RESEARCH PAPER

PRIELBRUSYE NATIONAL PARK ENVIRONMENTAL CHANGES DUE TO INCREASING TOURISM ACTIVITY

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Received: June 26th, 2022 / Accepted: November 11th, 2022 / Published: December 31st, 2022

https://DOI-10.24057/2071-9388-2022-108

ABSTRACT. Prielbrusye National Park is one of the most popular tourist destinations in Russia. In recent years internal tourism development, stimulated by restrictive measures (due to the COVID pandemic and geopolitical situation), resulted in significant growth of tourist flow to the national park's territory. A surge in anthropogenic load on the park's geosystems might degrade them and lead to environmental pollution. This research involved chemical studies of natural waters and snow from the south slope of the Elbrus and audit of the most popular tourist trails. The results have shown that in the snow alongside mountain hiking pistes to the Elbrus all the way up to 4,720 m above sea level (a.s.l.) oil stains concentration is up to 38 times higher than maximum acceptable concentration (MAC). Content analysis of heavy metals in snow cover on the Elbrus slopes and in the river Baksan has shown a significant rise in lead load over the period of 2015–2021 from the trace levels to 1.5 MAC, which is the result of increased anthropogenic load on the south slope of the Elbrus mountain. Ground observation of tourist trails has brought to light numerous patches of vegetation trampling, width extension and branching of the main trail, as well as campfire sites. The research results can be used as a rationale to take measures to reduce recreational load, to improve local geosystems' condition and to develop a plan of action on nature conservation within the park's territory.

KEYWORDS: Prielbrusye National Park, Caucasus, tourism, environmental protection, Elbrus

CITATION: Cherkasova A.A., Iurmanov A.A., Maslakov A.A., Petkovich M., Petrushina M.N., Tabelinova A., Tolipov A., Yakubov A., Yushina A. (2022). Prielbrusye National Park Environmental Changes Due To Increasing Tourism Activity. Geography, Environment, Sustainability, 4(15), 115-123

https://DOI-10.24057/2071-9388-2022-108

ACKNOWLEDGEMENTS: The research was carried out as part of a joint expedition of the Rossotrudnichestvo and the Russian Geographical Society as part of the New Generation program. The work of Dr. Alexey Maslakov has been supported by the Interdisciplinary Scientific and Educational School of M.V.Lomonosov Moscow State University «Future Planet and Global Environmental Change». The team would like to thank the Prielbrusye National Park, the Elbrus Alpine Search and Rescue Team of the Ministry of Emergency Situations of Russia, and the Joint-Stock Company KAVKAZ.RF for their help in organizing field work. Laboratory analysis of samples was sponsored by AST-Analitika, LLC.

Conflict of interests: The authors reported no potential conflict of interest.

INTRODUCTION

Given its physiographic features, high mountain territory can be characterized by regular natural processes, including disasters that increased landscape diversity and decreased resilience to anthropogenic load. Intensive recreational development of high mountain regions, first of all of the Greater Caucasus, that has been observed in recent decades, led to an increased anthropogenic load on the terrain. This includes building new innovative skiing and recreational clusters and further development of those in the Russian part of the Northern Caucasus. Such development has also expanded to specially protected natural reserves (SPNR) that were established in areas of diverse landscape and numerous natural attractions, including the oldest Teberda Nature Reserve, the status of which was downgraded to a national park due to intensification in recreational use[1], Caucasus Nature Reserve, and Prielbrusye National Park.

Prielbrusye National Park that was established in 1986 within the territory of the Kabardino-Balkar Republic occupies an area of 101,200 hectares. It includes a well-developed oldest mountaineering and tourism centre Southern Prielbrusye (the upper basin of the river Baksan) and a less developed area of the Malka upstream with a confluent – the river Baksan. The park is located on the north slope of the Central Caucasus along with the highest mountain summit in Russia – the two-headed Elbrus with peaks 5,642 m and 5,621 m high. It is one of the most high-altitude parks in Russia and Europe with complex landscape structure. Altitudinal zonality with high mountain glacial-nival, meadow (subnival, alpine and subalpine) and forest (birch and pine) landscapes, slope-facing landscape contrasts are typical to the study region (Petrushina 1992).

According to the Ministry of Resorts and Tourism of the Kabardino-Balkar Republic, within the 2014–2019 period the tourist flow tended to rise and more than doubled; in 2019 this region was visited by 600,000 tourists; the annual growth was 20%. At the same time, the tourist flow in the Prielbrusye NP more than tripled. COVID-19 pandemic, which started in 2020, has cut the tourist flow to Prielbrusye NP. According to the NP's data, in 2019 SPNR was visited by 209,392 tourists, in 2020 this indicator was a bit lower, equalling 142,284 tourists. In the first nine months of 2021, 572,000 people have already visited this region[2]. In compliance with the national programme aimed at developing a touristic and recreational entity in the Kabardino-Balkar Republic the local authorities plan to increase the tourist flow up to 1 million people by 2025. The programme provides for infrastructure development in the Elbrus and Cheget zones of the Prielbrusye NP, as well as for routing, equipping and marking at least 10 tourist trails a year[3]. Russian Federation's Main State Expert Review Board is known to have approved a construction project on building an additional five-storied hotel of the Ozon hotel chain in Azau; it will accommodate 45 rooms with a total area of 4,280 sq. m[4]. Given hundreds hotels, boarding houses and tourists' and mountain climbers' villages already built, the planned recreational development will result in growing anthropogenic load on landscapes and their degradation, which is already marked out nowadays (Petrushina 2018).

