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ABSTRACT: The study was conducted in 2 urbanized areas of the Baikal region of Russia. These are the cities of Shelekhov and Tayshet with their suburbs. Aluminum production has been carried out in Shelekhov for over 60 years and in Tayshet for 5 years. The purpose of the study was to determine the pollution of urban soils with toxic elements—Al, F, Be, Li, as well as Cr, Ni, Pb, and so on under the influence of industrial enterprises (aluminum and cable plants, thermal power plants). Also, the purpose of the research was to determine the effect of increased fluorite (F) in the environment on children's health. Pure aluminum is used much less frequently than in alloys. The addition of various elements (Be, B, Li, Fe, Si, Mg, Mn, Zr, Ag, Pb, Cu, Ni, and others) increases the hardness, density, thermal conductivity, and other properties of the alloys. The area of high F content in urban soil is 15 times higher than the regional context. The maximum content of Na, Be, and Al is 2 to 4 times higher than the regional background. An increased Li content is marked only near aluminum smelters. The F content in urine samples from children living in areas with long-term pollution exposure (Shelekhov) is 1.5 to 2 times higher than in the group of children with a short exposure period (Tayshet).

KEYWORDS: Soil contamination, aluminum smelters, environment pollutants, urban territories, human health

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Introduction

The soil cover is known as the depositing medium capable of accumulating practically all pollutants entering the environment.[1,2] Therefore, it offers an archive on the geochemical state of the environment. Chemical elements accumulate and migrate in soils due to some factors: type and composition of soils, physicochemical state of the element, forms of occurrence, sorption and migration features, and pH of the liquid phase and soil phase.[1] The urban soils, that is, ground soils, urban earths, and technical earths, represent the soils formed owing to economic activity. In urban territories and suburbs, the anthropogenic contribution to soil formation seems to be critical, so distinct soil horizons are not observed. At present, soils are factually a complicated natural-anthropogenic system due to the long-term inflow of toxicants caused by industrial production.[2-10]

Aluminum production has been continuously growing worldwide because this element is actually irreplaceable in diverse industries.[11] Aluminum is derived from a rock with a complex composition—bauxite. First, alumina (Al_2O_3) is obtained from bauxite. Then from alumina as a result of electrolysis in the melt of fluoride salts at a temperature of about 950°C, the main component of the melt, cryolite, is obtained. Cryolite is Na_3AlF_6 salt.[7,12,13] Russia is the world leader in aluminum production, with more than 10 factories in different cities (Irkutsk, Bratsk, Krasnoyarsk, Sayansk, Novokuznetsk, Volgograd, Volkhov, Kandalaksha, etc).[14,15] Many papers have been published on environmental pollution around aluminum plants in Siberia.[5,6,8] Most of the aluminum produced in Russia is sent abroad. China, Russia, and India are in the leading positions in aluminum production in the world.[12,14,16]

In the process of electrolysis, aluminum is deposited in special electrolysis baths. In its pure form, aluminum is used much less frequently than in the form of alloys.[17] The alloys additionally contain various elements that increase their hardness, density, thermal conductivity, and so on.[18] For this purpose, Be, B, Li, Fe, Si, Mg, Mn, Zr, Ag, Pb, Cu, Ni, and other elements are used. All of the above elements, which exceed the regional background content[19] or the city clarke[20] (Table 1), are to some extent toxic to humans, as evidenced by numerous publications.[12,21–28] They can accumulate in the human body for a long time and exceed the concentration (dose) necessary for life.[21] It is known that fluorine and its compounds have a narrow range of physiological optimum, which requires special attention to the problem of health effects.[22] Fluoride exposition can have some negative physiological effects, for example, nephrotoxicity,[23] thyroid dysfunction,[24] cardiometabolic risk,[25] neurodevelopmental disorder in children,[26,27] and reproductive endocrine disruption.[28]

Rare articles have reviewed potential health hazards that may also pose health risks[29] to some communities because of their proximity to aluminum smelters.[21,30,31] They pinpoint that there is a potential for materials such as sulfur dioxide, particulate matter, fluorides, and beryllium capable of posing health risks to communities.[21] Its toxic action is insignificant; however, many water-soluble inorganic compounds, as well as its satellite elements F, Be, and Li, are long-preserved and

Table 1. Element concentrations in the soil cover of Shelekhov and Tayshet towns.

