UDC 614.7
DOI: 10.21668/health.risk/2017.1.02.eng

CHEMICAL FACTORS OF SOIL POLUTION IN TAGANROG AS POPULATION HEALTH RISK FACTORS

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Our research goal was to perform a hygienic assessment of soil pollution with chemicals on areas aimed for housing and recreation zones in Taganrog, Rostov region. Due to the fact that surface layer of city soils is an open dynamic system which is tightly connected to atmosphere and hydrosphere we treated pollutants content in soils as indicators of territory anthropogenic transformation and technogenic load on population. We used atomic-adsorption spectrophotometry to detect heavy metals and highly efficient liquid chromatography to detect 3,4-benzpyrene content. The results comprise 660 examined soil samples taken from 19 monitoring points; they were examined to detect 7 pollutants content (lead, zinc, copper, nickel, cadmium, chromium, and mercury) over 2008–2015; 144 samples were examined to detect 3,4-benzpyrene content over 2013–2015. We determined that priority pollutants among detected metals were zinc and lead; their content in city soils amounted up to 5.91 and 1.95 maximum permissible concentration. Complex indicator of city soils contamination varied from 1.61 to 2.02, long-term average annual value being 1.83. 3,4-benzpyrene was confirmed to be a substantial risk factor for population health as its concentrations exceeded maximum allowable values in 65.28 % of examined soil samples at average and maximum concentrations (2.45 and 38.05 MPC correspondingly). We recommend to include this chemical into systematic environmental quality monitoring. We detected regional peculiarities of soil pollution with chemicals on city territories aimed for housing, territories of pre-school children facilities, and recreation zones.

Key words: *hygienic assessment, social-hygienic monitoring, risk assessment, risk factors, chemical soils pollution, heavy metals, 3,4-benzpyrene, carcinogenic risk.*

If we want to provide sanitary and epidemiologic welfare and hygienic safety for the population we should improve the national system of social and hygienic monitoring based on using the maximum full objective data on components of "environment - population health" system. It helps to substantially decrease influence exerted by uncertainty factor when working out management decisions in the

Ó Aydinov G.T., Marchenko B.I., Deryabkina L.A., Sinelnikova Yu.A., 2017

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sphere of prevention and health improvement. Implementation of modern highly efficient physical-chemical techniques applied for hygienic assessment of environment components becomes really vital as we need to take immediate action aimed at improving domestic risk assessment and analysis methodology including principles of hygienic standardization based on risk assessment [2, 6, 7, 9, 11, 12, 13].

Urban ecosystems which form in most contemporary cities are characterized with apparent destructive effects in all environment components including soils in areas aimed for housing. Soil is a most essential environment component and it to a great extent determines environment quality and safety parameters, exerts considerable influence on population health and sanitary-hygienic conditions of life activity. Therefore, data obtained via dynamic monitoring over chemical pollution of soils in urbanized territories and changes it undergoes under technogenic load influence attract most attention among other environment parameters which require hygienic characteristics in social-hygienic monitoring system. Such data are also of great importance when danger is identified and exposure is assessed within the procedure of population risk analysis. City soils are an open dynamic system closely connected with atmosphere and hydrosphere; chemical pollution content in their surface horizon is an evidence of intensity and character of their anthropogenic transformation. Thus, dynamic monitoring over geochemical pollution parameters becomes one of the obligatory directions in studying prevalence of ecologically dependent nosologic forms including malignant neoplasms characterized with specific localizations and process types among population of large industrial centers [1, 8, 10, 14, 18].