This study aimed to reveal the results of increased recreational load on some ecosystems and their components in Prielbrusye NP. The main study objects were snow cover and river water as one of the indicators of dynamic landscape components' condition. Additional observations were made on some tourist trails.

METHODS

Field studies

Field studies on the territory of Prielbrusye NP were conducted by the International Park School of Russian Geographical society from September 29 to October 10, 2021 (Fig. 1). Field studies were divided into three general directions: 1) snow studies along the main trail for Elbrus summit ascending; 2) water quality studies along the Baksan river – the main water stream of the Prielbrusye National Park; 3) main tourist trails inspection.

Snow cover was studied along the main trail to the Elbrus summit. Pitting snow test was conducted to determine stratigraphy and snow cover density, as well as oil traces and content of heavy metals in the snow (such as Fe, Mo, Pb, Cd, Zn, Ni, Mn, Co, Cr). Description and snow sampling points were located both on the snowcat (ratrack) piste and at some distance from it. The studies of snow cover structure included its description documenting snow decompaction levels and layers of ice; besides, snow density was determined layer by layer using a snow sampler. At the same time, temperature of air was measured, as was that of the snow surface, its middle part, and snow cover floor. After that, the test pit was photographed and snow samples were taken from the pit. At the moment of works above the Mir station (3,450 m a.s.l.) there was a permanent snow cover; that is why the research was conducted at heights ranging from 3,880 m (just above the Gara-Bashi station) to 4,720 m (just above the Pastukhov rocks) (Fig. 2).

To assess the contemporary state of the Baksan streams and their headwaters (the rivers Bolshoi and Malyy Azau and the Azau glacier) water samples were taken to measure concentrations of heavy metals. The points of sampling for water quality were located upstream or downstream from the main recreational entities (Azau Glade, Cheget Glade) and villages (Terskol, Verkhniy Baksan) (see Fig. 1). Evaluation criteria of water quality were maximum acceptable concentration for fisheries, since the susceptibility of aquatic organisms to pollutants is higher. Hydrochemical data was then compared to the previous studies (Reutova et al. 2014, 2018; Chizhova et al. 2017; Dreeva et al. 2017; Kerimov et al. 2018; Atabieva, Cherednik 2020).

During the expedition, sections of the five most popular equipped routes for hiking were also inspected: 1) the trail from the vil. Terskol to the Devichi Kosy waterfall, 2) the

[1]Decree of the Chief State Sanitary Doctor of the Russian Federation dated January 28, 2021 N 2 "On approval of sanitary rules and norms SanPiN 1.2.3685-21" Hygienic standards and requirements for ensuring the safety and (or) harmlessness of environmental factors for humans "(2021). Registered in Ministry of Justice of Russia on 29 January, 2021 N 62296. 1143 p. Available at: http://umka-nadym.ru/media/sub/962/documents/%D0%A1%D0%B0%D0%BD%D0%9F%D0%B8%D0%BD_1.2.3685-21_%D0%BE%D1%82_28.01.2021_2.pdf [Accessed 25 October 2021] (in Russian).

[2]https://tass.ru/ekonomika/13031877?ysclid=l2eszja22l

[3]Decree of the Government of the Kabardino-Balkarian Republic of September 23, 2019 N 167-PP On approval of the state program of the Kabardino-Balkarian Republic "Development of the tourist and recreational complex of the Kabardino-Balkarian Republic", 2019. Available at: https://docs.cntd.ru/document/561556122 (in Russian)