ELEMENTS	SHELEKHOV AND ITS ENVIRONS	TAYSHET AND ITS ENVIRONS	REGIONAL BACKGROUND OF BAIKAL REGION[19]	CLARKE URBAN SOILS IN CITIES[20]
Al, %	5.8 – **8.7** 7.2	4.0 – 8.0 6.6		3.82
K, %	1.2 – 1.7 1.6	1.0 – 2.8 1.9	1.7	1.34
Na, %	1.0 – 1.9 1.6	0.8 – 1.9 1.5		0.58
Fe, %	4.2 – 6.7 5.4	1.4 – 4.4 3.1		2.23
Mg, %	1.3 – 1.9 1.6	0.5 – 1.2 0.9	1.9	0.79
Ca, %	1.5 – 5.4 2.7	1.4 – 4.6 2.1	2.2	5.38
Li, mg/kg	24 – **54** 32	10 – 34 22.5		49.5
Be, mg/kg	1.5 – **12.0** 2.5	0.9 – 2.1 1.5	3	3.3
F, mg/kg	520 – **2100** 860	280 – 750 450	140	
Ni, mg/kg	23 – 55 40	10 – 46 30	44	33
Co, mg/kg	6 – 19 14	6 – 22 13	17	14.1
Cr, mg/kg	42 – 160 97	46 – 110 77	100	80
V, mg/kg	41 – 130 84	58 – 130 94	100	104.9
Mo, mg/kg	0.6 – 1.4 0.9	0.7 – 1.6 1.2		2.4
Cu, mg/kg	14 – 71 29	6 – 74 27	51	39
Zn, mg/kg	47 – 120 68	23 – 180 69	84	158
Pb, mg/kg	17 – **110** 31	10 – 36 17	10	54.5
B, mg/kg	5 – 130 29	13 – 110 31		45
S, mg/kg	100 – **1760** 400	100 – 400 150		1200
Number of samples	30	38	712	> 8000 (from 300 cities of different countries)

Numerator—minimum-maximum; denominator—average. Bold content above regional background and clarke for soils of cities in different countries.

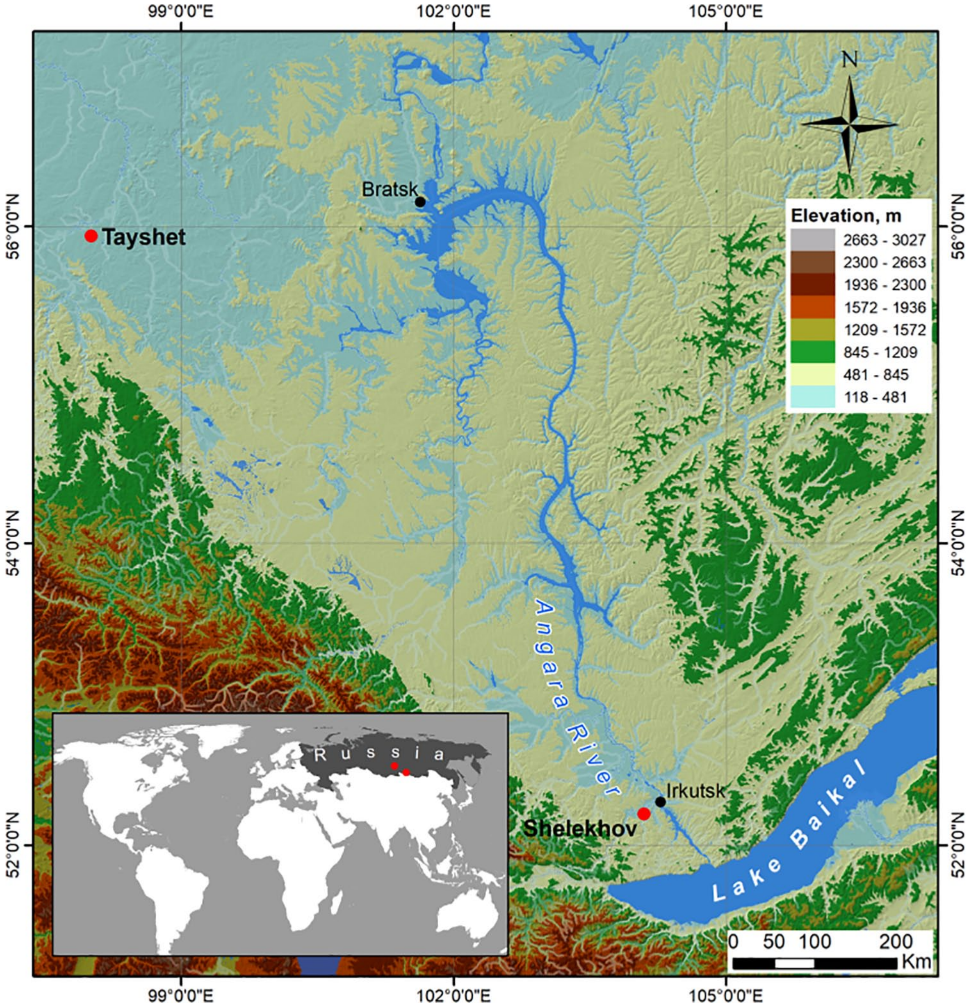

Figure 1. Overview map of the location of cities with aluminum production in the Baikal region (Russia).

might harmfully affect a human being and homoiotherms through drinking water, food, and soil.[32–38]

Recently, the problem of environment-safe aluminum production has been given serious concern.[39] At the Shelekhov aluminum smelter, the production lines have been modernized, up-to-date equipment has been installed, and atmosphere-polluting emissions have been markedly reduced. In the Tayshet region, it was envisaged to employ modern facilities with updated gas purification and minimal release of toxicants into the environment. However, different environment components and the health of the population need to be continuously monitored. Industrial emissions from aluminum electrolysis plants contaminate the environment of adjoining residential areas (particularly where the use of Soderberg anodes continues), demonstrating an association with considerable impairment to the health of newborns.[40–42]

Thus, the main purpose of this study was to identify additional inflow of toxic elements into the environment, compared with their regional background content, due to the existing and under construction aluminum smelters and providing them with thermal power plants that supply them with electricity. The work aims to identify pollution in areas with aluminum production: the city of Shelekhov with 60 years of industrial operation and the city of Tayshet with a pilot production.

