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# DAMAGE OF SOIL COVER DUE TO THE IMPACT OF TOURISM IN THE ALTAI MOUNTAINS

This article presents the results of a study on soil cover damage caused by uncontrolled tourism in the Kazakhstan Altai and Mongolian Altai ranges. According to the expedition and laboratory work, it was determined that the soil cover of 182,7 km long territory in the Mongolian Altay range was damaged due to the ruts of vehicles and the trampling of tourists. More than 56,9% of these measured areas were completely destroyed, and 35,4% became rocky or desert. In the Altai ridge of Kazakhstan, the soil cover was damaged due to the formation of branch roads on an area of 705,7 ha, which was 55,3 km long. Approximately 84,4% of the total recorded area is moderately damaged and the growth of plants and grasses has decreased. During the determination of soil contamination with heavy metals, a total of 40 samples were taken from 8 coordinates and analyzed. The amount of lead and nickel in the soil has increased by 2-4 times due to the influence of tourism in both the Mongolian Altai Range and the Kazakh Altai Range. Cadmium element was not found at all. The content of other heavy metals such as chromium, copper, and zinc is slightly increased and accumulated at the bottom of the road. In both Kazakhstan and Mongolia, it was determined that the soil is polluted with heavy metals only by tourists' cars, as there is no mining, metallurgical plants, or resorts within 300 km.

**Key words**: Kazakhstan Altai Ridge, Mongolian Altai Ridge, soil cover, soil pollution.

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## АЛТАЙ ЖОТАСЫНДАҒЫ ТОПЫРАҚ ЖАМЫЛҒЫСЫНЫҢ ТУРИЗМ ӘСЕРІНЕН ЗАҚЫМДАНУЫ

Бұл мақалада Қазақстандық Алтай және Моңғол Алтай жотасындағы бақылаусыз туризм әсерінен топырақ жамылғысының зақымдануы туралы зерттеу нәтижелері ұсынылған. Экспедиция және лабораториялық жұмыстар бойынша Моңғол Алтай жотасында барлығы 24,7 км-ге созылған 182,7 км аумақтың топырақ жамылғысының көліктердің тарам жол шығаруынан және туристердің аяғына тапталуынан зақымданғаны анықталған. Өлшенген бұл аумақтардың 56,9%-ы толық талқандалып, 35,4%-ы тастақ немесе шөлейтке айналған. Ал Қазақстандық Алтай жотасында барлығы 55,3 км-ге созылған 705,7 га алаңда тарам жолдар пайда болып, топырақ жамылғысы зақымданған. Өте жоғары талқандалып, зақымданған алаң жоқ. Есепке алынған барлық аумақтың 84.4%-ы орташа зақымданып, өсімдік шөптер өсуі азайған. Топырақтың ауыр металмен ластануын анықтау барысында 8 кординаттан барлығы 40 сынама алынып, зерттеулер жүргізіліп, талданған. Моңғол Алтай жотасында да, Қазақстандық Алтай жотасында да туризм әсерінен топырақтағы қорғасын, никелдің мөлшері 2-4 есеге артқан. Ал кадмий элементі мүлдем кездеспеген. Басқадай хром, мыс, мырыш қатарлы ауыр металдың мөлшері аздап артқан және жолдың төменгі жағына жинақталған. Қазақстанда да Моңғолияда да бұл аумақта 300 шақырымның ішінде ешқандай тау кен өндірісі, металлургия заводы, курорттар орналаспағандықтан, топырақ ауыр металдармен тек туристердің автокөліктерімен ғана ластанып отырғаны анықталған.

**Түйін сөздер:** Қазақстандық Алтай жотасы, Моңғол Алтай жотасы, топырақ жамылғысы, топырақтың ластануы.

 

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**Повреждение почвенного покрова из-за воздействия туризма в горах Алтая**