3,4-benzpyrene being a 1st danger category pollutant holds a special place among priority xenobiotics and super-ecotoxicants with high degree of persistence, potential carcinogens and chemical carcinogenesis modifiers which accumulate in soils of industrial cities; dangerous chemical pollutants also include lead, chromium, cadmium, and nickel. 3,4 benzpyrene is a most widely spread carcinogenic and mutagenic muiltring aromatic hydrocarbon (MAH) in environment. It can be found in emissions of stationary industrial sources and motor transport. As a result of sedimentation and precipitation, 3,4-benzpyrene pollutes soil mantle, penetrates into vegetation easily and becomes a part of nutritional chains through crop production with apparent biological magnification. So, detecting 3,4-benzpyrene in soils becomes greatly vital in ecological analytics system and in social-hygienic monitoring [1, 3, 5, 15, 16, 17, 19]. Thus, when research on ecological assessment of soil and vegetation pollution level was previously accomplished in Rostov region, 3,4-benzpyere was detected in a zone influenced by emissions from Novocherkasskaya state district power station and its concentrations were considerably higher (up to 39.2 times) than maximum permissible concentration (MPC) [4]. We should note that application of 3,4-benzpyrene mass concentration assessment results in social-hygienic monitoring system substantially increases information value of hygienic assessment of environment chemical pollution including soils pollution; this hygienic assessment is then followed by health risk assessment.

Our research goal was to give hygienic characteristics of chemical soils pollution in Taganrog as per data obtained in the course of social-hygienic monitoring allowing for applying highly-sensitive technique of 3,4-benzpyrene detection.

Data and methods. When performing complex assessment of chemical soils pollution in areas aimed for housing and recreation zones in Taganrog, Rostov region, we used the results of examining 660 samples tested as per seven pollutants content including lead, zinc, copper, nickel, cadmium, chromium, and mercury; all the samples were taken over 2008-2015. They were taken at 19 monitoring points, 8 of which were located on the territory of municipal pre-school children facilities, 8 were situated in areas aimed for housing and influenced by motor transport emissions (in close proximity to crossroads with heavy traffic), and 3 were in recreation zones (Pushkinskaya embankment, Primorskiy park and "Solnechniy" beach). Unfavorable situation with Taganrog population morbidity of malignant neoplasms determined the necessity to expand a range of sanitary-chemical examinations and to include a procedure of potential carcinogenic risk assessment. Thus, since 2013 research on 3,4-benzpyrene content in environment objects has been performed according to a new state assignment within social-hygienic monitoring frameworks; soils have been included into this research (144 soils samples were examined over 2013-2015). Metal content in soils was determined via atomic-absorption technique with the use of "Kvant-2A" atomic-absorption spectrometer. We applied a technique aimed at measuring benzpyrene mass concentration in soils, grounds and sewage precipitations via highly efficient liquid chromatography (certificate No. 27-08 dated March 04, 2008). The mentioned measuring technique can be applied to soil and ground and specifies benzpyrene mass concentration detection via highly efficient liquid chromatography with fluorimetric detection; it provides results of benzpyrene mass concentration measuring within 4-80 mkg/kg range. The applied equipment includes "Stayer" stationary liquid chromatograph with fluorimetric detector and a PC with installed software "MultiChrom for Windows XP", version 1.5.

Degree of chemical soil pollution was assessed as per complex soil pollution index (Кsoil). To detect the index, we used a sum of separate pollutants concentrations coefficients (quotients from division of actual substances content in soil by their maximum permissible concentration) according to the methodical guidelines issued by RF Goscomsanepidnadzor on February 26, 1996, No. № 01-19/17-17 "Complex detection of anthropogenic load on water objects, soil, and atmosphere in areas aimed for housing". Complex soil pollution index (Кsoil) was calculated both in the city as a whole, and for separate categories of monitoring points (territories of municipal pre-school children facilities, areas aimed for housing in close proximity to crossroads with heavy traffic and recreation zones). When processing data, we used our own specialized software and professional package of statistic programs «Statistical Package for Social Science» (SPSS) version 13.0.»

Results and discussion. Examination results over 2008-2015 prove that copper, nickel, and mercury content in soils of monitoring points doesn't exceed their maximum permissible concentrations. Average concentrations of these metals amounted to 23.03±1.04 mg/kg, 20.48±0.55 mg/kg and 0.049±0.008 mg/kg, correspondingly. And their share contribution into complex soil pollution index was 4.08 %, 5.99 % and 0.54 %, correspondingly.