Materials and Methods

Study area

The study objects are the soils of urban ecological systems of the Baikal region housing operational aluminum plants, for example, at the towns Shelekhov and Tayshet (Figure 1).

Shelekhov is located in the interfluve of the Irkut and Olkha rivers and is a small industrial town in the Baikal region founded back in 1956 during the construction of the Irkutsk Aluminum Plant (IrkAZ). The city is located 15 km southwest of the Irkutsk regional center (Figure 1). The industrial trends of this town are determined by nonferrous metallurgy, for example, IrkAZ and cable-producing plant, heat power engineering, and construction materials production. The flatlands of the suburbs are basically taken up by agriculture and collective vegetable gardens. Virgin pinery still grows within the town itself.

The operating aluminum smelter and its environment have for a long time been under research monitoring; therefore, extensive information was collected on the chemical state of some environmental components, for example, snow and surface water.[19,43] The primary aluminum is produced from imported raw alumina. The capacity of the smelter (annual production capacity of 419 000 tones)[44] is much higher than internationally required standards for environmental protection.[45]

Tayshet is located in the northwest (NW) of Irkutsk Region, 675 km from the Irkutsk regional center, on the right side of the Biryusa River, in the interfluve of its tributaries Tayshetka and Akulshetka Rivers (Figures 1 and 3). Approximately 10 km NW of Tayshet, there is a small town Biryusinsk. In the northeast (~7 km), the territory between Akulshetka and Baironovka Rivers was picked for a new aluminum smelter and anode-producing factory. The basic enterprises of Tayshet town are railway engine house, a sleeper factory, as well as printing, construction, and forestry industries.

As regards the geological characteristics, in these urban territories can be registered Jurassic rocks, for example, sandstone, siltstone, conglomerate, breccia, and coal deposits, used in power engineering in the Baikal region.[46] Beyond these towns, the soil cover largely consists of gray woody, sod-carbonate and sod-podzolic soils; the river valleys are covered with meadow-boggy soil.[47] As it was found out, the urban soil contains a wide range of chemical elements of natural and technogenous origin, as it represents the medium favorable for absorption.[48] In the towns and beyond, the territories are occupied with coniferous (pine) and mixed forests; in the river valleys, some places are devoid of forest and are mostly occupied by grassland.

On the study territories, the mean annual temperatures of air, water, and soil are commonly low (0°C), dropping to −40°C in winter.[19,47] Thus, they are marked by the continuous freezing of environmental components, at times for 5 months, which might explain their lowered capacity for self-purification from the anthropogenic effect.[8] The samples were taken from the urban soils of diversely functioning zones: industrial, residential, natural-recreation, and soils from town suburbs.

Soil mapping techniques

Soil sampling was carried out in 2 towns from 2012 to 2014 at a scale of ~1:100 000 spaced 1 × 1 km and further thickened to 500 × 500 m at mostly problematic sites, such as the location of sludge from production and places of unloading of raw materials. The soil samples were taken by an envelope-like mode from the surface of humus-accumulative layer about 2 to 10 cm thick. Samples are stored and transported in kraft-paper bags. The weight of the sample is 1 kg; after drying, sieving, and quartering, 200 g remains for analysis.

Preparation of soil samples for analysis was carried out according to a standard procedure:[49] drying in a well-ventilated room at room temperature, sieving through a nylon screen with a 2-mm mesh size, quartering to obtain the main sample and duplicate, taking the quartering samples weighing 150-200 g, abrasion to size 200 mesh in an abrasive with reinforced alumina ceramics, and taking the samples necessary to transfer to the appropriate types of analysis.

Laboratory analysis

To determine the total content of elements in the soil, a soil sample is transferred to a solution. To do this, a portion of the soil (0.1-1.0 g) is treated with a mixture of acids (hydrofluoric, perchloric and nitric), the resulting solution is evaporated to wet salts, and the residue is dissolved in 5% hydrochloric acid. In the resulting solution, the elemental composition of the soil is determined by atomic absorption spectrometers of model 403 and 503 manufactured by Perkin-Elmer (USA). The study of the forms of finding elements in the soil has been conducted earlier.[43]

Analysis of soil samples for fluorine was carried out by an individual method of arc atomic emission analysis using injection-dredging. This method is applied for the quantitative chemical analysis of gross content of soils by arc atomic emission spectrometry with photoelectric spectra recording and the introduction of matter into the arc discharge by the method of injection-dredging. The correctness of results was confirmed by an analysis of standard samples of soil,[50] which are available at the A.P. Vinogradov Institute of Geochemistry SB RAS, Irkutsk. The samples were analyzed with research equipment of the Center for Collective Use "Isotope-geochemical research at IGC SB RAS" at the Irkutsk Science Center.