В данной статье представлены результаты изучения ущерба почвенному покрову от неконтролируемого туризма в хребтах Казахстанский Алтай и Монгольский Алтай. По результатам экспедиции и лабораторных работ было установлено, что почвенный покров территории протяженностью 182,7 км в Монгольском Алтайском хребте был поврежден из-за колей транспортных средств и вытаптывания туристов. Более 56,9% этих измеренных площадей были полностью разрушены, а 35,4% превратились в скалистые или пустынные. В Алтайском хребте Казахстана почвенный покров был поврежден из-за образования ответвлений дорог на площади 705,7 га, протяженность которых составила 55,3 км. Примерно 84,4% от общей зарегистрированной площади умеренно повреждены, а рост растений и трав снизился. Во время определения загрязнения почвы тяжелыми металлами было взято в общей сложности 40 проб из 8 координат и проанализировано. Количество свинца и никеля в почве увеличилось в 2-4 раза из-за влияния туризма как в Монгольском Алтайском хребте, так и в Казахском Алтайском хребте. Элемент кадмий вообще не был обнаружен. Содержание других тяжелых металлов, таких, как хром, медь и цинк, немного повышено и накапливается в нижней части дороги. Как в Казахстане, так и в Монголии было установлено, что почва загрязнена тяжелыми металлами только автомобилями туристов, поскольку в радиусе 300 км нет горнодобывающих, металлургических заводов или курортов.

**Ключевые слова:** Казахстанский Алтайский хребет, Монгольский Алтайский хребет, почвенный покров, загрязнение почв.

## Introduction

The Altai Mountains are the largest mountain range in Central Asia, which stretches for about 2000 km on the borders of Russia, China, Kazakhstan, and Mongolia. The ecology of the Altai Range has a great impact on the world climate [1] and is considered a zone with high potential for tourism development [2]. The ecosystem has many threats from uncontrolled, chaotic tourism [3]. On Kazakhstan and Mongolian sides, there was planned to develop the main types of ecotourism, including mountain climbing, hiking, horse riding, traveling by car, and mountaineering [4-7]. However, due to the lack of infrastructure [8,9], there are unfavorable conditions for the environment, such as trampling of the soil surface due to an increased number of tourists, grass not growing due to damage to the soil layer, littering near tourist accommodations; animals being frightened and moving to other places due to loud noise in forested areas.

Tourists travel to worship a Besbogda mountain in Mongolian Altai. In Kazakhstan's Altai, tourist travel for a healthy drink "blood of deer antlers", and the beautiful nature of Katonkaragai national park. Tourists spend 3-4 days traveling Mongolian Altai and driving 580 km on dirt roads. In East Kazakhstan, tourists drive 1150 km to reach on Rakhman hot spring, Markakol, Zor Kerish, and Sibe lakes and spend 4-5 days on paved roads.

A total of 29 thousand domestic tourists traveled to Mongolian Altai in 2021 and 53 thousand domestic tourists until August 2022. In East Kazakhstan, 168 thousand domestic tourists, 181 thousand tourists in 2019, 121 thousand in 2020, 125 thousand in 2021, and 101 thousand until August 2022 traveled to the Katonkharagai, Ulan, Altai, and Bukhtyrma tourist zone [11].

There are a lot of papers about A large number of tourists trampling and damaging the soil cover in national parks. For example, Articles are written that study topic in the Lisia Góra Nature Reserve on the border of Poland [12], in Hulamuron of Inner Mongolia [13], in Zhangjiajie Geopark of China [14], in Turkey [15], in Borodur National Heritage of Indonesia [16], in Pakistan [17], in Kenya national parks [18]. A total of more than 900 articles can be viewed on this topic. Most of them are made in China. Even articles have been written about Italy's Vesuvius National Park [19], and China's ecotourism resorts to being contaminated with heavy metals such as Cr, Cu, Ni, Pb, Cd, Ni, and Cr [20] due to tourism. In addition, tourism indirectly affects environmental factors, thereby influencing the concentration of soil metals (Cr, Ni, Cu, Zn, As, Cd, Pb, and other heavy metals) as a result of a study conducted in Poyang wetland lake, China [21-22]. Tourism affects the increase in soil temperature. The studies carried out in Kamchatka, it was written about the erosion of vegetation and densification of the seashores, destruction of the fertile soil, destruction of the habitat of animals, water and air pollution from tourist vehicles, and problems of tourist garbage [23].

