Irkutsk National Research Technical University

MONITORING OF CARCINOGENIC RISK FACTORS FOR PUBLIC HEALTH (ON THE EXAMPLE OF THE IRKUTSK REGION)

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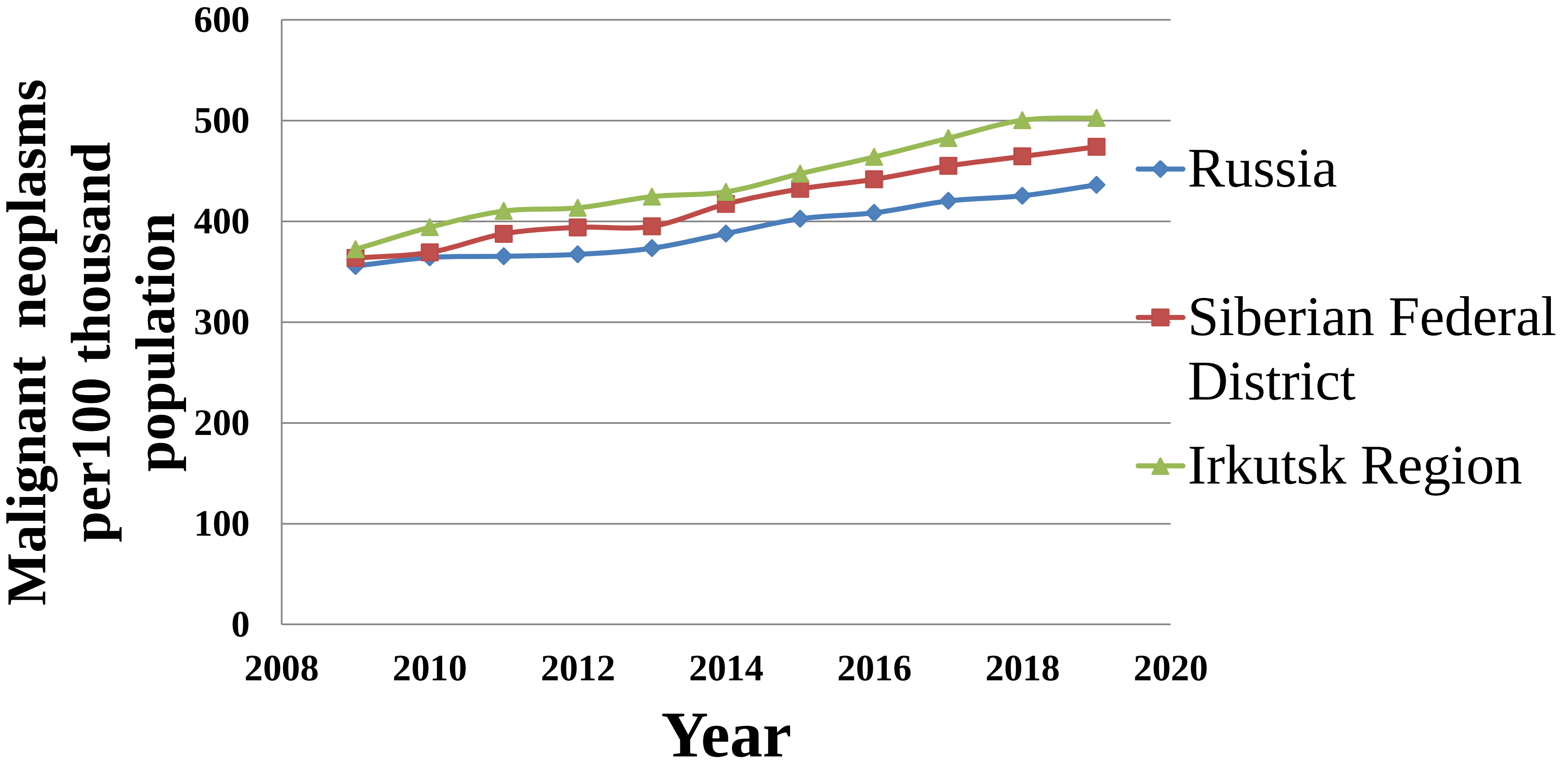
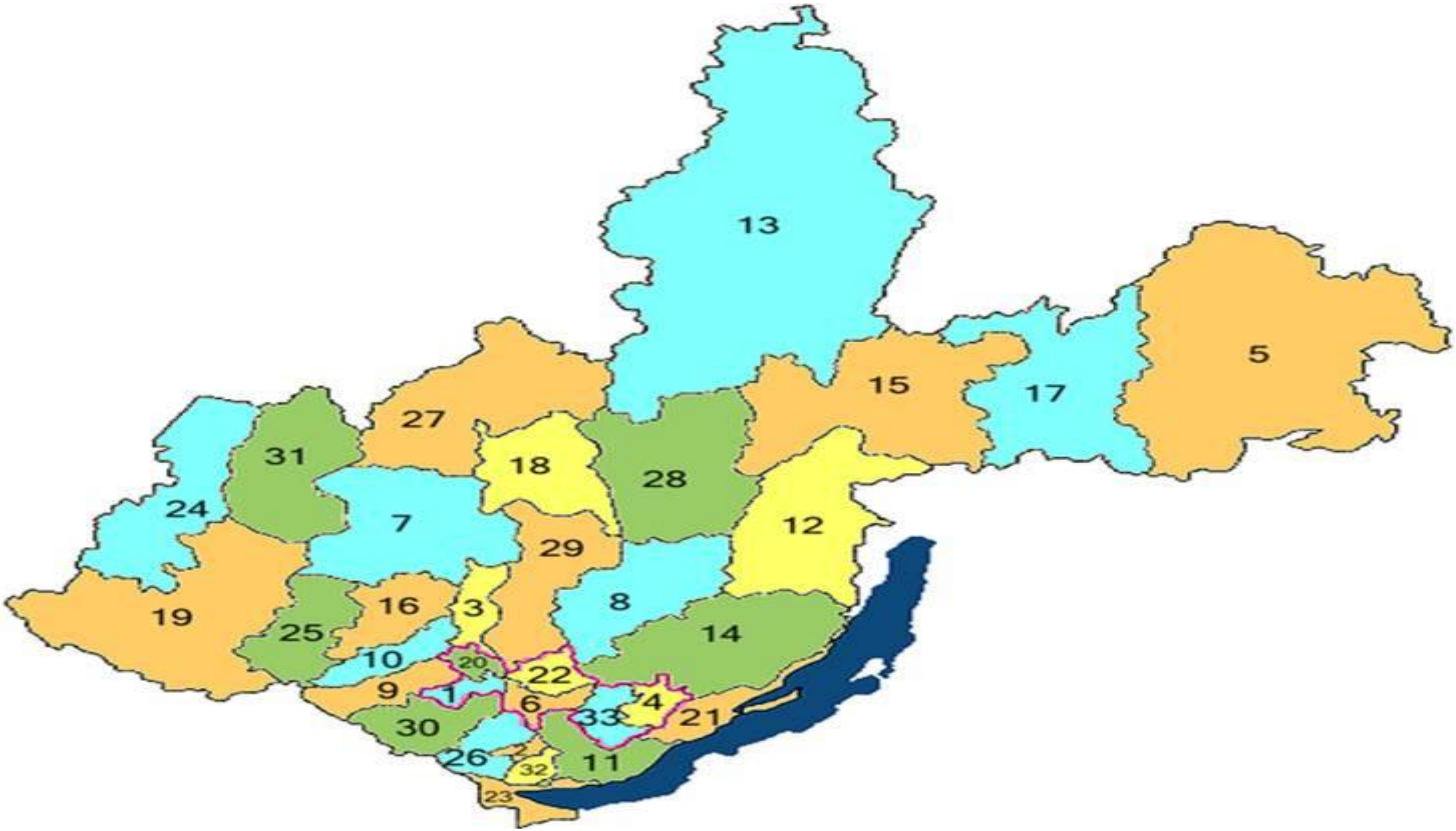
THE RELEVANCE OF THE PROBLEM is the incidence of malignant neoplasms (MN) in the population and the need to monitor carcinogenic chemical factors