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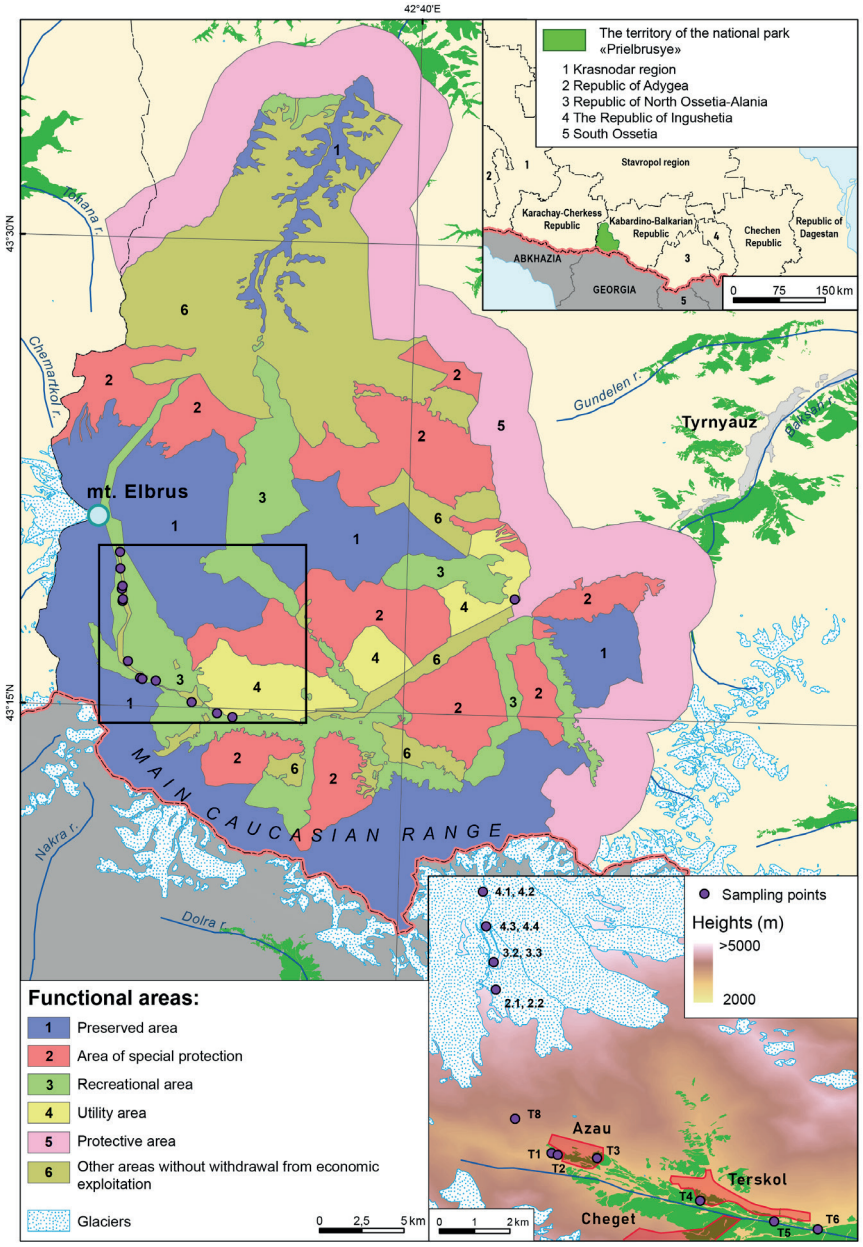

Fig. 1. Study area and sampling points

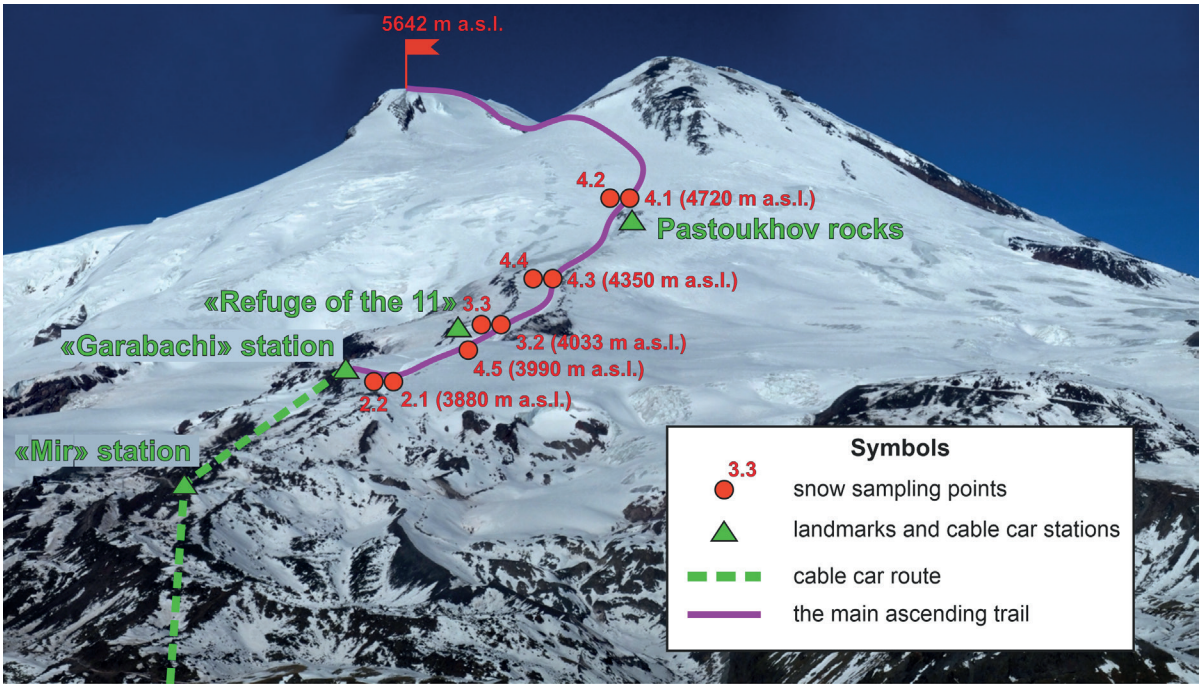

Fig. 2. Location of snow sampling points along the main trail to the Elbrus summit

