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## ENVIRONMENTAL STATE OF SURFACE WATERS AND BOTTOM SEDIMENTS IN WATER BODIES OF THE SOUTHWESTERN PART OF THE ALTAI TERRITORY

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Ecological research findings on surface waters and bottom sediments in water bodies of the southwestern part of the Altai Territory are presented. Samples were collected and analyzed between 2020 and 2021. Activities of natural ( $^{40}\text{K}$ ,  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ ) and artificial ( $^{241}\text{Am}$ ,  $^{239+240}\text{Pu}$ ,  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ ) radionuclides were determined in bottom sediments, research into the content of heavy metals (copper, zinc, lead and cadmium) in surface waters and bottom sediments was undertaken. As a result, it was found that radiation parameters of bottom sediments in water bodies of the southwestern part of the Altai Territory did not exceed the regulatory level. No residual nuclear plumes at the Semipalatinsk Test Site are currently detected in water of water bodies of interest. The content of heavy metals in bottom sediments does not correspond to the regulatory level. Ground water contamination with heavy metals was not detected.

**Keywords:** artificial and natural radionuclides, heavy metals, surface waters, bottom sediments, southwestern part of the Altai Territory.

### INTRODUCTION

The area of the southwestern part the Altai Territory the 50s through the late 80s of the last century was exposed to various man-made impact, which resulted in currently existing adverse ecological situation.

Natural resources of the Territory allow development of two main economy branches: agriculture and industry. Industrial enterprises are located in in big cities of the Territory: Barnaul, Biysk, Rubtsovsk, Zarinsk, Gornyyak. In the countryside, animal husbandry waste, fertilizers and toxic chemicals that are applied in the field and get into natural waters mainly by being washed out of soils, are a source of both environmental and natural water contamination.

Some of settlements of the Loktyovsk, Rubtsovsk, Zmeinogorsk, Krasnoschyokovsk, Kurinsk, Pospelikhinsk and Uglovsk regions of the Altai Territory, as reported by the Order of the Government of the Russian Federation No. 162-R dated February 10, 1994 [1] came under a zone, in which the population received a total effective exposure dose from 50 mSv to more than 250 mSv due to a nuclear test dated on August 29, 1949, while the normal annual exposure dose to the public is 1 mSv on average over any consecutive 5 years but not higher than 5 mSv per annum.

Many researchers of the Russian Federation and Kazakhstan were engaged in studying the content of radionuclides in different environmental compartments including in water bodies. Known publications are by I. Kolyado, A. Smagin, A. Trapeznikov and his disciples [2, 3, 4] concerning radiation research into water bodies contaminated with radioactive substances during anthropogenic activities. However, the review of scientific papers showed that no research into bottom sediments of water bodies in nuclear fallout plumes was undertaken over the entire period since testing at the Semipalatinsk Test Site.

As part of ongoing research, data on radiation parameters of bottom sediments in water bodies of the Altai Territory in its southwestern part was obtained for the first time: the Nikitkha, Krutishka, Korbolikha rivers as well as Lakes Gorkoye and Gorkoye-Pereshheychnoye (see Figure). Besides, figures on the level of heavy metal (copper, zinc, lead and cadmium) concentrations in water and bottom sediments in question were obtained.

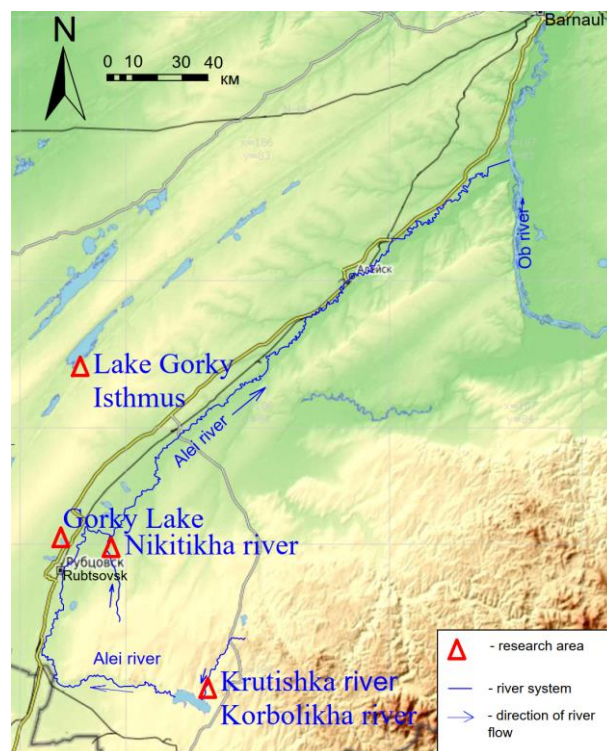


Figure. Schematic locations of research objects

## RESEARCH TECHNIQUES

For research, up-to-date analytical techniques that allowed correct data to be obtained on the content of natural and artificial radionuclides, heavy metals in environmental compartments were applied.