The study was conducted in accordance with the Helsinki Declaration.[51] The program for child observation was approved by the Ethics Committee of the East-Siberian Institute of Medical and Ecological Research. Besides, formal consent was obtained from the parents of the observed children, who received physical examinations and blood and urine workups. All participants were healthy without urinary tract obstruction and any other systemic and acute diseases. In all, 469 urine samples of children aged 5 to 17 residing in Shelekhov and Tayshet have been analyzed in the range of 2012-2014. Urinary fluoride excretion was assessed by a potentiometric method on a spot morning urine sample, and information on exposure factors was obtained by questionnaire. In accordance with current recommendations as to the permissible level of fluoride in urine, the value of 20.0 ± 4.9 µmol/L was adopted—in hair up to 150 mg/kg.[52] This was a long-term cohort study of fluoride measured in the urine of Tayshet-inhabiting children (as the indicators of an individual pre-exposed and exposed to fluoride, respectively) in the age groups 5-7, 8-10, and 11-17 years (Table 2).

Statistical analysis

Statistical analysis distribution pattern was verified using the Shapiro-Wilk method. They were tested statistically by analysis of variance (ANOVA) to compare the means of the outcome or

Table 2. Fluorine content in urine of children from industrial centers of Baikal region, μmol/L.

TOWN, GROUP OF CHILDREN	N	AVERAGE VALUE	MEAN VALUE ERROR	MODE	MINIMUM	95TH PERCENTILE
5-6 years						
Shelekhov	97	68$^{*P=-.000}$	3.0	58	15	135
Tayshet	133	30	2.9	51	15	121
7-10 years						
Shelekhov	66	63$^{*P=-.000}$	2.8	59	14	118
Tayshet	55	31	3.2	49	15	139
11-17 years						
Shelekhov	75	45$^{P=-.152}$	2.5	35	26	66
Tayshet	43	40	2.4	22	20	60

Abbreviation: n, number of observations.
**P*: statistical significance of differences after the Student test.

exposure within the groups defined according to the distribution of each covariate. The Spearman correlation coefficients (r_{xy}) were referred to when measuring the correlation between soil and urinal fluoride in the cohorts. The regression models were assigned to assess binding between pre-exposed and exposed fluoride. The statistical significance between groups was evaluated through the Student *t* test on *P* level of .05. Acquired results were processed with the software package Statistica.v.8.

Results and Discussion

Elements—toxicants in the soil of the cities with aluminum production

In the soil cover of Shelekhov and Tayshet towns, the contents of the main macrocomponents Ca, Mg, Fe, K, Na, and Al are fairly similar (Table 1), showing they belong to the same structural zone of the Baikal region and occur within the same formation of Jurassic soil–forming rocks. The concentrations in soils of S, Pb, and other items and satellite elements of aluminum production (F, Li, Be, etc) reveal contrasting differences. Maximum values are recorded in the soils of Shelekhov town, being in excess of the regional background values of Baikal region[19] and clarkes of urban territories.[19,20,53] The contents of the other toxic elements like B, Cr, Ni, Co, V, Mo, and Zn are common for the clarkes of urban soils, sometimes exceeding them and regional background values (Table 1).

Cities with aluminum production in the Irkutsk region

Now we look upon the areal distribution of some element concentrations within soils of the towns and suburbs considered herein.

Shelekhov. This region is distinguished by the presence of high Al, Li, Be, and F concentrations in soils (Table 1), that is, chemical elements indicating the presence of the aluminum industry located close to the town territory. The high content haloes of toxic elements generally coincide; they merely differ in some detail in their configuration (Figures 1 and 2). The latter is the case due to the varying migration abilities of elements. The chemical elements penetrate the soil cover through wind transfer of the primary raw material from discharge sources, accumulation of the industrial products in snow cover, snow melting, accumulation of snow in solid sediment,[43,48] and further entry into soil. High Al, Be, Li, F, and Na abundances and some other elements (from 2 to 20 times in excess of background ones and RPC and MPC$_{soil}$) are recorded at the entry to the plant territory, around it, and in the zone suitable for the wind rose of this territory (Figure 2). The impact of the aluminum plant may spread pollution of soil for 15 to 25 km, depending on wind direction and force. As a result, the halo of Al, Be, and F contamination around Shelekhov is NW- to SE-directed within the interfluve of Olha and Irkut Rivers. The halo of high F contents in the urban soil is 15 times more than the regional background of soils (Table 1); maximum values are measured for the haloes of Na and Be; Al is 2 to 4 times higher than the regional background and clarke of urban soils. The Li contents are not much in excess; they are, however, higher, closer to the aluminum plant area.

In addition to the enumerated elements for soils of Shelekhov territory and its suburbs, high concentrations of some toxic elements were measured: for example, B, S, Cr, Ni, Co, Cu, Pb, and Zn, as well as U and Th. They might be due to the effect of effluents of thermal power plant[54,55] and cable plant because there are no other large industrial enterprises in the city. The abundances of some toxicants exceed the clarke of urban territories (Table 1). The total area of the geochemical halo of elevated contents of toxicant elements can reach 200 to 400 km^2 (Figure 2).