Although we performed a thematic examination of 80% of the nearly 900 articles published in open scientific sources, and an abstract examination of about 190 articles, we did not find research information about the damage to the soil layer in the Altai Mountains. There was described as uncontrolled, hapless tourism as a rapidly growing threat in the Altai-Sayan territory [3, 24]. It can lead to the destruction of biodiversity, loss of recreational value of the Altai ridges, significant destruction of habitat, frequent forest fires, and accumulation of garbage.

It also shows that there have been no real scientific studies on the damage to the soil cover in the Altai Mountains due to tourism. Therefore, to research this topic, a special scientific expedition was organized in Mongolian Altai in August 2022 and Kazakhstan in September 2022 along the selected route. During the expedition, the size of the damaged areas was measured, soil samples were taken, and necessary information was collected.

The purpose of the research was to determine the extent of damaged soil cover along the route of the Altai mountain range, which is affected by tourists, and check the presence of heavy metals in the soil.

## Materials and research methods

In paper, using the following methodology to determine the damaged area of the soil cover due to tourism was used:

1. An expedition was organized in August 2022 in Mongolian Altai and September 2022 in Kazakhstan on the selected route. During the expedition in Mongolia, the team measured 6 damaged areas and determined the boundary coordinates of the damaged field with GPS. In Kazakhstan, the team measured 11 damaged areas and determined the boundary coordinates of the damaged field. The routes of the expedition are shown in Figure 1.


**Figure 1** – Measured fields during the expedition and selected routes Mongolia, Kazakhstan

The following methodology was used to determine vegetation growth. According to the standard, a square is created on a 1m x1,5 m area and counted the number of plant species and the determined percentage of vegetation cover in that area. If 10-30% of the 1m x 1,5 m area is barren with no vegetation, the damage level is "low", if it is 31-50% it is "moderate", if it is more than 51% it is "very high", if there is no vegetation, it is 100% damaged.

Samples for determination of soil contamination with heavy metals were taken from the extreme point of both routes. It was taken along the last 13 km of the road up to Tavanbogd, the most destroyed in the Mongolian Altai, along the roads up to the Rahman spring and Karakol in the Kazakhstan Altai. The sampled coordinates are shown on the map. The sample was taken from 2-5 coordinates according to the "envelope" method, and the amount of chromium (Cr), lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn), nickel (Ni) in the soil was determined in the laboratory.

2. The received coordinates were entered into the Google Earth Pro 7,3 program, and the length area of the damaged valley and branch roads was measured. The result was checked for errors using QGIS 3.26.3 software, and the result was mapped. The research was conducted in the "Remote Sensing & ArcGIS" laboratory of the Institute of Geography, Geoecology at the Mongolian Academy of Sciences.

3. Landsat data allow comparisons to be made, on multidecade time scales, of landscape changes due to human activity, such as soil cover damage, and changes in vegetation cover due to tourism. Landsat 8 and Landsat 9 have a higher imaging capacity, allowing more valuable data to be added to the Landsat global land archive of around 1,400 scenes per day. From the Landsat-8, and Landsat-9 satellite databases, images with less than 20% cloudiness from July-August 2010, 2015, and 2022 in the territory of Mongolia and Kazakhstan were downloaded. Nomenclature number is Mongolia-M45-105, 118, 129, Kazakhstan M45g, M45b. EIC dates and space images from the laboratory were used. At this stage of research, space images were processed in the following order using the "remote sensing" method.

Downloading images from the Landsat-8, and Landsat-9 satellite database on the open source (Time in August 2010, 2015, 2022) → superimposing "Band 2, 3, 4" on "Band 1" (Resolution 30 m) → the main ones at 3 different times preparing images → Overlaying the main images with Band-5 → if no change is observed, overlaying with Resolution 15-meter "Band-9" → Repeat changing the month and day until a change is noticed → Converting the image with a change to the ENVI program and analyze by radiometric.

## Research results and discussion

Soil cover damage. We organized an expedition along these routes in Mongolian Altai in August 2022 and collected the necessary data.

