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WORKPLACE MONITORING AND OCCUPATIONAL HEALTH STUDIES AT THE CENTRE FOR PRODUCTION OF PHOSPHORUS MINERAL FERTILIZERS, VOSKRESENSK (MOSCOW REGION, RUSSIA), USING NUCLEAR AND RELATED ANALYTICAL TECHNIQUES. Part II

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Мониторинг на рабочих местах
и изучение влияния производства фосфорных минеральных удобрений на здоровье персонала, занятого в этом производстве
(завод «Минеральные удобрения», Воскресенск, Московская область, Россия), с использованием ядерно-физических методов.
Часть II

В этой работе продолжен мониторинг на рабочих местах завода «Минеральные удобрения» в Воскресенске (Московская область), одном из крупнейших центров по производству фосфорных минеральных удобрений в России. Было проведено снеговое опробование, характеризующее как аэрозольную, так и газообразную составляющие загрязнения атмосферы. Приводятся данные по уровню концентраций катионно-анионного состава фильтрата снеговой воды, который не выходит за пределы, характерные для промышленных и городских зон. Распределение Sr, Y, Sb, Pb, РЗЭ и Th вдоль 15 км профиля от завода «Минеральные удобрения» было изучено посредством анализа пылевой фракции снега. Содержание микроэлементов в растительности и почвах позволяет утверждать, что наиболее интенсивное воздействие на организм рабочего персонала данного предприятия оказывают F, Sr, РЗЭ. Из полученных данных следует, что наиболее опасным цехом является цех экстракции фосфорной кислоты (ЭФК), а наиболее опасные специальности — рабочие. Содержание фтора в волосах рабочих превышает фоновые значения в 10–30 раз. Та же тенденция прослеживается и для зубов рабочего персонала. Четкой зависимости между стажем работы и уровнем содержания фтора в волосах не наблюдается.

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Workplace Monitoring and Occupational Health Studies
at the Centre for Production of Phosphorus Mineral Fertilizers, Voskresensk
(Moscow Region, Russia),
Using Nuclear and Related Analytical Techniques.
Part II

The results on further monitoring the workplaces of the «Mineral Fertilizers» plant in Voskresensk (Moscow Region), one of the largest centres for producing phosphorus mineral fertilizers in Russia, and adjacent to it territories are reported. Snow has been chosen as a depositing media to characterize both aerosol and gaseous components of atmospheric pollution. Data on cation-anion analysis in the snow filtrate are reported. They do not exceed hygienic normatives typical for the industrial and urban areas. The distribution of Sr, Y, Sb, Pb, REE, and Th along the profile: the «Mineral Fertilizers» plant — 15 km distance — was examined through the analysis of snow dust. Trace element concentrations in vegetation and soils allow one to state that F, Sr and REE produce the most intensive impact on the occupational staff. As follows from the results obtained, the most hazardous shop of the plant is that for phosphate oleum extraction (OPE), and the most hazardous professions are workers. The fluorine concentration in their hair exceeds the background ones by a factor of 10–30. The same tendency was observed for teeth of the workers. No definite correlation between the length of service and the level of fluorine content in hair and teeth was observed.

The investigation has been performed at the Frank Laboratory of Neutron Physics, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna, 1999

1. Introduction

The goal of this study is to determine how man's biosubstrates can be used to follow the rate of pathological changes in the organism when exposed to intense technogenic environments. Along with biosubstrates of the occupational staff examined in the present study, we extended our investigations for assessing the general environmental situation in the vicinity of the plant where the employees-local residents have been living and having their orchards and gardens.

The possibilities of using depositing media, in particular, snow to assess the distribution of pollutants in air flows, have been shown in numerous works (see, for example [1-3]).

One of the ways of such assessment is the analysis of snow samples collected in the vicinity of the acting emission sources. These data characterize both the aerosol and gaseous components of atmospheric pollution. The snow sampling is significantly cheaper and less labor consuming than the collecting of atmospheric aerosols by means of impactors. The snow sampling, besides, gives an integral picture of atmospheric pollution levels for the period of permanent snow cover.