Dynamics of cancer diseases in Russia



Schematic map of 33 districts of Irkutsk region

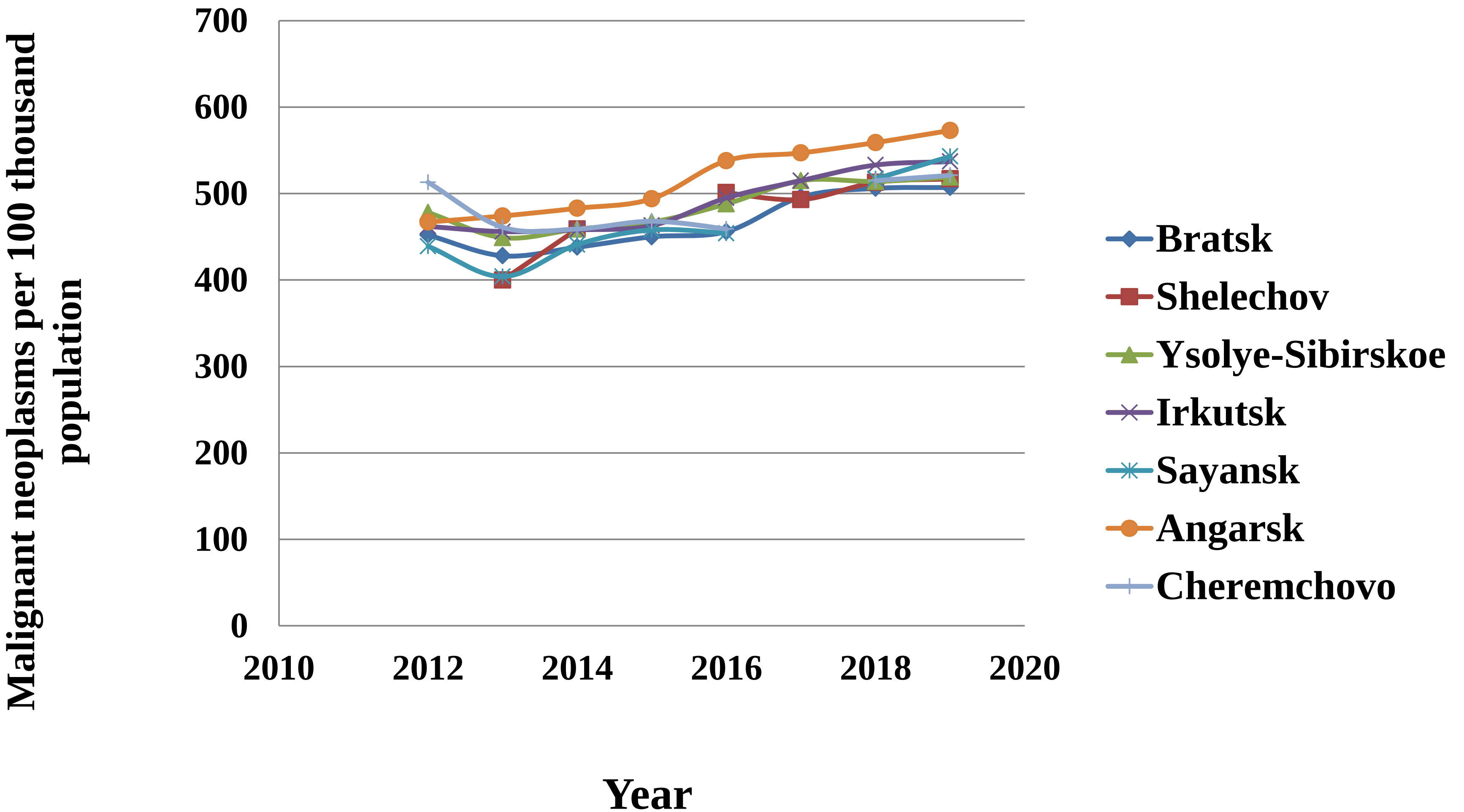
area of the region – 767900 км² population size – 2391200



Incidence of malignant neoplasms (MN) diseases

city	population, thousand people. (2020)	main production	MN, per 100 thousand people (min-max 2013-2019)
Svirsk	**13,649**	Timber processing	**530-634**
Angarsk	**224,630**	Petrochemicals	**476-538**
Shelekhov	**48,423**	Aluminum	**388-513**
Usolye-Sibirskoe	**83,364**	Chemical	**442-508,5**
Irkutsk	**623,562**	Heat and power engineering	**459-515,9**
Sayansk	**40,786**	Chemical	**451-478**
Bratsk	**226,269**	Aluminum	**439-472**
Cheremkhovo	**52,650**	Heat and power engineering	**443-467**
Zima	**32,522**	Heat and power engineering	**369-439**
Tulun	**44,603**	Heat and power engineering	**414-426**
Irkutsk region	**2391,2**		**424-502,0**
Russia	**146745,0**		**373-436,34**

Monitoring and dynamics of the incidence of malignant neoplasms in the cities of the Irkutsk region



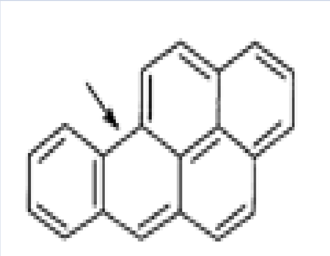
IARC classification of chemical carcinogens. These substances are determined in the atmosphere of the Irkutsk region

GROUP 1 (proven)	GROUP 2A (probably)
Benzene	Benzo(a)pyrene
Ethylbenzene	Formaldehyde
Soot	
Chromium (on chromium (VI) oxide)	

Priority pollutants in the atmosphere of the cities of the Irkutsk region in 2018-2019 year