ecotrail Cheget turn – Azau waterfall, 3) the ecotrail Narzanov Glade – Cheget Glade, 4) the trail Sand Castles from the vil. Elbrus to the Irick-Chat Gorge 5) the trail to Syltran-Kyol lake. Scientific assessment helped to determine the current state of soil and vegetation cover and the consequences of anthropogenic load.

Snow and water samples analysis

The snow samples were collected with plastic shovels, packed in plastic bags and delivered to a facility where the snow thawed in glass reservoirs (jars) at room temperature without being exposed to direct sunlight. After thawing, water was transferred to glass bottles, with a sample size of 1 litre. In situ water samples were taken in plastic bottles. The samples were analyzed within 10 days from the sample date in the Testing Laboratory Center "AST-Analitika", LLC (Saint-Petersburg, accreditation certificate RA.RU.21AK10) in compliance with regulations for defining mass concentration of oil in drinking water, surface water, and wastewater using the method of infrared spectroscopy of federal conservational regulatory document 14.1:2:4.5-95.

Analyzing instrument was spectrometer «Varian» Spectr AA 240FS/120GTA/120PSD. The principle of operation of the spectrometer is to measure the optical density of the atomic vapour of the studied sample and calculate the content of elements according to the calibration characteristics. The spectrometer is built on a modular principle and is equipped with flame and electrothermal atomizers and a hydride attachment. In the flame atomizer, depending on the elements to be determined, a flame of mixtures is used: "acetylene - air" or "acetylene - nitrous oxide". The optical system of the spectrometer is based on a monochromator with a diffraction grating according to the Czerny-Turner scheme. Heavy metals (lead, cadmium, zinc, nickel, manganese, cobalt, chromium) in snow samples were determined according to the Federal Environmental Regulatory Document (FERD) 14.1:2:4.214-06, molybdenum content according FERD 14.1:2:4.140-98, total iron - according to FERD 14.1:2:4.50-96.

The data obtained was then compared to maximum acceptable concentration values for oil (0.3 mg/l) provided by the provisions of the Chief State Sanitary Physician of the Russian Federation of January, 28 2021 on the approval of sanitary rules and regulations 1.2.3685-21 and on the hygienic standards and requirements for safety and (or) harmlessness to humans from environmental factors.

RESULTS

Heavy metals in snow and water

Heavy metals content in natural waters and snow are presented in a table (see Appendix A). According to the data obtained, cobalt and chrome concentrations are lower than MAC and are generally lower than minimal impurities quantitation level. Snow samples were detected lead and zinc MAC overruns. Our data indicates that lead content found in samples from along the snowcat pistes at 4,720 m and 4,356 m heights is triple and double the MAC, correspondingly, as opposed to the samples taken at a distance from the pistes. At the same time, at the heights of 3,880 and 4,033 m (sampling points 2.1, 2.2, 3.1, 3.2) the reverse pattern is observed: lead concentrations on the trail are less than at some distance from it (see Appendix A). Apparently, such pattern is explained by local activities caused by service of alpine huts, confined to this altitude ("Refuge of 11", "Maria" and several unnamed residential cabins). Manganese, molybdenum, and iron contents are mostly noted in river water samples. High manganese content is both registered in the river Malyi Azau, amounting to 3.1 MAC, and in the sample T2, taken downstream the point of its confluence with the river Bolshoi Azau, amounting to 2.6 MAC. Molybdenum concentration in the snow cover is lower than the quantified limit, whereas its content in the river water ranges from 1.7 to 1.9 MAC. Nickel concentration in water starts to noticeably augment in the last three sampling points (T5, T6 and T7) reaching the maximum level of 1.3 MAC downstream the influx of the river Donguz-Orun.

Cadmium content distribution differs from other heavy metals. The maximum was registered in the river Malyi Azau (sampling point T8) and amounted to 1.9 MAC. The values increased gradually from the sampling point T1 (located 300 m downstream from the Azau waterfall), where the concentration adds up to less than 0.001 mg/l, to the sampling point T7 (in the area of Verkhniy Baksan village which is the confluent of the rivers Adyr-su and Baksan), where the descriptor adds up to 0.005 mg/l.