The snow sampling was carried out in accordance with the wind-rose from the seven experimental sites along the profile A-B-C crossing the village Saburovo (7), "Mineral Fertilizers" plant (1), town of Voskresensk, village Lopatino (3), the Lopatinsky carrier (4), "Phosphate" enterprise (5), village Ostashevo (6). The profile is directed from the South-East to North-East, its length is about 15 km (**Fig.1**).

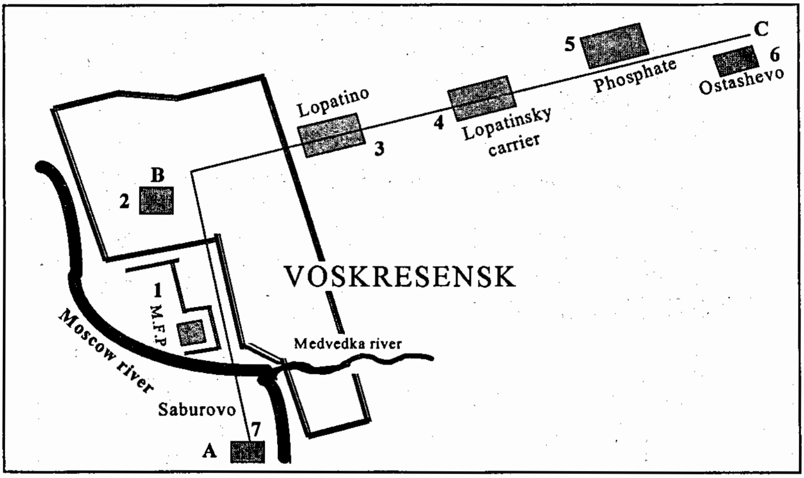

Fig. 1. The position of the experimental sites along the profile A-B-C.

2. Methodology

The sampling was carried out at representative experimental sites of 500 × 500 sq. m. No less than 7 samples were collected at each site. The background area was situated at a distance of 20 km from the plant where its technogenic impact is practically absent, as one may assume.

The snow samples were collected in the end of March, i.e. after 5.5 months of permanent snow cover. Sampling was carried out from the core, starting from the total depth of the snow cover. The volume of the snow core was fixed.

The samples were packed in double polyethylene bags and brought to the laboratory for the further processing: melting at room temperature, filtration of all amount of snow through a dense filter, drying and weighing the non-dissolved residual on the filter.

Filters with the non-dissolved residual and liquid filtrate were subjected to cation-anion analysis.

The trace element content of vegetation growing in the territory of the plant is an important characteristic reflecting the level of pollution coming from the environment. The importance of studying the selectivity of microelement accumulation by vegetation is evident: by a right choice of plants one may decrease the rate of the technogenic impact on the occupational staff. The vegetation was collected at two sites - in the middle of the plant, near the shop of oleum sulfate extraction (OSE-3) (see Fig. 2 in [4]) and 50 m from the fence near the Central Laboratory. Soil samples were collected in parallel. Leaves were collected at a height of 2 - 2.5 m practically from all types of trees found at the enterprise. Collected samples were rinsed with distilled water and dried at room temperature until constant weight.

As far as in the emissions of the plant fluorine and volatile fluorine compounds are present, fluorine determination in hair and teeth of the occupational staff is carried out. The procedure of teeth and hair sampling was done in accordance with method described in [4].

The trace element determination in all media under investigation was performed using NAA, XRF and ionometric methods at JINR and GIN, as described in [4], too.

3. Results and discussion

The cation-anion composition of snow filtrate water is given in **Table 1.** As a rule, the degree of pollution of the environment is determined by studying the amount of sulfur and nitrogen compounds and fluorine in the air. The data given in the **Table 1** evidences for fluoride, chloride, ammonium nitrate, sulfur oxide, nitrogen and phosphor presence in the examined atmosphere. Their concentration in the filtrate does not exceed hygienic normatives.

Table 1

Cation-anion content in the liquid phase of snow samples, mg/l.