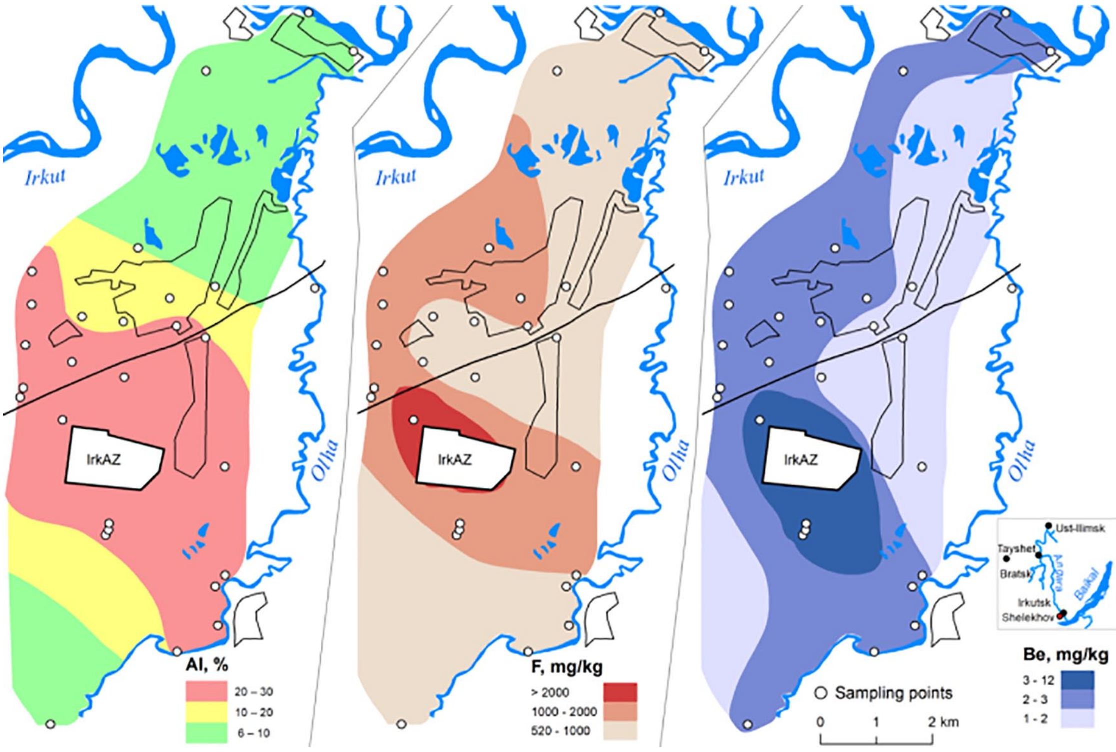

Figure 2. Distribution of Al, F, and Be contents in the soil cover of Shelekhov and its environs.

The obtained data of element contents in the soil of Shelekhov are confirmed by the work of other researchers in Russia[5,7,26,27] and in other regions of the world.[10,32–34] The soil cover survey shows the presence of contaminating chemical elements in its composition, which might result in their accumulation in the adjacent areas, in the composition of agricultural crops, biological substrate, that of the human one inclusive as noted by other researchers.[34,56,57] The minimum and maximum contents of some toxic elements in soils around aluminum and anode plants being built close to Tayshet town are markedly similar to those of Shelekhov (Table 1). But the content of F is lower because it takes longer to accumulate in the soil.

Tayshet. The construction of a plant near Tayshet began in 2008. The pilot smelter was operating for 3 years; later its work was stopped and recently recommenced again. The evidence of its effect on the chemical composition of soil cover is already noted. The abundances of Al and Na in soils seem to be nearly the same as in Shelekhov. The minimal values of the metals Cr, Ni, Co, V, Cu, and Mo occur at the same level of values. In Tayshet, when compared with the Shelekhov area, the maximum values of heavy metal concentrations are noticeably higher than the clarkes for urban soils.[20] The Pb and S contents are measured as essentially lower.

In the Tayshet region, the plant under construction is placed in the interfluve between the Biryusa, Akulshetka and Baironovka Rivers; the wind rose blows in the NW-SE direction. Around the plants under construction, the haloes of increased Al and its satellite elements F, Be, and Li look elongated; they are found between the Akulshetka and Baironovka Rivers (Figures 3 to 5). However, their maximum values are determined as minimal values marked in the soils of Shelekhov town and its suburbs, which could indicate the initial stage of territory pollution. It should be noted that the increased contents of the elements, being satellites of aluminum production, were measured in the soil cover of Tayshet town, where the raw materials for Al production had been supplied to.

Relatively increased contents of the elements such as B, S, Zn, and Pb and those of metal Cr, Ni, Co, and V are typical of the soils of the urban territories of Tayshet and Biryusinsk, which typify towns with developed railway and motor-car transport, heat stations, coal boilers, and treating enterprise. In the Tayshet region, these element contents are higher than the regional background values, but they are closer to the soil clarkes of urban territories (Table 1).

