DETERMINATION OF MAGNESIUM, ALUMINUM AND SILICON CONTENT IN WATER SAMPLES BY GAMMA-ACTIVATION AND NEUTRON-ACTIVATION ANALYSES USING THE MT-25 MICROTRON

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Abstract. The possibility of determining Mg, Al, and Si content in water samples using nuclear physical methods has been studied. The detections limits of 0.1, 0.03, and 0.1 mg/L for Mg, Al, and Si in water samples have been obtained.

Monitoring of the aluminum and silicon content in water is important because the high concentration of aluminum or the low content of silicon in drinking water may be risk factors for Alzheimer's disease.

INTRODUCTION

Aluminum occupies one of the main places among elements used in the production of industrial materials. Accordingly, there is a necessity of its control and analysis in the nonferrous metallurgy, in an alloy composition of the construction elements, in particular for the space rocket industry, in optical and glass industries. The aluminum content control is important as well in the food-processing industry, agriculture and at drinking water preparation. Aluminum arrives in natural waters from partial dissolution of clay and aluminum silicates, atmospheric precipitation, and waste waters from various manufactures.

Aluminum is rather well known as a metal, soluble forms of which can be poisonous and lead to encephalo- and polyneuropathy with dementia phenomena. Recent research confirms [1,2] that the growth of aluminum content in drinking water increases the risk of Alzheimer's disease. At present in Russia the aluminum maximum admissible concentration (MAC) in process water and public waters is established at a level of 0.2-0.5 mg/L, and in water of reservoirs used for commercial fishing – 0.08 mg/L [3].

According to the data of the American scientists [2], daily consumption of 0.1 mg of aluminum with drinking water increases the risk of dementia 2.26 times and considerably reduces intellectual abilities. However, daily consumption of silicon in drinking water up to 10 mg reduces the risk of a similar disease by 11%. Further research is planned to adjust the

norms of aluminum and silicon content in drinking water. It will be done for the purpose of protection from neurological diseases.

Silicon is a constant component of natural water chemical composition due to wide spread occurrence of silicon compounds in soils and mountain rocks. Significant quantities of silicon arrive into natural waters in the process of ground and water plant bodies dying off, with atmospheric precipitation, and also with industrial waste water of the enterprises producing ceramics, cements, glassware, silicate paint, binding materials, organosilicon rubber, etc. The concentration of silicon in river waters ranges usually from 1 to 20 mg/L. Silicon MAC is equal 10 mg/L [4]. Silicon is a powerful water activator and has important antibacterial properties. The presence of silicon at a concentration more than 2 mg/L detains and inhibits development of blue-green algae [5].

As a rule, chemical analysis methods are used for the determination of Al and Si [6, 7, 8, 9], and this methods are rather labour-consuming. But the urgent character of this problem requires development of new and approbation of the known methods for the elements analysis in environmental media and food.

EXPERIMENTAL

Element analysis of water samples was carried out by gamma-activation and neutron activation analyses using the MT-25 microtron.

Water samples from the Volga river and drinking water samples after standard filter treatment were taken for analysis. Water samples in the volume of 1 L were evaporated, solid residue was packed into packages of 10-micron lavsan film.

Gamma activation and neutron activation analyses. The analysed samples were positioned in the centre of the irradiation unit and irradiated with 22 MeV bremsstrahlung (the average electron current was equal approximately to 15 μA) or with a thermal neutron flux for 5-15 minutes in a water moderator on the MT-25 microtron. Gamma spectrometric measurement of the irradiated samples for the determination of elements was carried out with the HPGe detector with 1.5 keV resolution on the line of 1.33 MeV (^{60}Co). Si, Mg, and Al were determined by the foloowing reactions: ^{29}Si (γ, p) ^{28}Al ($T_{1/2}$ = 2.2 min, E_γ= 1779 keV); ^{30}Si (γ, p) ^{29}Al ($T_{1/2}$= 6.6 min, E_γ = 1273 keV); ^{25}Mg (γ, p) ^{24}Na ($T_{1/2}$ = 14.96 h, E_γ = 1369 keV) and ^{27}Al (n, γ) ^{28}Al ($T_{1/2}$ = 2.2 min, E_γ = 1779 keV).

RESULTS AND DISCUSSION

The results of some chemical elements determination in water samples are given in Table 1. Fig.1 shows a gamma spectrum of a water sample after activation.