The maximum pollution index among all the detected metals belonged to zinc with its average concentration being 166.50±7.51 mg/kg (0.76 MPC) and share contribution into Ksoil being 17.71 %.

Table 1

Indices of soil pollution with metals in Taganrog, Rostov region, over 2008-2015

Indices		Taganrog as a whole, over 2008-2015	including:		
			Municipal pres-school children facilities	Housing areas (crossroads)	City recreation zones
Number of examined soil samples	abs.	660	288	288	84
LEAD (MPC is 130 mg/kg)					
Specific weight of samples with content higher than MPC	%	1,67	I 0,69	3,11	0,00
Average actual concentration	MPC	0,295	0,282	0,351	0,145
Minimal actual concentration		0,008	0,008	0,025	0,010
Maximum actual concentration		1,953	1,759	1,953	0,922
ZINC (MPC is 220 mg/kg)					
Specific weight of samples with content higher than MPC	%	15,76	12,80	22,92	1,19
Average actual concentration	MPC	0,757	0,720	0,905	0,367
Minimal actual concentration		0,025	0,025	0,025	0,031
Maximum actual concentration		5,913	1,917	5,913	1,724
COPPER (MPC is 132 mg/kg)					
Specific weight of samples with content higher than MPC	%	0,00	0,00	0,00	0,00
Average actual concentration	MPC	0,174	0,169	0,193	0,128
Minimal actual concentration		0,002	0,002	0,010	0,005
Maximum actual concentration		0,958	0,958	0,890	0,523
NICKEL (MPC is 80 mg/kg)					
Specific weight of samples with content higher than MPC	%	0,00	0,00	0,00	0,00
Average actual concentration	MPC	0,256	0,270	0,250	0,228
Minimal actual concentration		0,005	0,028	0,005	0,015
Maximum actual concentration		0,681	0,681	0,479	0,428
CADMIUM (MPC is 2 mg/kg)					
Specific weight of samples with content higher than MPC	%	0,45	0,35	1,19	0,35
Average actual concentration	MPC	0,174	0,184	0,135	0,175
Minimal actual concentration		0,000	0,030	0,000	0,014
Maximum actual concentration		5,300	1,010	5,300	2,070
CHROMIUM (MPC is 6 mg/kg)					
Specific weight of samples with content higher than MPC	%	0,34	0,00	0,79	0,00
Average actual concentration	MPC	0,146	0,130	0,188	0,060
Minimal actual concentration		0,000	0,010	0,003	0,000
Maximum actual concentration		3,983	0,988	3,983	0,438
MERCURY (MPC is 2.1 mg/kg)					
Specific weight of samples with content higher than MPC	%	0,00	0,00	0,00	0,00
Average actual concentration	MPC	0,023	0,016	0,033	0,014
Minimal actual concentration		0,000	0,000	0,000	0,000
Maximum actual concentration		0,881	0,192	0,881	0,098