From yearly observations on admixture contents in soils at the towns housing operational aluminum industries, the F compounds are priority pollutants.[58–60] Maximum fluorine concentrations enter the human body through foodstuff and water, but in the zones of man-made pollution an important route of impact is atmospheric air, and in child groups it is soil.[37,38,61,62] The study of the relationship between the F compound contents in the surface soil horizon and snow cover (Figure 5) points to a direct and strong relation ($r_{xy} = 0.76$, $P < .05$) (Figure 6). The coefficient summation ratio of the content in the atmosphere of solid fluorides and hydrofluoride to their MPC (K_{sum}) was calculated in the study.[36] Between F content in soil and calculated values of

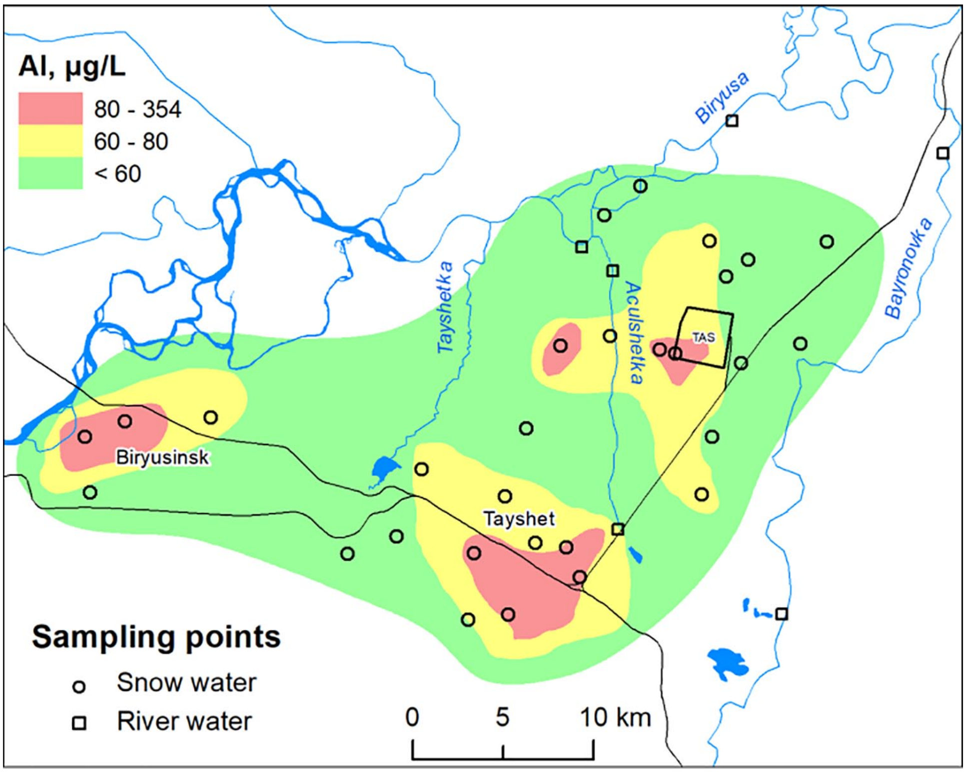

Figure 3. Distribution of Al contents in the soil cover of Tayshet and its environs.