Measurements of alpha- and beta particle fluences above surfaces of bottom sediments were performed in the field using a dosimeter-radiometer  $\mu$ S-03SA.

Activities of  $^{241}\text{Am}$  and  $^{137}\text{Cs}$  in samples of bottom sediments were assessed with a gamma-spectrometer ORTEC GEM25P4-70. The content of  $^{90}\text{Sr}$  in a sample was determined by daughter  $^{90}\text{Y}$  following radiochemical isolation with a beta-spectrometer TRI-CARB 3110TR PerkinElmer. Plutonium isotopes ( $^{239+240}\text{Pu}$ ) were measured with an alpha-spectrometer Alpha Analyst A1200-32AM CANBERRA following a counting sample preparation by extraction-chromatography isolation and electrolytic precipitation.

Research into bottom sediments and water for the content of heavy metals was undertaken using an atomic absorption spectrometer PinAAcle 900t.

Research objects are minor water streams and lakes south-west of the Altai Territory (the Nikitikh, Krutishla and Korbolikha rivers, Lakes Gorkoye and Novoyegoryevskoye). One water sample (deeper than 0.5 m) and one bottom sediment sample across the entire layer thickness were collected from each water body.

## RESULTS AND DISCUSSION

As a result of the analysis of water samples from the Nikitikh, Krutishka and Korbolikha, concentrations of heavy metals (copper, zinc, lead and cadmium) in there were found to be low without exceeding MPC. Analytical data on bottom sediments in these rivers showed that the health standard established for soils is exceeded by 1.14 to 2.11 times. In bottom sediments of Lakes Gorkoye and Gorkoye-Peresheychnoye, the content of heavy metals also exceeds the MPC regulatory level by 1.24 to 2.09.

According to field research, the gamma dose rate in bottom sediments of the Gorkoye-Peresheychnoye varied from 0.10 to 0.12  $\mu\text{Sv/h}$ , that of the Gorkoye – 0.14 to 0.15  $\mu\text{Sv/h}$ , the Nikitikh – 0.13 to 0.15  $\mu\text{Sv/h}$ , the Krutishka – 0.18 to 0.19  $\mu\text{Sv/h}$ , the Korbolikha – 0.11 to 0.12  $\mu\text{Sv/h}$ . Beta-particle fluence above surfaces of bottom sediments in Lake Gorkoye-Peresheychnoye is (beta-particles)/(min $\cdot\text{cm}^2$ ) – 1.3, Lake Gorkoye – 1.8, the Nikitikh – 1.9, the Krutishka – 3.3, the Korbolikha – 0.5.

Rapid studies of bottom sediments showed no excess of radiation indicators (dose rate and beta-particle fluence).

Laboratory research findings showed that at this point in time, the content of artificial radionuclides  $^{137}\text{Cs}$  and  $^{241}\text{Am}$  produced during nuclear tests and reactor fission is less than 1 Bq/kg in bottom sediments of water bodies of the southwestern part of the Altai Territory. The exception are bottom sediments of Lake Gorkoye-Peresheychnoye and the Nikitikh river containing 2 Bq/kg of  $^{137}\text{Cs}$ . Activities detected correspond to the

global fallout background and cannot be definitely identified as residual radioactivity from fallout plumes of the Semipalatinsk Nuclear Test Site.

The content of  $^{90}\text{Sr}$  in bottom sediments was detected in Lake Gorkoye to a research depth of 0.4 m in the Nikitikh.

Plutonium isotopes were detected in bottom sediments of all water bodies of interest.  $^{239+240}\text{Pu}$  activity in bottom sediments varies from 3.7 to 5.8 Bq/kg.

The content of natural radionuclides ( $^{40}\text{K}$ ,  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ ) in bottom sediments corresponds to the natural level, a standardized radioactivity indicator of NRN – the effective activity concentration ( $A_{\text{eff}}$ ) of test samples varied from 69 to 136 Bq/kg, which does not exceed the regulatory level (370 Bq/kg, [5]).