Oil products traces in snow

Laboratory studies have shown that MAC overrun for oil has been registered in all snow samplings with a maximum in points 3.1–3.3 adding up to 10-12 MAC (Fig. 3). Oil pollution was found both along the ratrack and snowcat piste and at a distance of 10–50 m from it or, in other words, in the backcountry. The point 3.3 also evidences maximum above-limit lead concentration (3.5 MAC). It is located near camping sites (Refuge of the 11) where, apart from snowcats performing uphill assistance, snowcats transfer people and cargo from a cableway to huts.

Traces of technical liquids on the fresh snow cover (fallen 1 to 2 days prior to the sample date) were found within the snowcat ascending trail at a distance of every 10 to 30 meters along the trails on the Elbrus slopes (Fig. 4). At least three liquids were identified: fuel, antifreeze substance, and engine oil.

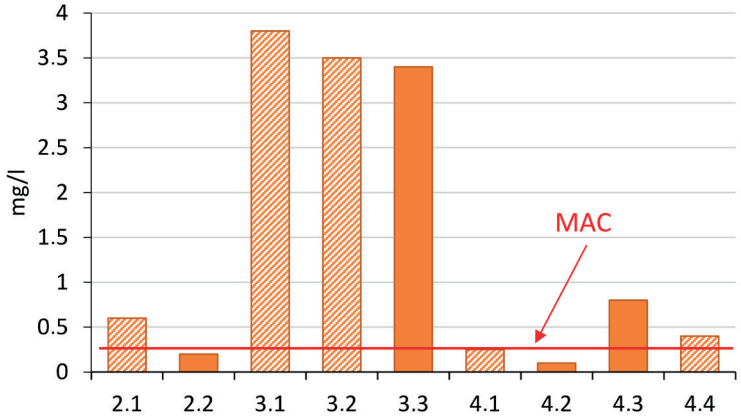

Fig. 3. Oil products concentrations in snow samples. Samples description is given in Appendix A. The concentration values in the hatch have been derived from snowcat trails

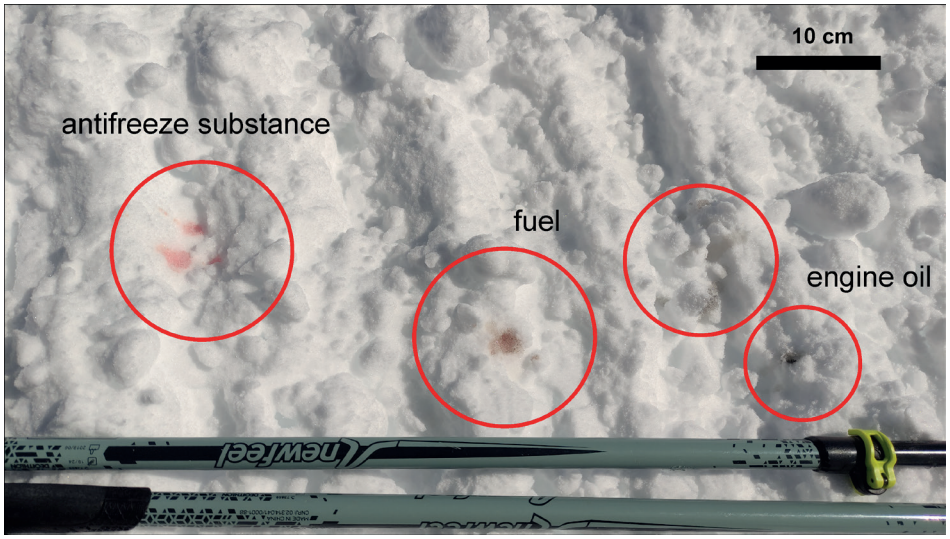

Fig. 4. Technical liquids within the snowcat ascending trail at the altitude of ~4000 m a.s.l. (photo by A. Maslakov, 2021)

Tourist trails impact

Within the framework of field studies, the inspection looked into 5 tourist and sportsmen-heavy equipped functioning trails in Prielbrusye NP. Trails analysis has identified ways of equipping, as well as anthropogenic load on soil and vegetation cover (Table 1).

The trails have been equipped by both national park staff and third parties, including volunteers. As a result, there is a disparity in the style and informativity of the facilities installed. The information board at the beginning of the Irick-Chat Gorge (trail 4) is informative and includes a description of the difficulty, duration, dangerous sections and a map-scheme of the trail itself (Fig. 5a). The information is written both in the Russian and in the English languages. At the same time, the map of functional zoning of the territory of the National Park is presented before the start of the trail to Syltran-Kyol Lake (trail 5) without additional information on the trail (Fig. 5b). The ecotrail "Polyana Narzanov – Polyana Cheget" (trail 3) is better equipped than the others: there are necessary signs and stands along the trail with additional information about flora, fauna, mineral springs, and rivers. All the trails are differently equipped.