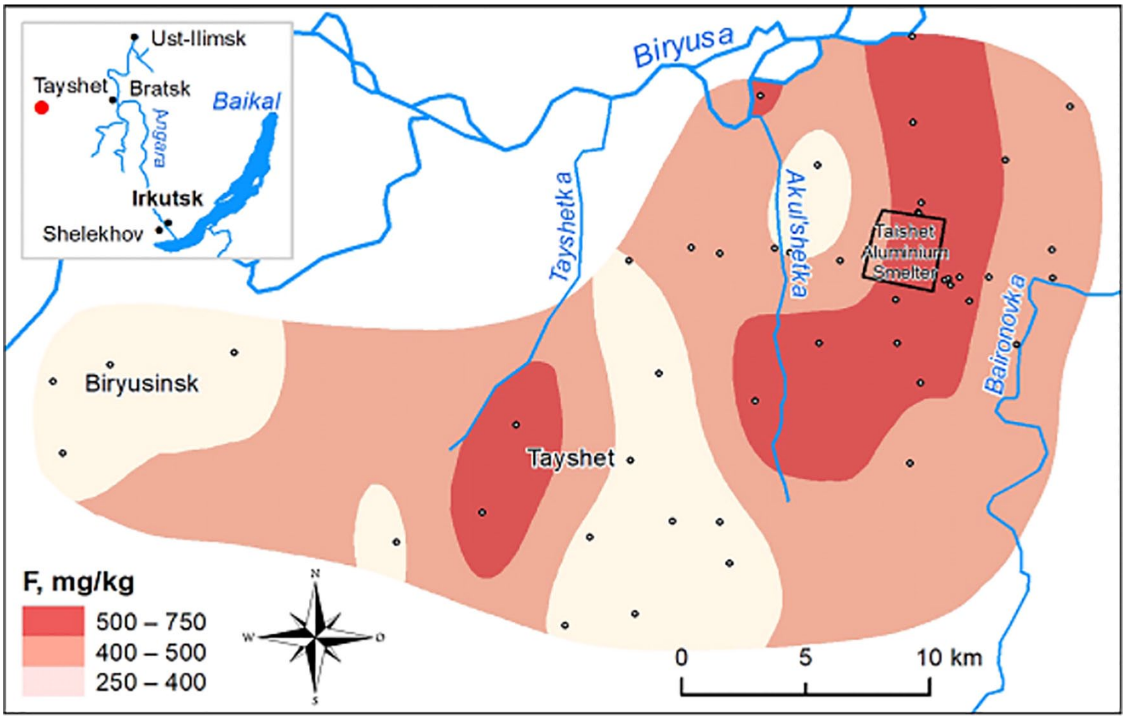

Figure 4. Distribution of F contents in the soil cover of Tayshet and its environs.

air pollution, the correlation coefficients display the relations of medium force with K_{sum} ($r_{xy} = 0.49$, $P < .05$; solid fluorides $r_{xy} = 0.52$, $P < 0.05$; hydrofluoride $r_{xy} = 0.47$, $P < .05$). The relationship between fluorine accumulation in deep soil and surface layers is presently featured by the tendency ($r_{xy} = 0.37$, $P < .1$).

Acquired data indicate that the soil cover around the aluminum smelter in Tayshet shows geochemical specifics and already experiences anthropogenic impact. Having defined the genesis of sites of enhanced pollutant abundances, either natural or technogenous one might employ the obtained data for recognizing ecologically unfavorable zones and priority toxicants in

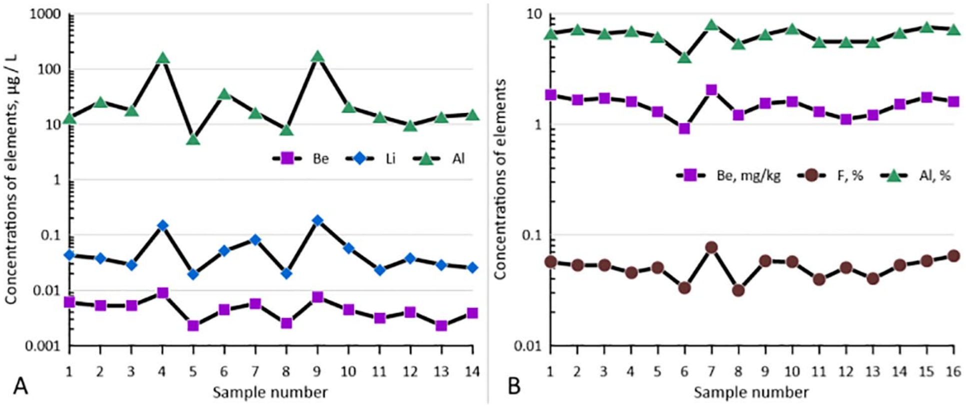

Figure 5. Correlation of element contents in the environmental components around the Tayshet aluminum smelter: (A) in snow water (µg/L) and (B) in soil (mg/kg) cover.

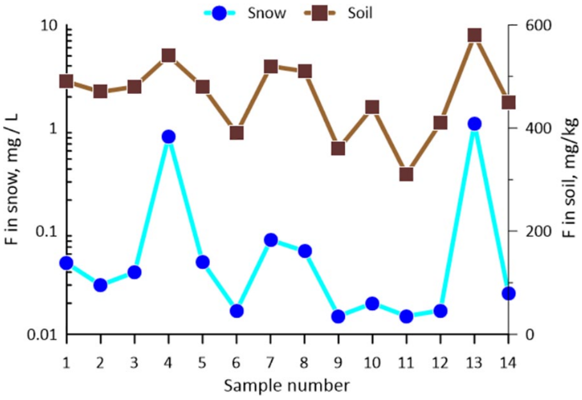

Figure 6. Correlation of F content in snow water (mg/L) and in soil (mg/kg) around the Tayshet aluminum smelter.

the urban territory; substantiation and realization of the measures focused on health preservation. The excess of the content of elements (above MPCs) is characteristic not only of soils in the environment of smelters but also affect nearby residential areas of cities, for example, in Norway,[58] Spain,[63] and Russia.[36,56]

Fluorine (F) contamination of urban child populations

Contamination of soil at the residential zones may cause penetration of toxic admixture into the human body. In Shelekhov, in a 10-year period, the daily intake of fluorine and its compounds from soil for adults is on average 0.4 mg/kg, that is, 20% of the required average daily dose of fluorine; for children, it is 1 mg/kg per day, that is, 67% of the required average daily dose of fluorine. In Tayshet, these values were not in excess of 5.5% and 25% of the daily rates (Table 2).