Table 1. Element content in water samples, mg/L

Elements	MAC, mg/L [4]	Samples			Analysis method	Detection limit, mg/L
		Volga	1 stage of water purification (coal)	2 stage of water purification (industrial filter)		
Si	10	5.3±0.1	1.4±0.1	0.8±0.1	GAA	0.1
Mg	20-85	17.1±0.4	12.5±0.4	7.6±0.4	GAA	0.1
Al	0.2-0.5	1.02±0.07	0.69±0.07	0.19±0.07	NAA	0.03
Cl	350	2.6±0.3	10.7±0.3	1.3±0.3	NAA	0.1
Na	200	8.7±0.6	8.7±0.6	8.2±0.6	NAA	0.3

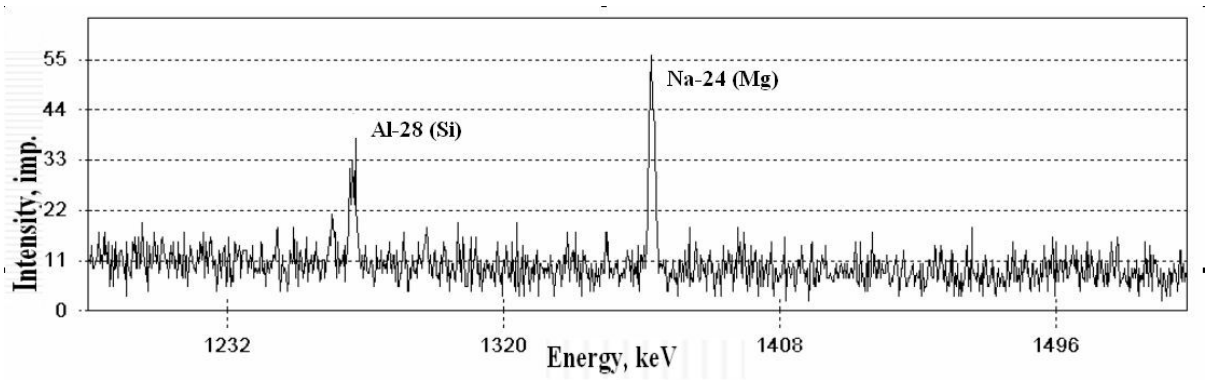

Fig.1 Gamma spectrum of the evaporated sample of water after gamma activation

On the basis of the carried out experiments, the maximum limit detection of Si – 0.1 mg/L, Mg – 0.1 mg/L (GAA), and Al – 0.03 mg/L (NAA) was evaluated. These limits are sufficient for estimation of the given elements at water quality determination.

The content of elements in the Volga water is within the limits of MAC except for aluminum, which exceeds twice the limits. The standard water treatment allows one to lower the Al content to tolerable norms. However, it can be seen from the Tables that water

treatment with coal and industrial filters reduces silicon quantity 10 times in comparison with MAC.

It should be noted as well that the water purification leads hardness salts (Ca, Mg) extraction, as a rule. The low content Ca and Mg is not always favorable for health. A number of ecological and analytic epidimeological studies have found a significant dependence between water hardness and cardiovascular disease [10].

CONCLUSION

1. The techniques of the analysis of Si, Mg, and Al with the use of the MT-25 microtron are developed. Si, Mg and Al were determined by the following reactions: ^{29}Si (γ, p) ^{28}Al ($T_{1/2}$= 2.2 min, E_γ= 1779 keV); ^{30}Si (γ, p) ^{29}Al ($T_{1/2}$ = 6.6 min, E_γ = 1273 keV); ^{25}Mg (γ, p) ^{24}Na ($T_{1/2}$= 14.96 h, E_γ = 1369 keV) and ^{27}Al (n, γ) ^{28}Al ($T_{1/2}$ = 2.2 min, E_γ = 1779 keV).
2. The detection limits of Si – 0.1 mg/L, Mg – 0.1 mg/L (GAA) and Al – 0.03 mg/L (NAA) are determined. The results obtained are sufficient for estimation of the given elements at water quality determination.
3. The content of elements in the Volga water is within the MAC limits except for aluminium, which exceeds twice the limits, but standard water treatment allows one to lower the Al content to tolerable norms. However, the water purification with coal and industrial filters results in a 10-times reduction of silicon quantity in comparison with MAC.

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