The most severe disruption (trampling) was observed near Devichi Kosy (Maiden's Braids) Waterfall (Trail 1) (Fig. 5c) and on the ecotrail Cheget turn– Azau waterfall (trail 2). The highest number of bonfires and a trail width extension (Fig. 5d) were found near the Azau Glade. There is a reduction in the species diversity of vegetation, a decrease in the proportion of forest and post-forest species, a sharp increase in ruderal species, destruction of woody undergrowth and a reduction in the shrub layer and height of herbage. Disturbance of the vegetation cover indicates high recreational pressure in these areas and contributes to the activation of slope processes on the slopes that aren't turfed. The Sand Castles trail in the Irick-Chat Gorge often branches off and there is an extensive area of degraded soil cover on the main trail. Existing trail markings are insufficient to limit anthropogenic load and curb the appearance of branching of a single trail.

Miscellaneous equipment for hiking trails, as well as the chaotic and dense development by private recreational and residential facilities also led to decrease the aesthetic properties of unique high mountain nature.

DISCUSSION

Oil contamination of Elbrus glaciers

Geochemical composition of snow of Mount Elbrus depends both on natural conditions and human impact

Table 1. Examined trails, equipment quality and registered anthropogenic load

№	Trail title	Length of the explored area, km	Elevation difference, m	Equipment along the trail	Traces of anthropogenic load
1	Devichi Kosy (Maiden's Braids) Waterfall	5	704	trail marking, gazebos, litter bins, toilets	Trail width extension, branching of the trail, inscriptions on stones
2	Ecotrail Cheget turn– Azau waterfall	5	332	information boards, direction indicators, gazebos, toilets	Littering, unauthorized bonfires, trail width extension, chaotic choice of tent sites
3	Ecotrail Polyana Narzanov - Polyana Cheget	4	178	information boards, direction indicators, gazebos, bridges, toilets	Movement of prohibited means of transport (ATVs, horses)
4	The Irick-Chat Gorge Sand Castles	2	407	Information boards	Trail width extension, branching of the trail, soil trampling
5	To Lake Syltran-Kyol	5	846	Information boards, trail marking	Chaotic choice of tent and toilet sites

Source: authors' data.

Fig. 5. Tourist trails of the Prielbrusye National Park: (a), (b) information board at the starting points of trails 4 and 5; (c) the downtrodden grass near Devich'i kosy waterfall; (d) trail width extension at the trails 2 (photos by: A. Tabelinova & Yu. Yushina, 2021)

(Vasil'chuk et al. 2020; Chernyakov et al. 2020). The traces of oil concentrations indicate the only latter activity.

According to the emergency services workers who are on duty on the south slope of Mount Elbrus, the movement of snowmobiling equipment on the slope is not regulated or restricted in any way. Taking into account the small flow of tourists during the expedition (due to the off-season), it can be assumed that during the peak of tourist activity in the summer and winter months, the degree of snow pollution and the intensity of traffic on the slope may be several times higher. Uncontrolled traffic, accompanied by the discharge of technical fluids, leads to the pollution not only of the snow cover, but also of the underlying Gara-Bashi and Malyi Azau glaciers. Accumulating in the snowpack every day, oil products and other chemical pollutants (e.g. lead) move from snow to ice at subzero temperatures, accumulating in the glaciers that feed the rivers of the North Caucasus. As the snow fallen in the accumulation zone of a glacier reaches its tongue only several decades or even centuries later, oil contamination can act as a time bomb. Decades later streams and rivers will have elevated concentrations of oil products, which in turn will poison crops, livestock, and local residents.

Given all of the above, special attention should be paid to regulating snowmobile traffic on the south slope of Mount Elbrus and introducing strict environmental measures to reduce snow cover pollution by oil products and other technical fluids.

Potential sources of heavy metals

Heavy metals, especially their soluble phase, have negative effects on biota and humans by accumulating in tissues, inhibiting growth and development, and reducing productivity. However, not only tourism and construction, but also natural conditions can serve as their sources.

Reutova T.V. et al. (2018) recorded distribution of zinc concentrations in water and snow, as well as increased lead content at 4500 m altitude, which is similar to our data. Chizhova Yu.N. et al. (2017) noted that high zinc concentrations in the overlying snow may indicate that dry deposition of aerosols to the surface is the main mechanism of zinc accumulation. In addition, Kerimov A.V. et al. (2018) suggest that volcanic activity is one of the natural sources of zinc and its high concentrations, due to the presence of fumaroles in the area near the peak of Elbrus, may be the result of some volcanic activation.