The average F-ion content in the children of Shelekhov at the age of 5 to 7 years was 68 ± 3.0 and at the age of 7 to 10 years was 63 ± 2.8 µmol/L ($P > .05$) (Table 2). In groups of children of Tayshet, the concentrations were 30 ± 2.9 and 31 ± 3.2 µmol/L ($P > .05$). When comparing the levels of fluorine excretion in children at Shelekhov and Tayshet, it was revealed that in groups with prolonged exposure the excretion of F-ions is significantly higher than in children residing in the territory of recently located emission sources ($P = .000$). The World Health Organization (WHO) suggests a reference value of 1 mg/L for healthy adults when monitoring renal fluoride excretion in community preventive programs.[62] It should be noted that at Shelekhov children show the 95th percentile of fluorine excretion above the level recommended by the WHO as safe. The average values are lower than in the regions of high natural fluoride content in water, such as Pakistan,[64] China,[61,65] Sri Lanka,[32] and Ethiopia.[66] Remarkably, on the territories of smelter placement, the researchers identified significant differences in the level of child and youth sickness rate: for example, increase in the rate of bone-and-muscle sickness in children by 5.6 times and in adolescents by 12 times compared with unexposed groups.[56]

In comparing the groups of adolescents, no statistically important differences were recognized. This is possibly due to the lower significance of the channel of toxicant transfer to adolescents because no direct contact was the case.

With the cohort study, the researchers evaluated the dynamics of fluorine excretion in urine in the residents from a formerly unexposed territory, and it was established that, prior to launching pilot smelter in Tayshet, the primary observation of children assessed showed an average concentration of 15.9 µmol/L. After commissioning the enterprise, the concentration increased to 38.1 µmol/L; in 89% of children, the F abundance in urine was much in excess of the regional background level. Maximally high values (over 95 percentile) varied from 97.8 to 140.2 µmol/L (Table 2). Dynamics of F-ion excretion, following from the data of linked samples, shows nonlinear dependence and is described by the equation $y = -0.03x^2 + 0.314x + 0.045$ (approximation coefficient $R = 0.87$, $P < .05$). Interestingly, after stopping raw aluminum production, fluorine is being eliminated from the human body during 2 years at a level having no statistically important differences with the indices at low exposure. The obtained results point to the possible capacity of fluorine to accumulate in the body and then gradually move away. In comparing the average-group levels of F-ion excretion in urine in children, some differences were observed depending on the distance of residence from the source of F-compound emission. In the groups of exposed people, the median of F-ion excretion is higher than in contemporaries and the residents of a conventionally clean region—1.2 times in preschool children and 1.6 times in schoolchildren ($P < .05$). It should be noted that significant differences in the level and structure of certain situations among children and adolescents, such as an increase of 5.6 times in the incidence of musculoskeletal ailments in children and 12 times in adolescents compared with unexposed groups, have been found in the territories housing aluminum plants.[56]

Different studies have shown that the aluminum industry discharges fluoride into the air, and several studies have shown a slight but significant contribution to the intake of fluoride by children living around aluminum smelters.[30,31] The research[30] found that fluoride excretion decreases with age in children ($r = 0.31$), but the authors do not discuss any interfering factors, for example, dental treatment with fluorine-containing drugs or the use of bottled water with fluorine. In a different country, total fluoride intake, urinary excretion, and consequently fluoride retention no longer reflect residence in a community with a nonfluoridated or fluoridated water supply[67,68] because of fluoride toothpaste of 57%, 35%, and 47% for children receiving low, suboptimally, and optimally fluoridated water, respectively.[69] Considering the wide variations in the F concentrations of different foods and drinks, it is important to assess differences in F intake and consequently fractional urinary F excretion in children.[70]

Thus, the nonspecific changes revealed in the health of children and the data on biological monitoring necessitate further monitoring of the situation from individual and population (statistic) data. To optimize preventive measures, it is reasonable to develop prognosis of health measurements regarding the data acquired through perennial observations in the territories where similar industrial enterprises operate.

Conclusions

The chemical survey of soils conducted in the urban territories housing aluminum industries identified contamination and degradation of soil cover. The comparison reveals similarities and differences in the content of Al, F, Be, and Li around aluminum plants. Other toxic elements (Pb, Zn, Cu, Cr, Ni, V, etc) accumulate in the soil due to the impact of thermal power plants that serve the aluminum smelter and city and can be fixed at a distance of 25 km from the emission source. The geochemical halo of pollutants in the city of Shelekhov can reach 200 to 400 km^2. Maximal elevation of element contents (above $\text{MPC}_{\text{soils}}$) is common for the soils occurring close to plants and neighboring residential areas.

The fluorine content in the urine samples of children living in areas with long-term pollution by emissions from an aluminum smelter is 2 times higher than in the group of children from the territory of the new development. In the exposed children, the median of F-ion excretion is higher than in the residents of the unexposed territory—1.2 times in preschool children and 1.6 times in schoolchildren. Although urinary fluorides may be used for exposure surveillance, additional details on individual exposure agents and patterns of exposure over time are required for a complete assessment.

Toxic substances from industrial pipes can travel up to 25 km and have long-term effects on environmental components such as soil, air, water, and food. It is harmful to public health due to the inhalation and ingestion of toxins by humans. The location of industrial sources in urban areas creates zones of soil pollution, oriented along the wind rose.

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