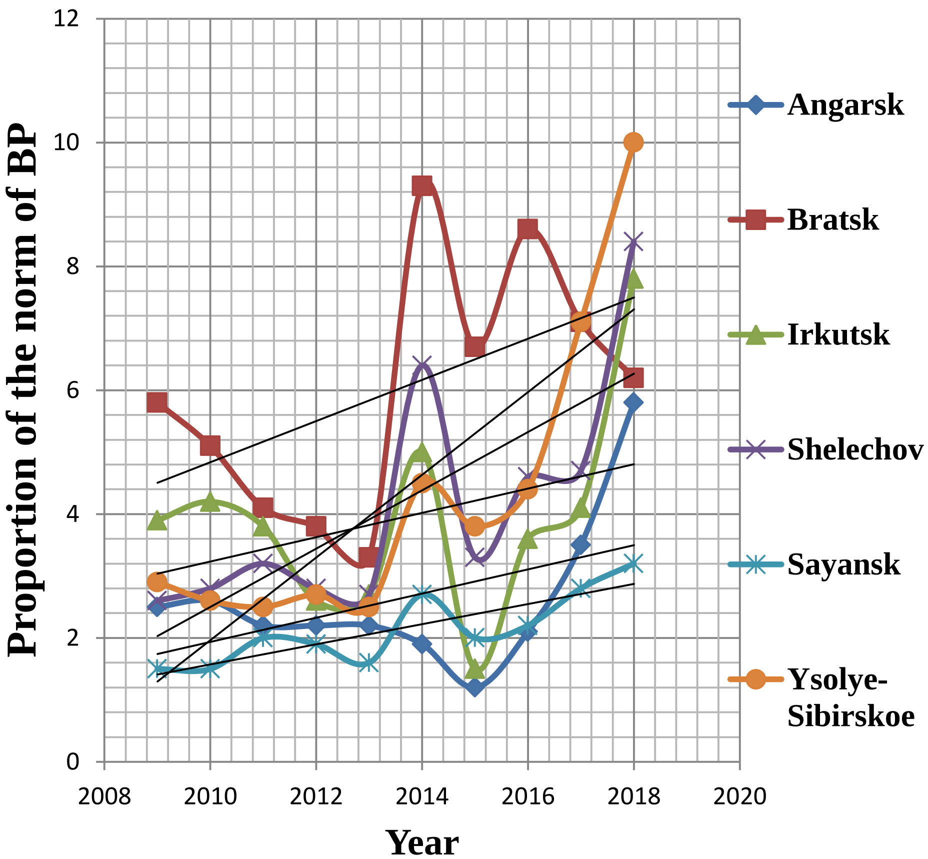
city	Priority pollutants
Svirsk	**Benz (a)pyrene**, carbon monoxide, nitrogen dioxide, suspended solids, sulfur dioxide
Angarsk	**Benz (a)pyrene**, nitrogen dioxide, ozone, suspended particles PM10, formaldehyde
Shelekhov	**Benz (a)pyrene**, suspended solids, suspended particles of PM10 fraction, ozone, nitrogen dioxide
Usolye-sibirskoe	**Benz (a)pyrene**, formaldehyde, suspended solids, nitrogen dioxide, sulfur dioxide
Irkutsk	**Benz (a)pyrene**, nitrogen dioxide, suspended solids, formaldehyde, nitric oxide
Bratsk	Carbon disulfide, **Benz (a)pyrene**, suspended solids, hydrogen fluoride, formaldehyde.
Cheremkhovo	**Benz (a)pyrene**, nitrogen dioxide, suspended solids, sulfur dioxide, nitrogen oxide
Zima	**Benz (a)pyrene**, nitrogen dioxide, hydrogen chloride,

Properties of carcinogenic substances

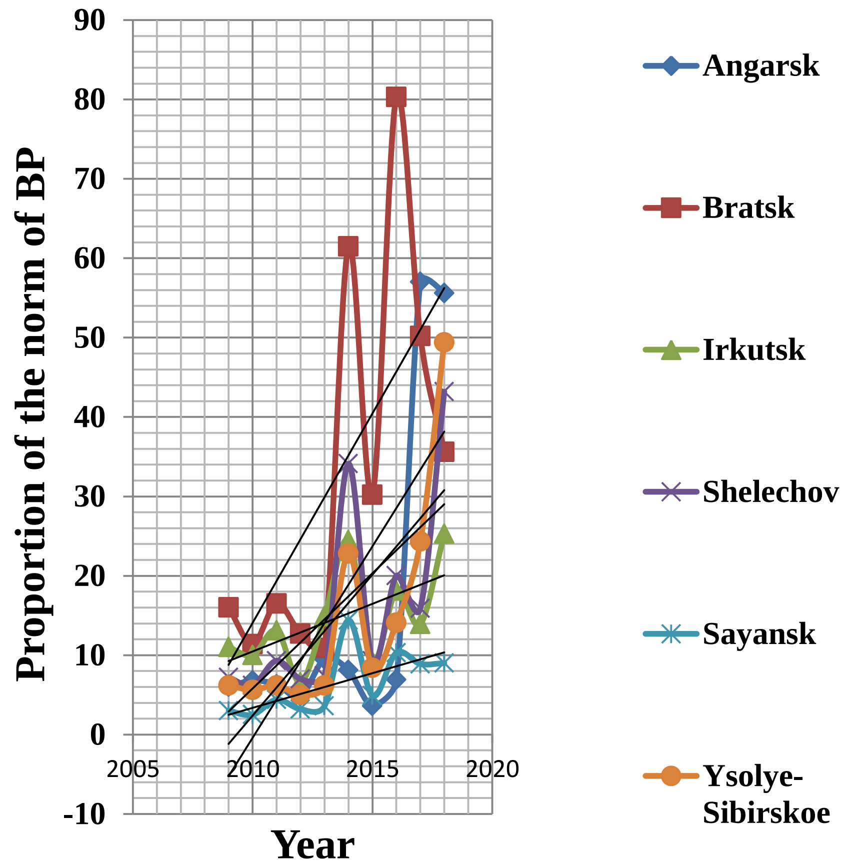
Substance	CAS	Formula	Structure	Norma (hazard class)
Benzo(a)pyrene	50-32-8	$C_{20}H_{12}$		ПДК$_{сс}$ 1 нг/м^3 1 кл. опасн. **carcinogen**
Soot	1333-86-4	C_n	–C–C–C–	ПДК$_{сс}$ 0,05 мг/м^3 ПДК$_{мр}$ 0,15 мг/м^3 3 кл. опасн. **carcinogen**

Monitoring and Dynamics of benz (a) pyrene in the atmosphere of industrial cities