Dreeva F.R. et al. (2017) in their work note the highest exceedance of MAC for manganese in the area of the confluence of the Baksan and Adyl-su rivers is 7 MAC. The T7 sample we collected 11 km downstream of this point also has elevated values of 2 MAC. Dreeva F.R. et al. (2019) identify manganese as a typical pollutant of the Adyl-su and Irick rivers flowing in the zone of a tectonic fault, where there are many sources of iron- and manganese-enriched carbonaceous mineral waters. Kerimov A.V. et al. (2018) note that molybdenum content in river waters often exceeds the MAC, especially in the Gara-Bashi and Azau rivers. The authors attribute this distribution of concentrations to natural factors. In the work of Reutova T.V. et al. (2014), the maximum nickel concentrations were registered in the estuary of the Terskol River (0.0149 mg/l). The moraine lake of Donguz-Orunkel also showed a high level (0.0137–0.0139 mg/l). In our case the T6 sampling point is located 100 m downstream from the place where the Donguz-Orun River where the maximum level was recorded flows into Baksan.

Although the MAC for fishery reservoirs is 0.005 mg/l, the cadmium clark in river waters is much lower and is only 10-4 mg/l, and in groundwater – $5 \cdot 10^{-5}$ mg/l (Mukha et al. 2012). Reutova T.V. et al. (2014) note in their work that cadmium content in water objects of Elbrus region has ultratrace concentrations and is less than 10^{-4} mg/l. We determined the concentrations of cadmium $1\text{-}9 \cdot 10^{-3}$ mg/l that is 10-100 times higher than the available literature data. According to Vinokurov et al. (2016), the same concentration in this region was once recorded only in the area of influence of the Tyrnyauz tungsten-molybdenum factory. In this way, the obtained results on cadmium concentrations are ambiguous and require further investigations.

The results obtained can be determined by seasonal variations in water flow. Most of the works is devoted to the study of dynamics during winter low-water and summer floods, sometimes spring floods, while our study was conducted in the autumn period. However, it should be noted that the overall pattern of heavy metal distribution over the study area agrees

well with other studies. In general, in 2013 the indicators of heavy metals sampled from the Baksan River described in the work by Reutov T.V. et al. (2018) are predominantly lower than ours. Heavy metal concentrations in the paper were considered by the authors at 8th and 35th km of the road along the Baksan River, which we can compare with our observation points T4 and T7, respectively.

Recommendations on reducing tourist load on ecosystems

Many protected areas, like Prielbrusye National Park, struggle to obtain data on the actual number of tourists to estimate the current strain on the environment. To regulate tourist flows, it is necessary to keep a statistical record of attendance to the most popular trails. In this case, the creation of an electronic registration system could, to some extent, increase the number of recorded tourists. Such a booking system is actively used in Europe and is free of charge. Keeping record of trail attendance will allow tracking statistics on tourist flows as well as identifying the most popular trails that require redirection of tourist flows. For example, the trail to Syltran-Kyol Lake is less popular due to its remoteness from the tourist core area (the Elbrus ski resort) and the lack of a distinct trail surface in the second part of the trail. Redirection of the tourist flow will reduce anthropogenic load on the national park's ecosystems. In addition, it is also recommended to conduct regular monitoring of trails condition, keep the boundaries of the main trail distinct to preventing the trail width extension and the emergence of uncoordinated branches, mark camping sites not only on maps, but also in the field, to conduct phytomelioration and engineering activities to improve the stability of the slopes. There are still problems that have been raised before (Kozova et al. 2010; Petrushina et al. 2010). The information system needs to be improved, especially at the entrances to the park, which is facilitated by having only two entrances due to the natural features of the park. Unfortunately, to date, there is no optimal functional zoning for the national park, with the removal of sloping forest landscapes from the recreational zone. According to the current zoning, the protection area includes predominantly nival-glacial and mountain-meadow landscapes, which are the least accessible to tourists. Forest landscapes, which play important ecological functions, do not fall within this zone and are heavily impacted by human activity. The lack or underdevelopment of wastewater treatment plants is an urgent problem. One of the most important tasks of the national park staff and volunteers is to raise environmental awareness of tourists.

CONCLUSIONS

Based on the conducted research, the following conclusions can be drawn:

1) Heavy metals in natural waters and snow have both natural and anthropogenic sources. Concentrations of cobalt and chromium are below the established MACs and, in most cases, below the limit of determinable impurity levels. Increased content of manganese (1.7–1.9 MAC) and nickel is the result of natural processes. Increased cadmium concentrations have been noted in snow on the slope of Elbrus and in the Baksan River. While in 2012–2015 the content of this element was estimated at a safe "trace" level, in our case concentrations increased to 1.1–1.5 MAC, which appears to be an indicator of anthropogenic pollution. However, our results must be confirmed by repeated studies.There is a significant increase in lead concentrations at sampling points above 3,500 m. Comparison of observation data from 2012–2015 (Reutova et al. 2015), with our results from 2021, shows a sharp increase in lead concentration (the MAC was exceeded in five samples out of eight). This appears to be due to direct contamination from technical fluids (POL, antifreeze) used in snowcats and snowmobiles.