## CONCLUSION

Research findings showed that the content of artificial and natural radionuclides in bottom sediments of water bodies in the southwestern part of the Altai Territory does not exceed the regulatory level. No residual nuclear plumes at the Semipalatinsk Test Site are currently detected in water of water bodies of interest. In water of water bodies, the content of heavy metals does not exceed the permissible level whereas an excess of the health standard by up to 2 times was registered in bottom sediments.

Taking into account findings, authors decided to sample and undertake research into water and bottom sediments of other water bodies south-west of the Altai Territory so as to obtain a complete picture of radioactive contamination of bottom sediments in lakes and rivers being economically important to reduce social strain related to ecological issues of the region.

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## АЛТАЙ ӨңІРІНІҢ ОҢТҮСТІК-БАТЫС БӨЛІГІНДЕГІ ЖЕР ҮСТІ СУЛАРЫНЫҢ ЖӘНЕ СУ ОБЪЕКТІЛЕРІНІҢ ТҮПТІК ШӨГІНДІЛЕРІНІҢ ЭКОЛОГИЯЛЫҚ АХУАЛЫ

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Алтай өлкесінің оңтүстік-батыс бөлігіндегі жер үсті сулары мен су объектілерінің түптік шөгінділерін экологиялық зерттеу нәтижелері ұсынылған. Үлгілерді іріктеу және олардың аналитикалық зерттеулері 2020–2021 жж. орындалған. Төменгі шөгінділерде табиғи ( $^{40}\text{K}$ ,  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ ) және жасанды радионуклидтердің ( $^{241}\text{Am}$ ,  $^{239+240}\text{Pu}$ ,  $^{137}\text{Cs}$  және  $^{90}\text{Sr}$ ) белсенділігі анықталды, жер үсті суларында және ауыр металдардың (мыс, мырыш, қорғасын және кадмий) төменгі шөгінділерінде зерттеулер жүргізілді. Зерттеулер нәтижесінде Алтай өлкесінің оңтүстік-батыс бөлігіндегі су объектілерінің түптік шөгінділерінің радиациялық параметрлері нормативтік деңгейден аспайтындығы анықталды, қазіргі уақытта зерттелетін су объектілерінің суында Семей сынақ полигонының ядролық сынақтар іздерінің қалдықтары табылған жоқ. Төменгі шөгінділердегі ауыр металдардың құрамы нормативтік деңгейге сәйкес келмейді, жер үсті суларының ауыр металдармен ластануы анықталған жоқ.  
**Түйін сөздер:** жасанды және табиғи радионуклидтер, ауыр металдар, жер үсті су-лары, түп шөгінділері, Алтай аймағының оңтүстік-батыс бөлігі.

## ЭКОЛОГИЧЕСКОЕ СОСТОЯНИЕ ПОВЕРХНОСТНЫХ ВОД И ДОННЫХ ОТЛОЖЕНИЙ ВОДНЫХ ОБЪЕКТОВ ЮГО-ЗАПАДНОЙ ЧАСТИ АЛТАЙСКОГО КРАЯ

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Представлены результаты экологических исследований поверхностных вод и донных отложений водных объектов юго-западной части Алтайского края. Отбор образцов и их аналитические исследования выполнены в 2020–2021 гг. В донных отложениях определены активности естественных ( $^{40}\text{K}$ ,  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ ) и искусственных радионуклидов ( $^{241}\text{Am}$ ,  $^{239+240}\text{Pu}$ ,  $^{137}\text{Cs}$  и  $^{90}\text{Sr}$ ), выполнены исследования содержания в поверхностных водах и донных отложениях тяжелых металлов (меди, цинка, свинца и кадмия). В результате исследований установлено, что радиационные параметры донных отложений водных объектов юго-западной части Алтайского края не превышают нормативного уровня, остатки следов ядерных испытаний Семипалатинского испытательного полигона в воде исследуемых водных объектов в настоящее время не обнаружены. Содержание в донных отложениях тяжелых металлов не соответствует нормативному уровню, загрязнение поверхностных вод тяжелыми металлами не обнаружено.

**Ключевые слова:** искусственные и естественные радионуклиды, тяжелые металлы, поверхностные воды, донные отложения, юго-западная часть Алтайского края.