Average annual rate concentration BP

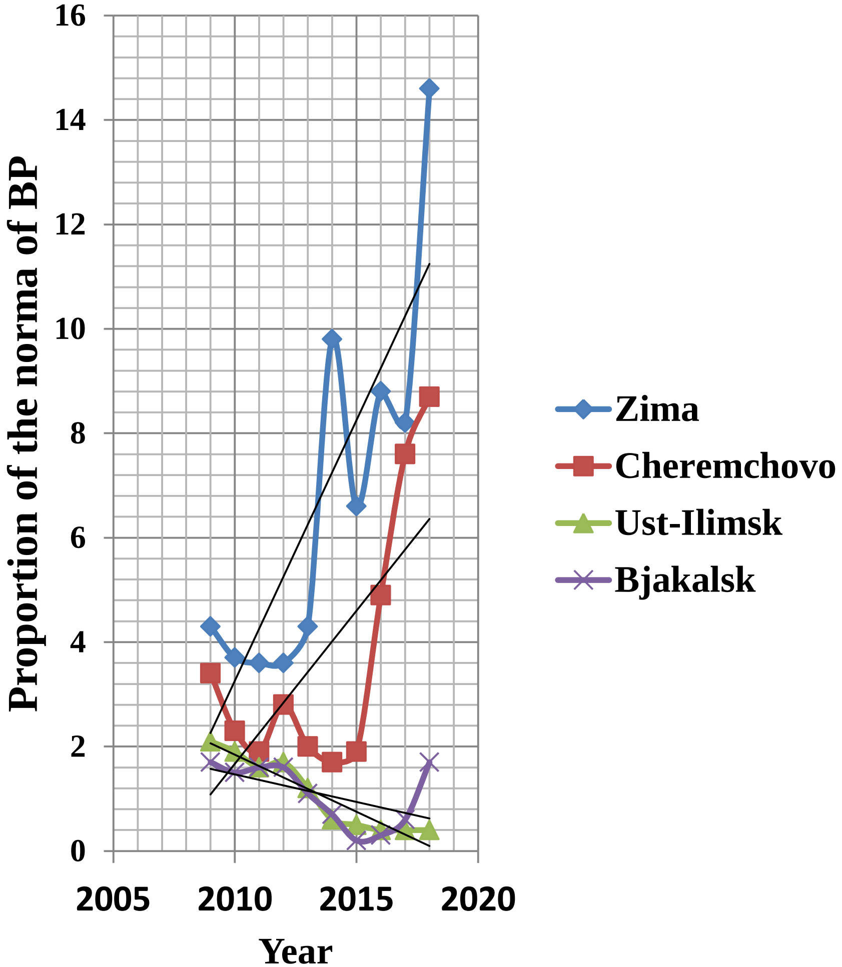


Maximum monthly average concentration BP

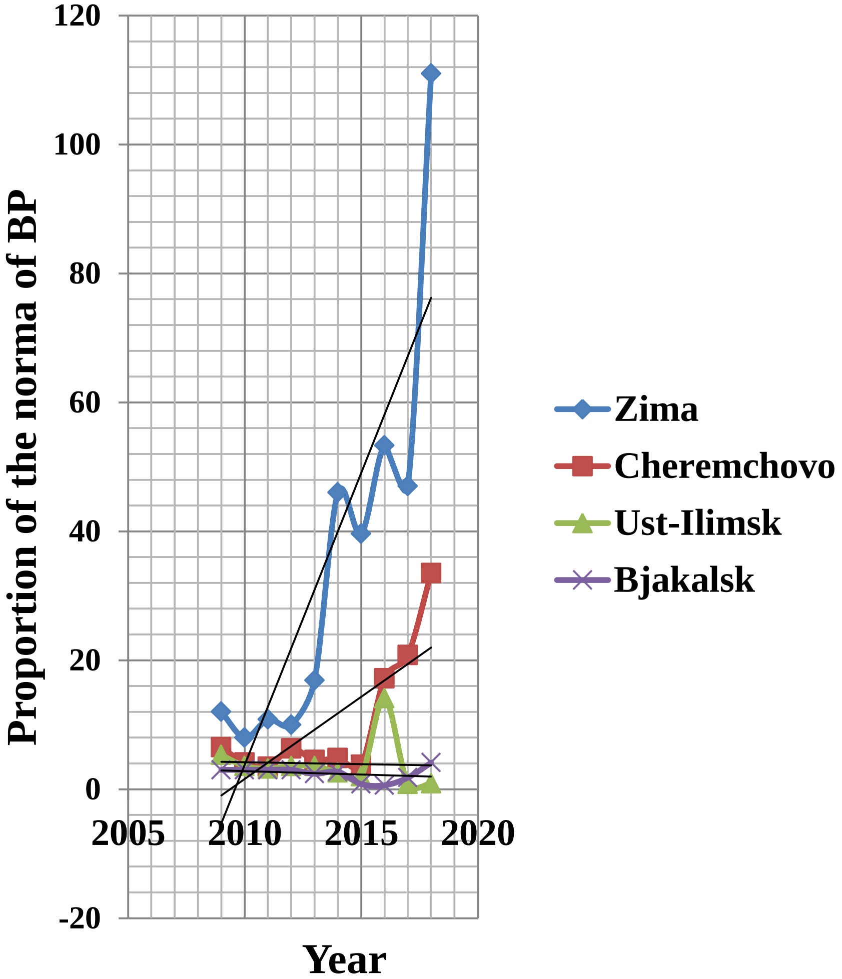


Monitoring and Dynamics of benz (a)pyrene in the atmosphere of agricultural cities

Average annual rate concentration BP



Maximum monthly average concentration BP



Relevance of the problem-monitoring of sources of atmospheric pollution with benz (a)pyrene and its analogues-polycyclic aromatic hydrocarbons (PAH)

- The following sources of B(a)P and PAH emissions were studied
- 1. Heat and power engineering of "small" capacity
- 2. Forest fires
- 3. Road transport

Monitoring of benz (a)pyrene and polycyclic aromatic hydrocarbons in "low" power heat sources (boiler houses, house furnaces)

- **Method for calculating emissions of a substance:**
- 1 The instantaneous mass emission (mij, kg/sec) is calculated from the measurement results :

$$\mathbf{m_{ij} = C_{ij} \cdot V_i \cdot 10^{-3},}$$

where Cij is the concentration of the j-th component (g/m3) obtained for the i-th measurement number; Vi is the volume flow rate of flue gases (m3/sec); 10-3 is the coefficient of recalculation of the contents of g in kg.

- 2. The specific emission (Mud j, kg/GJ) is calculated :

$$M_{ud\,j} = \frac{1000}{B \cdot Q_{н}^{r}} \Sigma\,(m_{ij} \cdot \Delta t\ i)$$

- gorenje, where B is the mass of the fuel burned during the combustion cycle, kg; Qr is the lowest heat of combustion of the fuel, MJ / kg; i is the measurement sequence number, n is the number of measurements; Δt i is the time interval between the i-th and i+1 measurements, sec.
- 3. The gross emission (Mg j, kg / year) of the j-th component is calculated:

$$\mathbf{M_{g\,j} = M_{ud\,j} \cdot Qr \cdot B/year}$$

Specific emissions of benz (a)pyrene and PAH from "small" heat sources

№	PAH	Average specific emissions, g·GJ-1			
п/п		House oven		Heating boiler	
		coals	firewood	coals	fuel oil
1	Fenantren	**1,970**	**0,0187**	**0,620**	**0,0028**
2	Anthracene	**0,517**	**0,0025**	**0,140**	**0,0003**
3	Fluoranten	**1,650**	**0,0211**	**0,470**	**0,0005**
4	Pirene	**2,064**	**0,0322**	**0,690**	**0,0014**
5	Benz (a)anthracene	**0,350**	**0,0136**	**0,102**	**0,0005**
6	Chrysene	**0,400**	**0,0143**	**0,132**	**0,0012**
7	Benz(b)fluoranten	**0,360**	**0,0205**	**0,090**	**0,0009**
8	Benz (k)fluoranten	**0,250**	**0,0174**	**0,100**	**0,0019**
9	Benz (a)pyrene	**0,480**	**0,0183**	**0,130**	**0,0003**
10	Benz (g,h,i)perylene	**0,120**	**0,0104**	**0,035**	**0,0004**
11	Benz(1,2,3-c,d) pyrene	**0,250**	**0,0216**	**0,062**	**0,0005**
12	Amount of 11 PAHs	**8,418**	**0,1906**	**2,580**	**0,0107**