No.	Sampling site No.	Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+	HCO_3^-	SO_4^{2-}	F^-	Cl^-	PO_4^{3-}	NO_3^-
1	1	2.2	3.7	51	4.8	0.8	70	43	1.1	6.8	0.7	2.1
2	2	1.2	2.0	28	6.4	1.4	58	26	0.6	5.6	0.2	2.4
3	3	0.6	1.2	20	1.9	1.2	54	10	0.3	4.8	0.2	1.1
4	4	0.6	0.8	16	2.0	0.9	52	9.6	0.2	5.8	0.3	0.8
5	5	0.4	0.5	14	1.8	1.3	32	6.4	0.2	5.6	0.2	0.9
6	6	0.5	0.3	12	1.6	1.0	33	5.1	0.3	6.2	0.7	0.6
7	7	0.6	1.6	20	3.2	1.8	55	11	0.1	7.5	0.2	1.5
8	Back-ground	1.3	1.8	12	1.7	1.2	40	4.2	0.02	4.9	0.3	2.4

The concentrations of fluoride and sulfur oxides exceeding background levels were determined at the sites of the "Mineral Fertilizers" plant and the northern part of town of Voskresensk **(Fig. 2).**

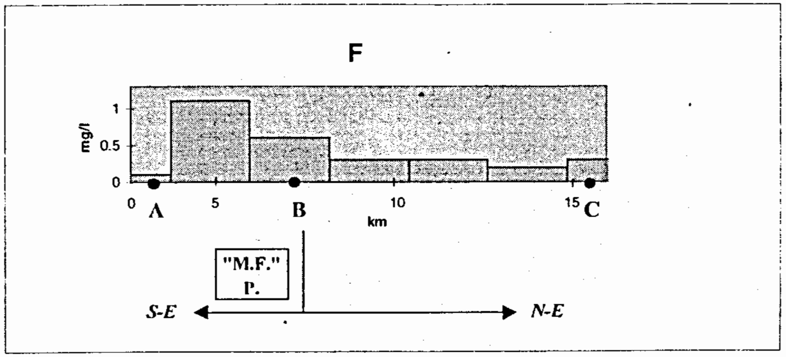

Fig. 2. Fluoride distribution in the liquid phase of snow along the profile A-B-C.

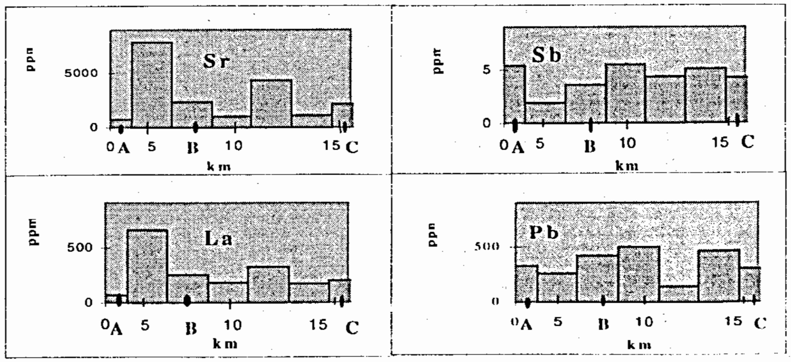

Fig.3. Heavy metal distribution in the solid phase of snow along the profile A-B-C.

The fluoride and sulfate ion concentrations exceed the background values by a factor of 10-60. At the same time, the concentration level of cation-anion component is within the range of concentration, typical for the industrial and urban areas.

The results of the analysis of snow dust are given in **Table 2.** These data show that the pollutants could be sub-divided into two groups according to different behavior of their distributions along the profile. Such elements as Sr, Y, REE, and Th are referred to as the first group. The distribution of these elements along the profile is practically identical to that of fluoride (see **Fig. 2** and **Fig. 3)** and is connected with the activity of the plant.

