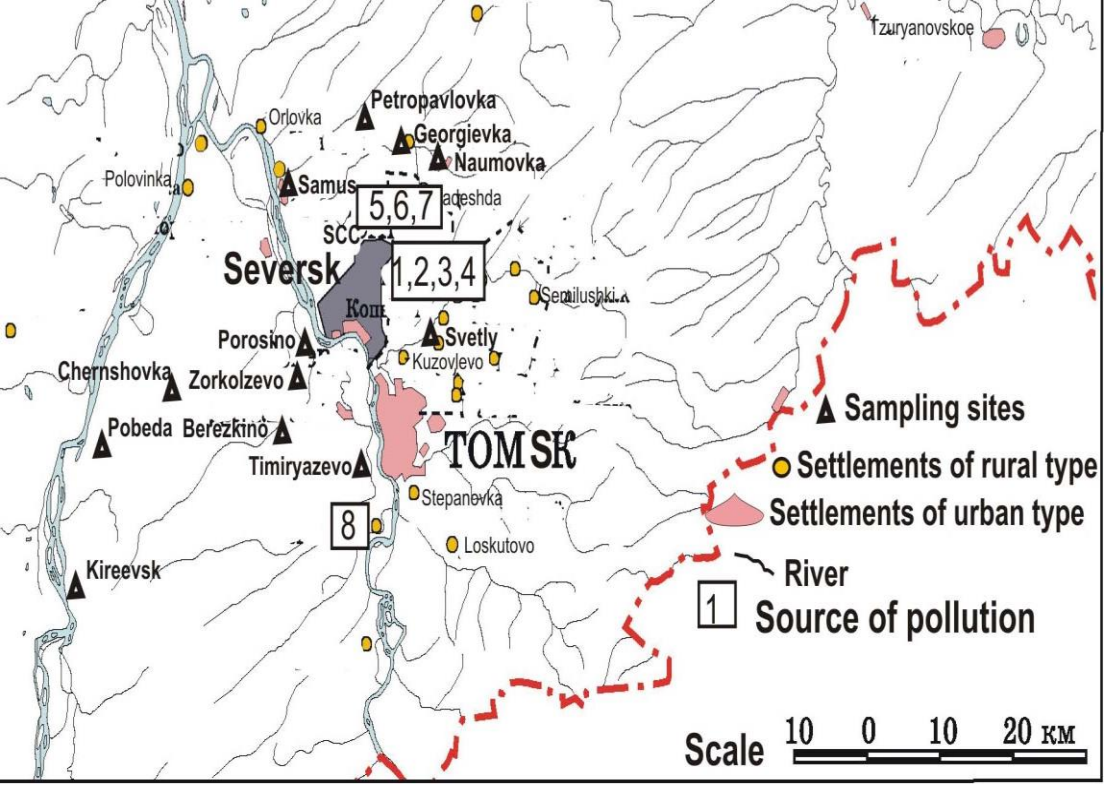
Tracks density of *dispersed* modes *distribution of radioactive fissionable elements*

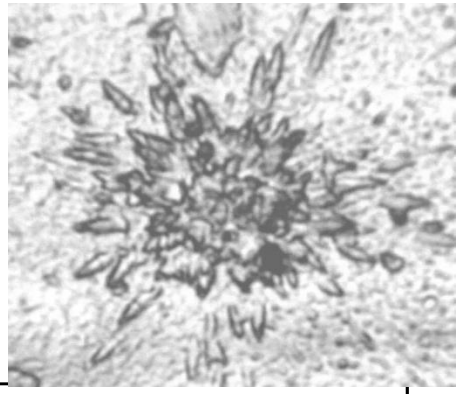


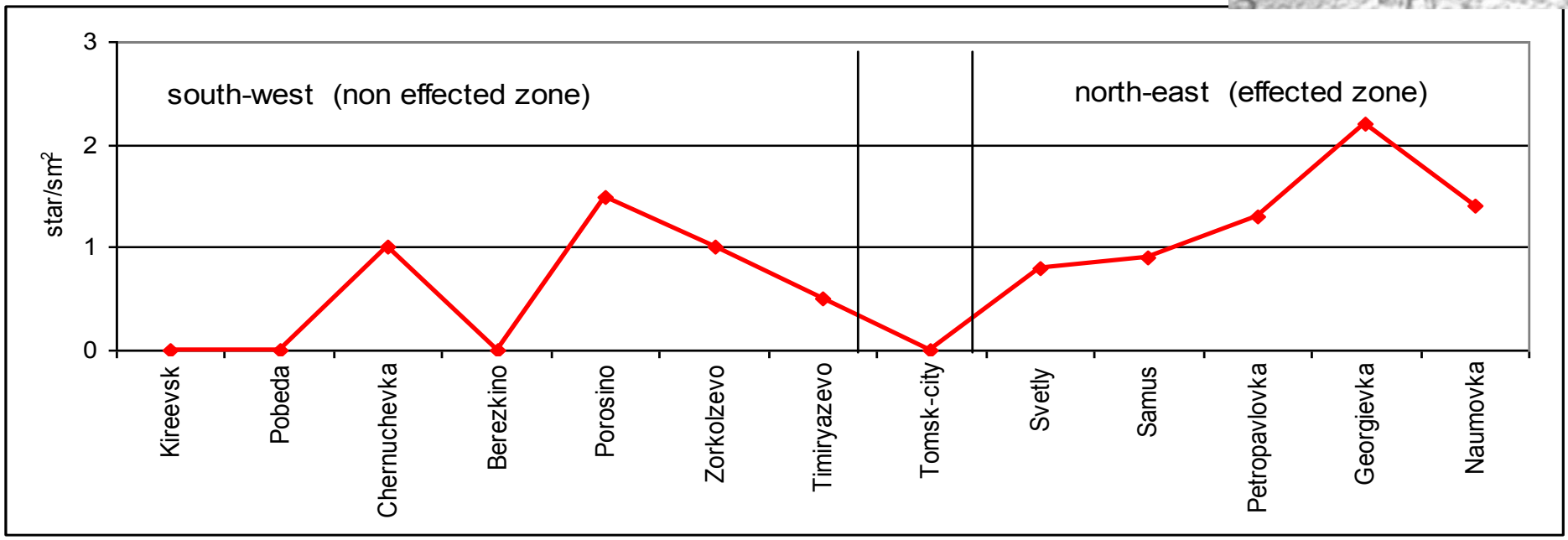




Density of micro-inclusions modes distribution of radioactive fissionable elements







Conclusion

- One uses the modern and high sensitivity analyses to determine trace elements concentration.
- Treatment the analytical data includes calculation of the concentration coefficient, concentration coefficient, daily fallout of elements, factor of relative increase in total elements load and total element load.
- Geochemical associations of trace elements in dust aerosols should be determined by the method of multivariate correlation analysis (Ward's method) using the software Statistica.

Conclusion

- According to micro-element content in dust aerosols it is possible to map the anthropogenic transformation zones on the area and the souses of the elements.

- Investigations of dust aerosols in the impact zones of nuclear-fuel plant are given certainty that f-radiography method makes it possible to identify “hot” particles in dust aerosols and perform radio ecological assessment of the territory.

Thank you for your attention!