2) Concentrations of traces of oil products exceeding the MAC up to 38 times were recorded along the Elbrus ascending trail up to the altitude of 4720 m, and numerous traces of technical fluids such as fuel, antifreeze, and oil were found on the trail. Uncontrolled traffic on the Elbrus snow cover leads to pollution of the Gara-Bashi and Malyi Azau glaciers, which in the future will reduce water quality in the rivers flowing from the south slope of Elbrus, namely the Baksan and Malka, which carry their waters to the Terek.

3) The most popular trails – Cheget turn – Azau waterfall and Devichi Kosy (Maiden's Braids) Waterfall – show signs of the disturbed soil and vegetation covers, caused by trampling of roadsides, branching of the main trail, as well as activation of slope processes. To reduce the negative impact of sports and tourism activities on the ecosystems in the vicinity of the trails it is recommended to redirect the tourist flow from more popular to less popular trails, to conduct electronic tourist registration, to monitor and equip the trails and to take phytomelioration and engineering measures to improve the stability of slopes near the trails. Tourists' environmental awareness needs to be raised.

The conducted research proves that the increased anthropogenic activity has a negative impact on the natural environment of the Prielbrusye National Park on the south slope of Mount Elbrus. The growth of the tourist flow leads to the degradation of the soil and vegetation cover not only in places of tourist concentration, but also near the equipped tourist trails. Anthropogenic load on geosystems manifests itself through the accumulation of heavy metals and traces of oil products in the natural environment. The results of the research can be used to elaborate plans on the national park's territorial development, to carry out land audits and to justify the need to reduce recreational activity, improve local ecosystems' condition and develop measures of environmental protection in the park territory.

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APPENDIX

Appendix A. Heavy metals concentration in snow and water samples

Sample number	Altitude, (m)	Sampling point description	Microelements' concentration, mg/l									
			Dry residue	Fe	Mo	Pb	Cd	Zn	Ni	Mn	Co	Cr
4.1	4720	Snowcat piste	<50	<0.1	<0.0001	0.0180	0.0073	0.0150	<0.005	<0.001	<0.005	<0.005
4.2	4720	50 meters west of 4.1	<50	<0.1	<0.0001	<0.002	0.0050	0.0203	<0.005	<0.001	<0.005	<0.005
4.3	4356	30 meters west of 4.4	64	<0.1	<0.0001	<0.002	0.0044	0.0170	<0.005	0.0028	<0.005	<0.005
4.4	4356	Snowcat piste	<50	<0.1	<0.0001	0.0130	0.0045	0.0160	<0.005	0.0012	<0.005	<0.005
3.2	4033	Snowcat piste	64	<0.1	<0.0001	0.0080	0.0014	0.0110	<0.005	0.0020	<0.005	<0.005
3.3	4033	10 meters west of 3.2	168	<0.1	<0.0001	0.0210	0.0024	0.0190	<0.005	<0.001	<0.005	<0.005
2.1	3880	Snowcat piste, slightly above the Gara-Bashi Station	126	<0.1	<0.0001	<0.002	0.0057	<0.001	<0.005	<0.001	<0.005	<0.005
2.2	3880	5 meters east of 2.1	<50	<0.1	<0.0001	0.0140	0.0012	0.0150	<0.005	<0.001	<0.005	<0.005
T1	2341	300 meters downstream of the waterfall	104	<0.1	0.00063	<0.002	<0.001	<0.001	0.005	<0.001	<0.005	<0.005
T2	2338	Near Azau tourist camp, below the waterfall, near the sewer. The Baksan river	84	<0.1	0.00063	<0.002	0.0010	<0.001	<0.005	0.026	<0.005	<0.005
T3	2328	Along the road from Azau tourist base to Terskol, in the concrete well	124	0.16	0.0019	<0.002	0.0011	<0.001	0.0051	<0.001	<0.005	<0.005
T4	2141	30 meters downstream from the place of a confluence of the Gara-Bashi river into the Baksan	62	0.16	0.0018	<0.002	0.0016	<0.001	<0.005	<0.001	<0.005	<0.005
T5	2054	The Baksan river below the bridge to Cheget	108	0.11	0.0015	0.0060	0.0016	<0.001	0.0063	<0.001	<0.005	<0.005
T6	2013	The Baksan river 100 meters from the place of confluence of the Donguz-Orun river	52	0.22	0.0005	<0.002	0.0020	<0.001	0.0129	<0.001	<0.005	<0.005
T7	1518	50 meters from the place where the rivers Syltrans, Kyrtyk and Adyr-su join the Baksan	102	0.10	0.0014	<0.002	0.0050	<0.001	0.0090	0.0190	0.0060	<0.005
T8	2802	The Malyi Azau river, ~400 meters east of «Krugozor» cableway station	134	<0.1	0.00167	0.002	0.0093	<0.001	<0.005	0.031	<0.005	<0.005
Maximum acceptable concentration (MAC), mg/l			-	0.1	0.001	0.006	0.005	0.01	0.01	0.01	0.01	0.05