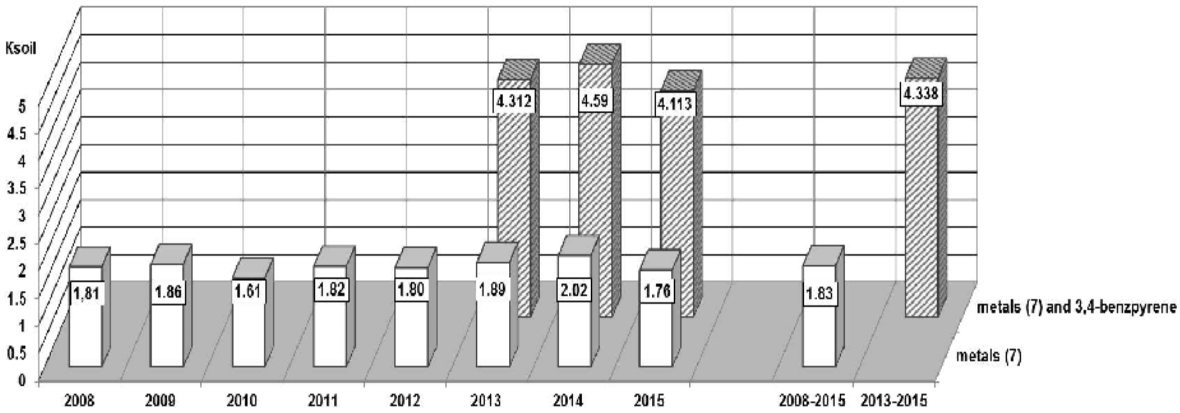

Figure 1. Complex index of chemical soils pollution in Taganrog over 2008-2015

Zink content was higher than maximum permissible concentration in 15.76% samples with maximum index being 5.91 MPC. Lead took the second rank place with its concentration being higher than MPC in 1.67% of examined samples and its average content in soils being equal to 38.36±2.30 mg/kg, maximum index being 1.95 MPC and specific weight in Ksoils equal to 6.90 %. Cadmium content higher than MPC was detected in 3 samples (0.45 %), and chromium content higher than MPC in 2 samples (0.34 %). maximum cadmium content was equal to 5.3 MPC, and chromium, 3.98 MPC.

The accomplished comparative analysis revealed that the highest content indices for such metals as lead, zinc, cadmium, and chromium, were detected in areas aimed for housing influenced by massive emissions of motor transport (crossroads), when their content was higher than MPC in 3.11 %, 22.92 %, 1.19 % and 0.79 % of examined samples. Soil pollution indices were significantly lower on territories of municipal pre-school children facilities where lead content (0.69%), zinc content (12.80%), and cadmium content (0.35%) in examined samples was higher than MPC. The lowest soil pollution indices were detected in recreation zones where only one sample had zinc content which was higher than MPC (table 1).

Complex city soils pollution index (Ksoil) determined by content of seven metals varied within 1.606 to 2.019 during the whole examined period. Average value amounted to 1.825, including municipal pre-school children facilities with 1.956, areas aimed for housing in close proximity to crossroads with heavy traffic with 1.910, and recreation zones with 1.077 (table 1, figure 1).

Results obtained over 2013-2015 prove that city soils are heavily polluted with 3,4-benzpyrene. Thus, 65.28% of 144 examined samples contain this pollutant in concentrations exceeding MPC, its actual average concentration being equal to 0.049±0.013 mg/kg (2.45 MPC). And its maximum registered content amounted to 0.761 mg/kg (38.05 MPC). And it is understandable that 3,4-benzpyrene pollution was considerably higher in areas aimed for housing in close proximity to crossroads with heavy traffic. MPC was exceeded in 71.30% of all examined samples with its average actual concentration being equal to 0.053±0.016 mg/kg (2.65 MPC). Recreation zones were less polluted with 3,4-benzpyrene as its concentrations higher than MPC were detected only in 50.00% of samples and its average and maximum concentration amounted to 1.85 MPC and 7.71 MPC, correspondingly (table 2, figure 2).

Table 2

Indices of soils pollution with 3,4-benzpyrene in Taganrog, Rostov region, over 2013–2015