Table 2

Trace element content in snow dust determined by INAA and XRF, mg/kg

No.	Sampling site No	Dust impact g/m^2 per day	Cu	As	Pb	Sb	Y	Sr	La	Ce	Sm	Eu	Yb	Th	U
1	1	0.25	160	25	260	1.9	130	7900	660	970	46	11	3.1	11	3.8
2	2	0.22	170	25	420	3.6	50	2400	250	320	21	4.1	2.1	7.4	2.5
3	3	0.11	160	23	500	5.5	30	1000	180	240	14	2.7	1.8	6.0	2.2
4	4	0.22	160	23	140	4.3	70	4400	320	520	46	5.5	3.7	8.0	2.5
5	5	0.065	140	28	460	5.1	36	1100	170	220	19	3.1	1.9	7.8	4.6
6	6	0.052	180	37	300	4.2	55	2200	200	290	27	4.4	2.6	11	6.6
7	7	0.051	370	27	330	5.4	10	720	70	100	9	2.7	1.5	4.9	2.1
8	Back-ground	0.012	50	15	190	2.7	10	270	35	75	5	1.1	1.1	6.0	2.4

Table 3

Trace element content in the vegetation and soil of the "Mineral Fertilizers" plant and background territory, µg/g

Type	Sampling \ Trace elements	Na	K%	Sc	Cr	Fe	Co	Zn	As	Br	Sr	Sb	Cs	La	Ce	Th
Aspen	OSE-3	270	2	0.043	2.1	660	0.4	130	0.46	0.5	160	0.07	0.04	5.1	9.9	0.11
	background	150	1.9	0.005	0.9	130	0.2	100	0.03	0.5	30	0.02	0.03	0.5	0.9	0.02
Willow	OSE-3	76	1.5	0.03	0.5	290	0.2	100	0.1	0.1	100	0.03	0.03	2.1	4.6	0.04
	CL	120	2	0.04	1.2	300	0.3	150	0.16	0.1	80	0.04	0.06	4.7	7.7	0.08
	background	62	1.9	0.02	1.8	110	0.3	100	0.01	0.9	25	0.02	0.01	0.6	0.9	0.01
Poplar	CL	100	1.5	0.02	0.5	280	0.2	100	0.24	3.9	100	0.11	0.03	9	15	0.04
	background	60	1.6	0.006	0.5	110	0.3	220	0.02	1	27	0.01	0.03	0.7	1.3	0.01
Acacia	CL	100	2.3	0.01	0.6	300	0.3	100	0.12	2.7	110	0.03	0.04	2.1	4.6	0.04
	background	100	1.8	0.02	0.9	170	0.2	36	0.04	0.4	20	0.03	0.08	1.3	3.1	0.02
Birch	CL	120	1	0.01	1.1	90	0.4	100	0.19	0.8	70	0.1	0.04	4.5	9.1	0.08
	background	50	0.8	0.002	0.4	90	0.4	65	0.02	0.5	6	0.03	0.02	0.2	0.4	0.01
Soil	CL	2800	0.7	3.1	48	16400	4.9	140	20	3.3	390	0.59	1.2	35	74	4
	background	3000	1	3	39	9600	5	130	4.7	2.5	100	0.6	1	14	25	3.4

Table 4

Fluorine content in the hair of the occupational staff from the "Mineral Fertilizers" plant