Since the entire stretch of this route in the Mongolian Altai is not paved with asphalt, the roads are especially rutted and the soil layer is damaged a lot (figure 2).


a


b

c

d e

f

**Figure 2** – Damaged areas of soil cover in the Altai mountains
a) Mongolia-Tavanbogd b) Mongolia-Songinot Pass c) sampling, d), e) Kazakhstan, Karakol-2018 and 2022.
f) Branching of the road to Abylaikit, Google Earth image taken from 650 m sea level, 2022

As the number of tourists increases, the number of branch roads increases; the 580 km long route was branched at least 2 times and at most 27 times. However, we saw that many of these roads have been used by the local people for a long time and have been branched off for a long time. The authors of the research have already traveled along this route several times, so they know the damaged places that have appeared in recent years. Therefore, only the areas damaged by tourists were measured and coordinates were obtained.

In recent years tourists built new roads through Songinot Pass to Tavanbogd. Before locals used another way. And Tourists created a new road short way from Tavanbogd to Hoton lake, Baga Turgen waterfall, by crossing the high passes.

Over the last 3 years, tourists have made 101 km of new roads along this route. For example, 66.3 hectares belonging to the hayfield area were damaged because the new tourist road over the Songinot Pass through the hayfield and the soil layer was washed away by the rainwater that flowed through the roads. As a result, in 2022, the grass did not grow here, it remained dry. There are places where tourists stop to have a rest and take pictures. Such sites include the monument above the Songinot pass, the vicinity of the President's ovoo worship (number 3 on the map), and the vicinity of the Akgol bridge (number 4 on the map). Such areas have been trampled by tourists and cars turned into sandstones. In recent years, no grass has grown on the trampled lands. We visually identified such areas, created a 1m x 1,5m square for the area according to the MNS5546:2005 [25] standard, and determined the number of plant species and the percentage of plant cover in that area. It was estimated that there are 182,7 hectares of land, which is 24,7 km along the road, and about 60 square samples have been created.

In addition, there are many cases of vehicles getting stuck in muddy areas at the foot of the high mountains. A total of 1,1 hectares out of 6 especially destroyed territories, the area of which does not exceed 20-50 courts, were measured, but not marked on the map; 103 hectares along the 13 km road to the President ovoo worship (number 3 on the map) were especially destroyed.

In the areas where tourists mainly stay, the soil layers are moderately damaged. For example: since there are no resorts on the shores of Lake Hoton (number 5 on the map), guests can stay here with tents and open fires. As a result, the grass on the 6 km long lake shore began to become barren and rocky.

An expedition was organized along the Kazakhstan Altai Route on September 21-26, 2022. Since 90% of all roads are asphalted, there are very few branching roads compared to Mongolia. However, due to the difficulty of the road, there is a branching of roads in places where asphalt is not laid, or in the vicinity of tourist facilities, on the shores of lakes. For example, from Karayrik to Karakol shown in the picture below, since it is impossible to lay asphalt, roads have been branched and meadows destroyed to bypass some swampy areas. Such roads that cannot be paved with asphalt are 15 km up to Rahman spring, and the roads up to Burkhaty on the Austrian road are built on the side of the mountain, so there is no possibility of branching. However, a 2,1 ha area near Burkhaty lake was particularly damaged (number 2 on the map) and the soil layer was washed away, so we thought that this was a phenomenon caused by tourists in the last years. In the 90 kilometers above Burkhaty to the village of Markakol-Uriankhaika, there are branches in some places, but we did not take into account that it is unreasonable to say that the soil layer has been damaged by tourists because it has been used since 20 century. In addition, a new 6.7-km tourist road was created on the beach of Markakol (number 3 on the map), the village of Uriankhaikha. On this beach, tourists camp with their tents and make open fires. We estimated the entire area along the coast to be 4,6 hectares.

Most of the domestic tourists from Kazakhstan like to bathe in the lake and rest on the beach. In recent years, the residents of the city have been looking for warm beaches on the shores of Buktarma instead of Alakol lake. In last years, the number of visitors to the "Goluboi Zaliv" of Buktyrma, where many tourists come here, has decreased, and they used to go to the beach of Svinchatka. The main reason is that the water in Goluboi Zaliv is cold and there is no sandy beach. And the beach of Svinchatka, like the beach of the Maldives with white sand, is suitable for bathing in the lake and sunbathing. Therefore, in July and August, it has become normal to see a group of tourists stretching 6-7 km along the beach of the lake near the village of Svinchatka (number 6,7,8 on the map). As a result, the soil of the meadows on the beach has become compacted, and the roads have started to be damaged. However, it is very little damaged compared to other areas.