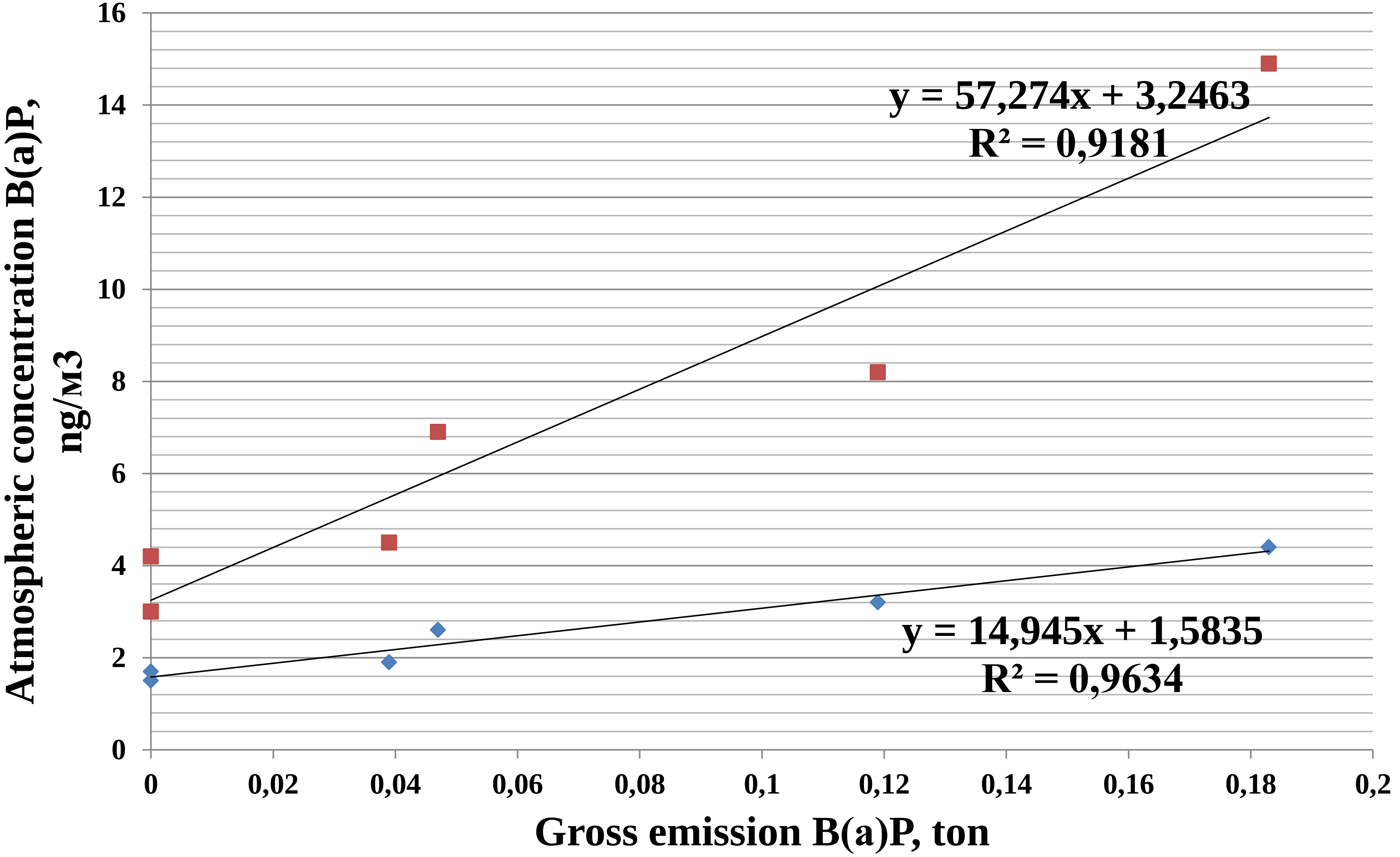
"Small" heat sources in the cities of the Irkutsk region (1.01.2019)

CITY	BOILER ROOMS		HOUSE STOVES		
	quantity	coal thousand T/J	Proportion of furnaces, %	coal thousand T/J	firewood, thousand T/J
Irkutsk	13	0,680	5	0,625	1,875
Bratsk	3	0,157	3	0,125	0,375
Angarsk	0	0	2	0,087	0,262
Usolye-Sibirskoe	4	0,210	10	0,172	0,517
Ust-Ilimsk	3	0,157	2	0,035	0,105
Shelekhov	1	0,052	3	0,025	0,075
Zima	6	0,315	45	0,267	0,800
Cheremkhovo	10	0,525	48	0,550	1,650
Sayansk	0	0	0,05	0,0003	0,0012
Baikalsk	0	0	5	0,0125	0,0375
In TOTAL::	40	2,100	-	1,888	5,663
By region:	**631**	**33,165**	near **40**	-	-

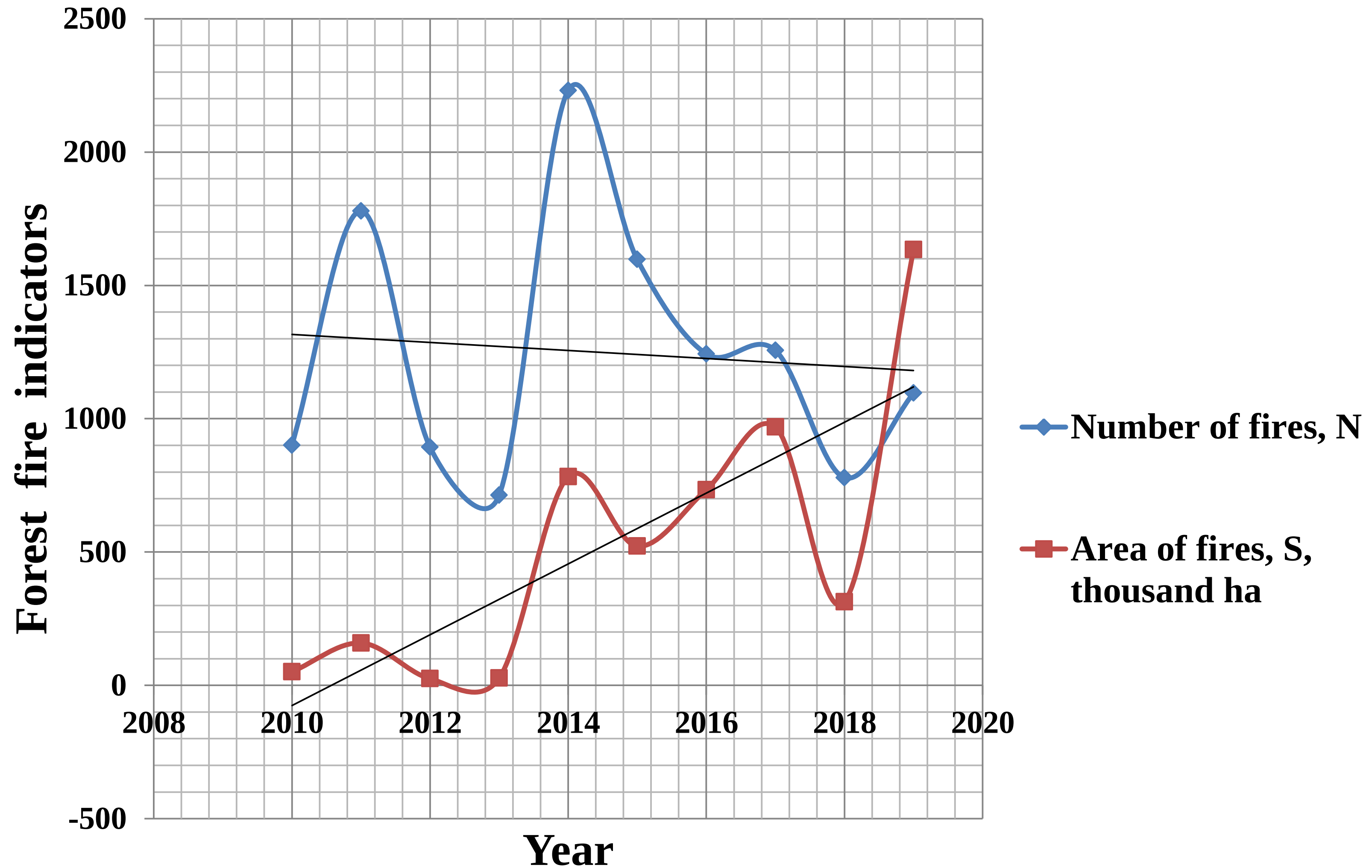
EMISSIONS OF HARMFUL SUBSTANCES FROM "SMALL" HEAT SOURCES IN THE CITIES OF THE IRKUTSK REGION