Indices		Years of monitoring			Taganrog as a whole over 2013-2015	including:	
		2013	2014	2015		Areas for housing (cross roads)	City recreation zones
Number of examined soils samples	abs.	48	48	48	144	108	36
Samples with concentrations higher than MPC (0.02 mg/kg)	abs.	35	34	25	94	77	18
Specific weight of samples with concentrations higher than MPC	%	72,92	70,83	52,08	65,28	71,30	50,00
Average actual concentration	mg/kg	0,0484	0,0514	0,0471	0,0490	0,0529	0,0369
	MPC	2,42	2,57	2,35	2,45	2,65	1,85
Its limiting error (±□, p<0.05)	mg/kg	0,0198	0,0114	0,0321	0,0127	0,0163	0,0128
Specific weight of pollutant in Ksoil	%	56,17	56,00	57,20	56,44	58,92	63,41
Minimum actual concentration	mg/kg	0,0044	0,0077	0,0032	0,0032	0,0044	0,0032
	MPC	0,22	0,39	0,16	0,16	0,22	0,16
Maximum actual concentration	mg/kg	0,3710	0,1542	0,7610	0,7610	0,7610	0,1542
	MPC	18,55	7,71	38,05	38,05	38,05	7,71

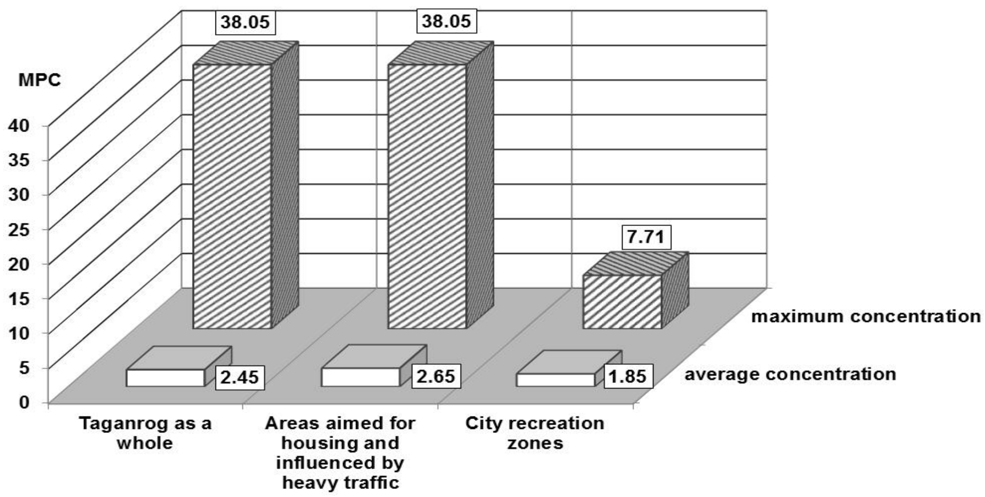

Figure 2. Indices of soils pollution with 3,4-benzpyrene in Taganrog, Rostov region, over 2013–2015

With 3,4-benzpyrene content taken into account in hygienic assessment of chemical soils pollution, its complex chemical index value and structure changes greatly. Thus, average value of complex index (Ksoil) over the last three years amounted to 4.338, with 3,4-benzpyrene share contribution being 56.44 % (table 2, figure 1).

Conclusion. So, in our research we detected high level of soils pollution with

3,4-benzpyrene in Taganrog. This pollutant is highly stable, has great accumulation capacity in natural ecological systems and penetrates nutrition chains quite easily. Its carcinogenic, mutagenic and teratogenic effects on people are proved. It is advisable to examine 3,4-benzpyrene as a priority pollutant. In our opinion, integration of relevant databases into regional geoinformation systems (GIS) and software providing data transfer into assessment of carcinogenic effects risk caused by chemical soils pollution in Rostov region would be a very promising trend in developing hygienic assessment of chemical soils pollution in social-hygienic monitoring system. Sampling examination of crop production (fruit and vegetables) grown on personal plots in the city in terms of 3,4-benzpyrene content in it is to take place in accordance with State Standard P 51650-2000 "Food stuffs. Techniques for detecting benzpyrene mass concentration". All the results obtained in this work will give grounds for population health risk assessment.

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Aydinov G.T., Marchenko B.I., Deryabkina L.A., Sinelnikova Yu.A. Chemical factors of soil polution in taganrog as population health risk factors. Health Risk Analysis, 2017, no. 1, pp. 13–20. DOI: 10.21668/health.risk/2017.1.02.eng