No.	Shop, occupation	Length of service In the given shop	Length of service General	F content µg/g
1	OPE-3 apatite storehouse	6	16	120
2	OPE-3 senior master	26	26	610
3	OPE-3 operator	15	15	2800
4	OPE-3 operator	11	11	2800
5	OPE-3 foreman	3	3	2200
6	OPE-3 measuring device mechanic	24	26	980
7	OPE-3 electrician	26	26	3600
8	OPE-3 mechanic	7	7	2100
9	OPE-3 conveyor mechanic	5.5	19	900
10	driver	25	29	95
11	OPE-3 apatite storehouse	2.5	30	180
12	OPE-3 apatite storehouse	13	24	150
13	OPE-3 apatite storehouse	16	26	78
14	OPE-3 apatite storehouse	19	19	130
15	OPE-3 electrical welding mechanic	21	21	2300
16	OPE-3 mechanic-repairman	1	1	1200
17	OPE-3 shop chief	16	16	500
18	OPE-3 mechanic	1.5	1.5	2200
19	OPE-3 mechanic	0.2	28	2000
20	AMM-2 furnaces fireman	8	17	150
21	AMM-2 electrician	1	16	100
22	AMM-2 hopper -operator	7	12	70
23	AMM-2 hopper -operator	3	21	120
24	AMM-2 installation operator	12	12	310
25	AMM-2 installation operator	18	28	550
26	AMM-2 installation operator	6	14	380
27	AMM-2 chief deputy	17	33	160
28	AMM-2 mechanic	0.1	12	150
29	OPE-1 chief deputy	8	15	1200
30	OPE-1 installation operator	16	18	2400
31	OPE-4 conveyor mechanic	1	19	440
32	OPE-4 apparatus mechanic	7	25	660
33	CL technician	11	11	160
34	AMM-1 hopper -operator	2.5	2.5	450
35	AMM-1 apparatus mechanic	13	29	710
36	OSE-3 senior apparatus mechanic	8.5	23	2200
37	OSE-3 installation operator	7	7	4500

Antimony and lead are related to the second group. Their distribution by no means is connected with the "Mineral Fertilizers" plant that is confirmed by the minimal concentrations of these elements at the industrial premises of the plant.

The trace element concentrations in vegetation and soils are given in **Table 3.** It follows from these data that the background concentrations of trace elements in the examined types of plants (vegetation) are rather similar. Thus, for example, the abnormal concentrations of Sc, Fe, As, Sr, La, and Ce in leaves of aspen exceed the background values by a factor of 5-10. In acacia the concentrations of the same set of elements exceeds background values by a factor of 2-3. For soil, a relatively inert system, we noted only 3-4 times increased content of As, Sr, La, and Ce.

All above said allows one to state that F, Sr and REE produce the most intensive impact on the occupational staff. Therefore the priority task of the current year was the investigation of fluorine distribution in biosubstrates of man (the distribution of the other trace elements was presented in [4].

The fluorine content in hair of the occupational staff of the main shops of the enterprise is shown in **Table 4** (see page 7). It follows from these data that the fluorine concentration varies within the range of 80-160 ppm. As known from the literature, for example, [5], the background value is considered as 100 ppm that is quite similar to our values. So far, the fluorine content in the anomalous samples exceeds the background ones by a factor of 10-30. As it is seen, the most hazardous shop is that one for phosphate oleum extraction (OPE), and the most hazardous professions are workers. No definite correlation between the length of service and the level of fluorine content in hair was observed.

The fluorine concentration in teeth of the workers is given in **Table 5**. In spite of the insufficient number of samples, the same tendency, nevertheless, could be observed as in hair: the highest fluorine concentration are characteristic for the oleum phosphate extraction (OPE) shops.

Table 5

Fluorine content in the teeth of the occupational staff

No.	Sampling sites	Shop, occupation	Fluorine content µg/g
1	3-1	OPE-3	1600
2	3-2	AMM-2	65
3	3-3	AMM-2	20
4	3-4	OPE-3	250
5	3-5	CL	41
6	3-6	OPE-1	350
7	3-7	Administration	60
8	3-8	Administration	50
9	3-9	Administration	95
10	3-10	Service personnel	50
11	3-11	Administration	50
12	3-12	Service personnel	100
13	3-13	Driver	150
14	3-14	AMM-1	50
15	3-15	AMM-1	20
16	3-16	AMM-2	190

4. Conclusions

1. The impact of the "Mineral Fertilizers" plant on the environment is characterized by emissions of fluorine, strontium, lantanides and sulfur oxides into the atmosphere.
2. This impact is spread far beyond the site of the plant – up to 15 km.
3. Considering levels of elemental pollutants in vegetation, recommendations to administration could be given: to plant at the premises of the enterprise the following trees: aspen, poplar, birch.
4. The most intensive impact of fluorine on man takes place in the shops of oleum phosphate extraction.

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