CITY	GROSS EMISSIONS FROM BOILER HOUSES / HOUSE STOVES, ton			
	CO	soot	B(a)P	11 PAH
Irkutsk	1836 / 7812	258 / 437	**0,088/0,334**	**1,750/5,618**
Bratsk	424 / 1562	60 / 87	**0,020 / 0,067**	**0,40/1,123**
Angarsk	0 / 1090	0 /61	**0 / 0,047**	**0 / 0,782**
Usolye-Sibirskoe	567 / 2153	80 / 120	0,027 / 0,092	0,540 / 1,546
Ust-Ilimsk	424 / 437	60 / 25	0,020 / 0,019	0,403 / 0,315
Shelekhov	140 / 312	20 / 17	**0,007 / 0,013**	**0,134/0,224**
Zima	850 / 3337	120 /187	**0,041 / 0,142**	**0,811 /2,40**
Cheremkhovo	1417 / 6875	200 /385	**0,068 / 0,294**	**1,35/4,944**
Sayansk	0 / 3,75	0 / 0,21	0 / 0,0001	0 / 0.003
Baikalsk	0 / 156	0 / 8,74	0 / 0,007	0 / 0,112
In TOTAL:	**5658 / 23738**	**798 / 1328**	**0,271 / 1,015**	**5,390 / 17,064**

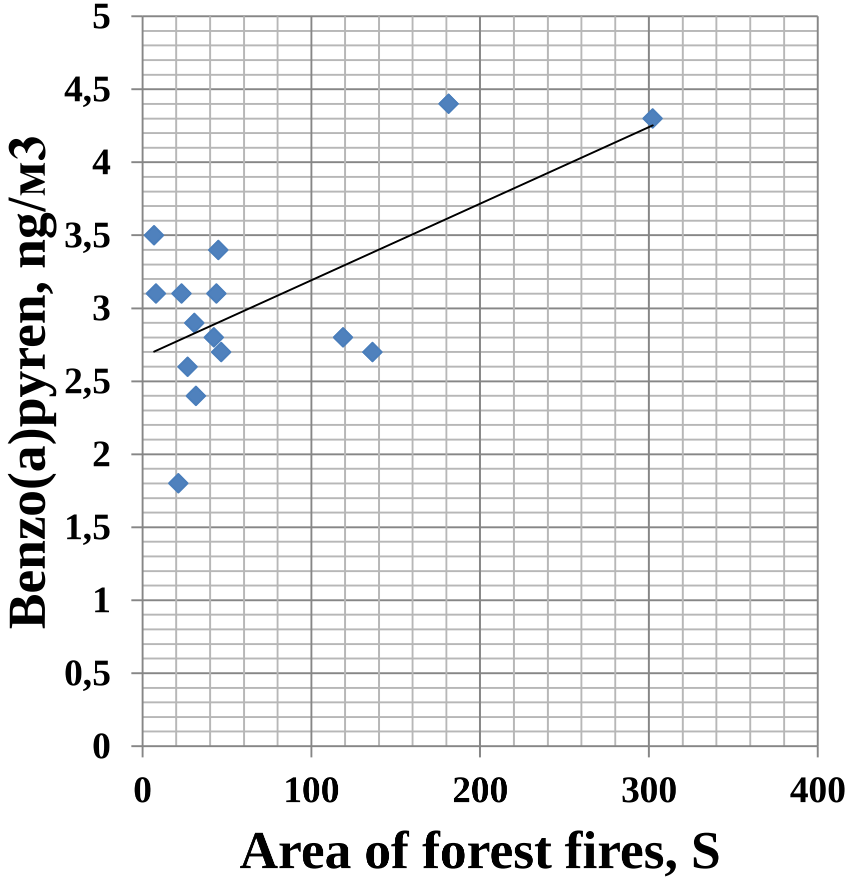
Dependence of atmospheric pollution in the cities of the Irkutsk region on gross emissions of B(a)N boilers and furnaces

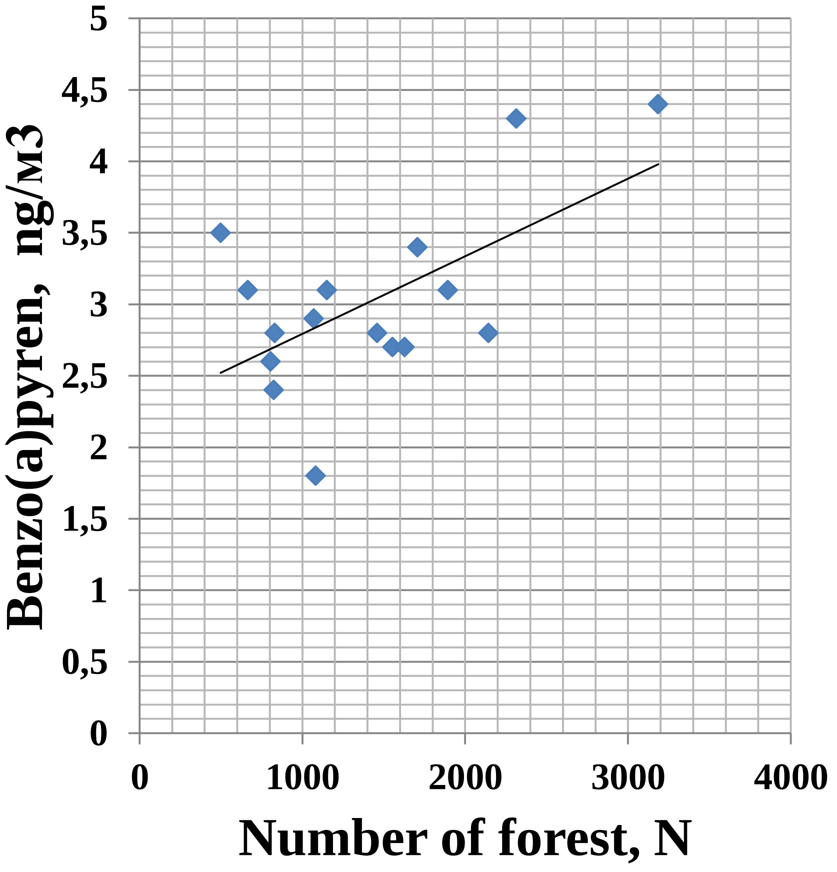


Forest fires as a source of benz (a) pyrene in the Irkutsk region



Dependence of the average annual concentrations of benz (a) pyrene in the atmosphere for 10 cities of the Irkutsk region on the indicators of forest fires

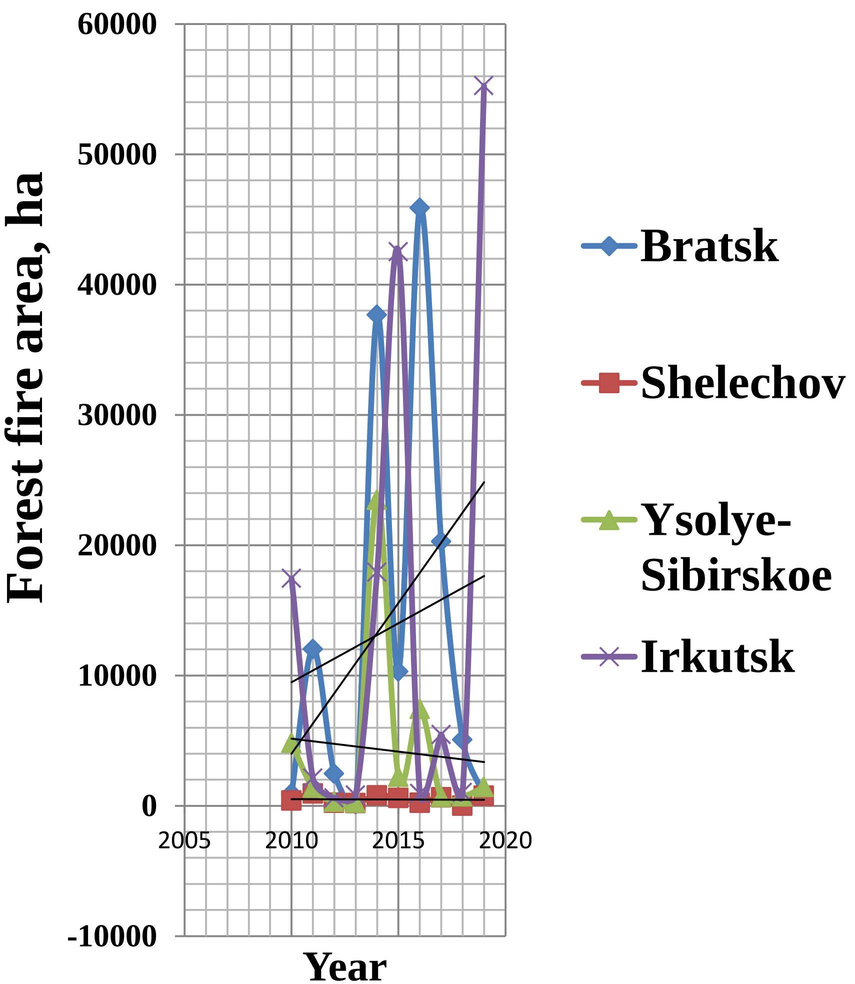


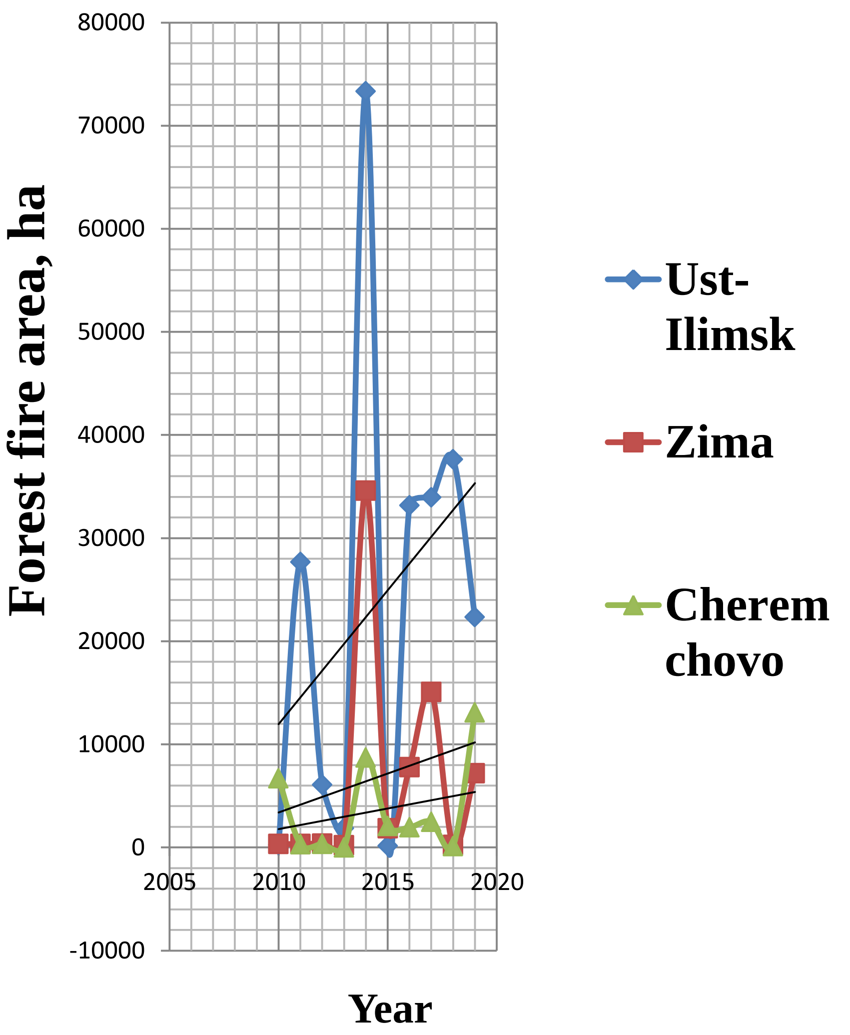


Linear dependences of the average content of benz (a)pyrene in the atmosphere of 10 cities of the Irkutsk region on the indicators of forest fires

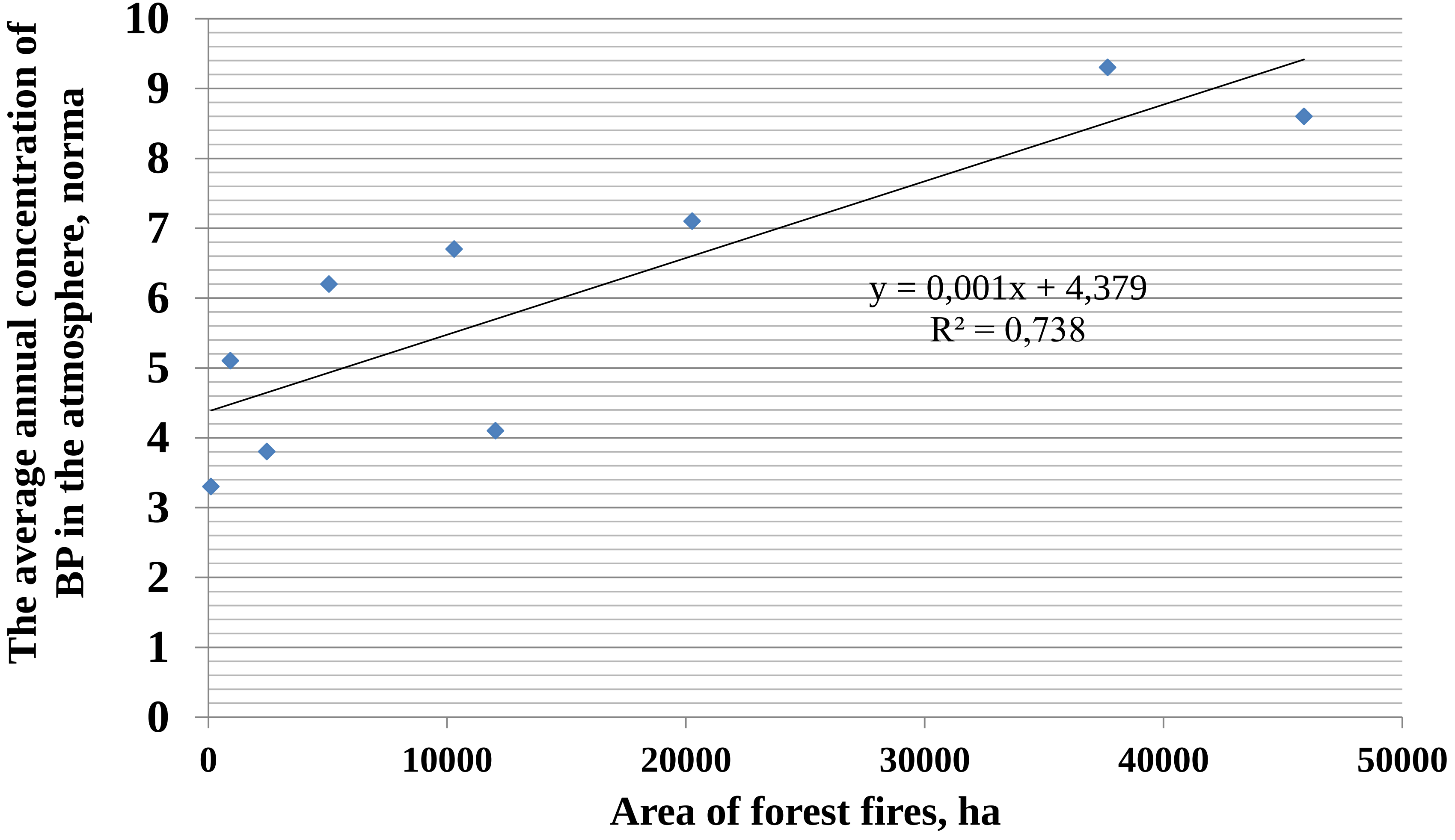
Observation period	Correlation coefficient, r_{xy} (α, f)	
	$C_{БП}$= f (N)	$C_{БП}$= f (S)
2000-2015 2005-2014	+ 0,594 (0,02; 14)	 + 0,780 (0,01; 8)
	$СИ_{БП}$=f (N)	$СИ_{БП}$= f (S)
1999-2014 2005-2014	+ 0,466 (0,10; 15) + 0,620 (0,05; 9)	+ 0,735 (0,01; 14) + 0,865 (0,01; 8)
Concentration:	$C_{БП}$ - average annual rate	СИ – maximum monthly average

Monitoring and Dynamics of forest fires in various districts of the Irkutsk region





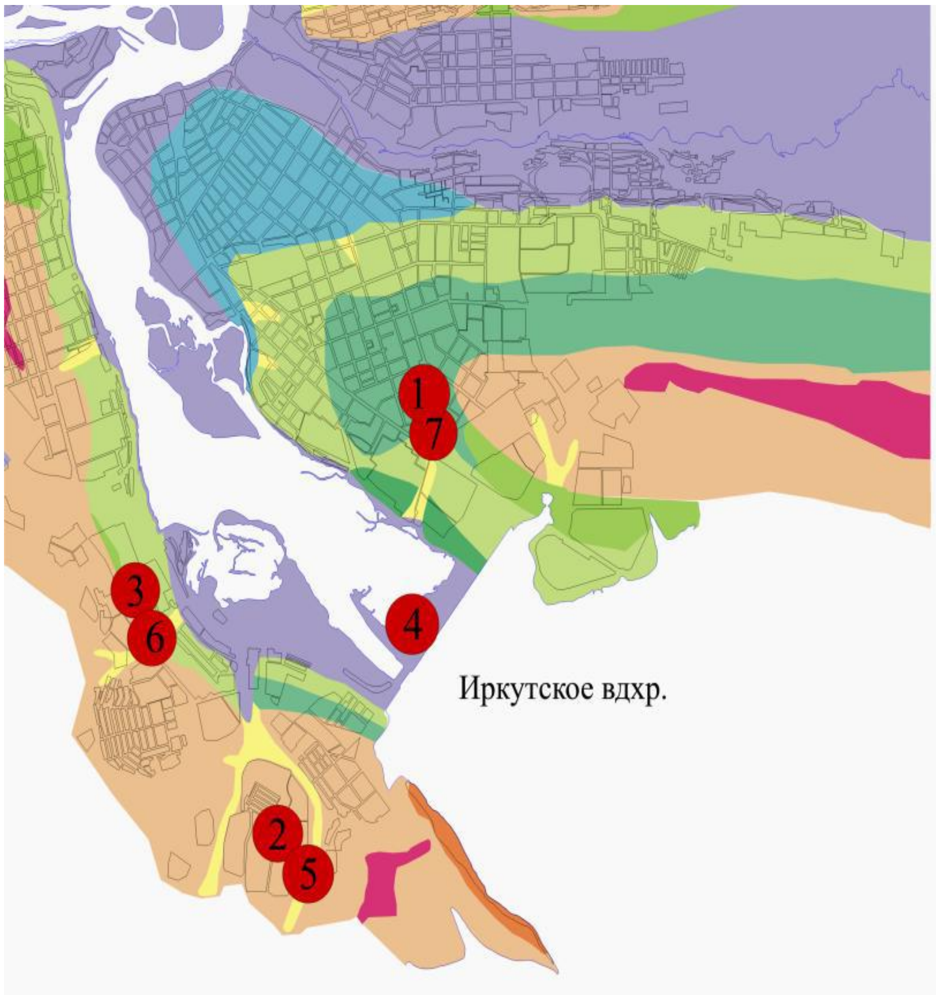
Dependence of the content of benz (a)pyrene in the atmosphere of the city of Bratsk on the area of forest fires in the Bratsk district



Assessment of landscape and transport impact on the atmosphere of the city of Irkutsk by the method of bioindication of tree leaves for the content of benz (a) pyrene

- The city of Irkutsk is located on the southern edge of the Siberian Platform. The terrain is divided by the valleys of the Angara and Irkut rivers. The floodplain (0.75–2.5 m), above-floodplain first (4-8 m), second (10-15 m), third (16-20 m) and fourth (20-25 m) terraces are expressed. Above are the slopes.
- The climate is sharply continental. Precipitation is 350-430 mm per year. The average annual temperature is 1.1 oC.
- In winter and summer, unfavorable conditions in the lower 20 m layer due to the concentration of a significant part of vehicle exhaust emissions here.

The research method is bioindication of tree leaves (poplar, birch, maple) for the content of benz (a) pyrene



Sampling location

- 1 - Stanislavsky yard (4th terrace)
- 2- «Yubileyny» yard
- 3 - yard "Akademgorodok"
- 4-hydroelectric dam (floodplain of the Angara River)
- 5-Yubileynaya road
- 6-Lermontov Street
- 7-Baikal Street

Content B(a)P in the leaves of trees

Distance from roads (all samples)	Concentration B (a)P, mcg/kg (n is the number of samples)	
	All leaves	**Poplar leaves washed from dust**
From the roads 3 m	*13± 9 (n=11)	**14 (8-25, n=14)
From the roads 5 m	8± 5 (n=22)	11 (8-12, n=14)
From the roads15-20 m	6± 3 (n=10)	10 (7-12, n=14)
Courtyards and squares	**7± 3 (n=16)**	**9 (8-12, n=14)**
BACKGROUND (birch, poplar)	3± 2 (n=19)	3 (1-5, n=15)
* Arithmetic mean ± standard deviation; ** Average (minimum – maximum)		

Conclusions

- 1. The incidence of malignant neoplasms in the cities of the Irkutsk region tends to increase both in industrial (Svirsk, Angarsk, Shelekhov, Irkutsk, Usolye-Sibirskoye) and agricultural cities, exceeding the indicators of Russia.
- 2. Monitoring B(a)P in the atmosphere of the cities of the Irkutsk region shows at the beginning of the XX1 century a decrease to the average annual MPC of 2-10 (up to 30-80 maximum monthly averages) with a weak difference between industrial and agricultural cities.
- 3. The assessment of heat sources of "low" power (boiler houses and house stoves), which are sources of emissions of carcinogenic B(a)P and PAH in the atmosphere, especially in agricultural cities.
- 4. It is shown that forest fires are sources of pollution of the atmosphere of the cities of the Southern Baikal Region with carcinogenic benz (a) pyrene.
- 5. The method of bioindication of tree leaves growing on the terraces of the city of Irkutsk shows the influence of transport on atmospheric pollution, which decreases with distance from roads, is minimal in squares and courtyards, but exceeds the background levels of B (a)P.

Research areas

- Development of methodological support for monitoring and controlling the distribution of carcinogenic factors in the system "source of emissions – environment object - phytocenoses – human health".
- Assessment of the load of carcinogenic factors from industrial, transport and natural sources of isolation with the establishment of the zones of greatest danger in the territory of the Irkutsk region.
- Conducting ecological zoning of carcinogenic factors and assessing their risk to human health and ecological systems of the Irkutsk region.