There are the black and dark brown soil of the mountain is covered with many combs, types of grass, and meadows. Such places are less damaged by machinery and recover quickly. However, areas with stony desert soil are quickly damaged by human and animal trampling. For example, Kerish, Kyzyl Kerish tourist object belongs to the paleontological region, so the soil surface is covered with little green vegetation, desert, and soft sand. Therefore, this area is damaged by tourists' trampling. After going down the highway for a while, there are rutted roads, soil damage, natural erosion, and a large area of small sand accumulation in the area of 4,3 km. We measured its size as 387 hectares (number 4 on the map). In addition, near Kyzyl Kerish (number 5), 101 hectares of roads were branched and the soil layer was damaged.

The following conclusions were clear from the first and second stages of research. The measured areas were divided into 4 categories depending on the percentage of plant growth.

In the Mongolian Altai, 182,7 hectares of land with a total length of 24,7 km were damaged by tourists' vehicles. However, the soil cover is damaged at different levels. In some places, the soil is simply compacted, while in other places, the soil layer is destroyed. Therefore, we divided all the measured areas into 4 groups (table 1, figure 3).

**Table 1** – Basic information on the measured areas in the expedition

| Names of lands | Start of coordinate | End of coordinate | Percentage of vegetation | Length | Territory and level |
|---|---|---|---|---|---|
| **Altai of Mongolia** | | | | | |
| 1) Under the Songinot Pass | 49°16'13.27" N 88°35'49.81" E | 49°17'7.45" N 88°39'11.02" E | 60-75% | Along the road5100 m | 66,3 ha |
| 2) Songinot pass | 49°16'18.42" N 88°35'11.79" E | 49°16'17.76" N 88°35'25.29" E | 50-65% | The square is 250 m wide | 6,0 ha |
| 3) The road to the Presidential ovoo | 49° 8'43.51" N 87°59'31.04" E | 49°11'4.36" N 88° 5'34.13" E | 100% | Along the road – 13 km | 103 ha |
| 4) The beach of the Akgol bridge | 49° 4'37.00" N 88°35'42.35" E | 49° 4'43.30" N 88°35'41.86" E | 30% | The square is 130x200m long on the river beach | 3,6 ha |
| 5) The beach of Hoton lake | 48°34'17.62" N 88°29'11.24" E | 48°35'59.96" N 88°25'34.08" E | 30-35% | 6.0 km along the place on the lake beach | 117 ha |
| 6) The parking site of Baga Turgen | 48°31'38.48" N 88°24'21.76" E | 48°31'42.40" N 88°24'28.74" E | 10-15% | 200 m wide | 2,7 ha |

*Продолжение таблицы*

| | | | | | |
|---|---|---|---|---|---|
| Places where cars were destroyed due to getting stuck in the mud | - | - | 100% | Total 6 places | 1,1 ha |
| Total | | | | 24.7 km | 182,7 ha |
| **Altai of Kazakhstan** | | | | | |
| 1) The road from Kara Ayrik to Karakol | 49°26'57.68" N 86°20'39.46" E | 49°33'33.84" N 86°18'15.05" E | 60-65% | Along the 22 km road that goes up to the lake | 8,8 ha |
| 2) Near Burkhaty Lake | 49° 8'28.54" N 86° 2'17.92" E | 49° 8'35.13" N 86° 2'16.82" E | 75% | The proof roadside | 2,1 ha |
| 3) The beach of Marka lake | 48°47'0.05" N 86° 1'12.91" E | 48°44'48.86" N 85°57'19.11" E | 30-45% | Along the 6.7 km road on the lake beach | 4,6 ha |
| 4) Paleontological site Khyin Kerish | 48° 9'34.04" N 84°26'25.11" E | 48° 7'58.99" N 84°29'3.45" E | 30-45% | Along the road 4.3 km | 387 ha |
| 5) Red Kerish | 48°10'5.28" N 84°24'27.1" E | 48° 9'22.97" N 84°25'0.96" E | 30-45% | Along the road 1.5 km | 101 ha |
| 6) 1st beach of Svinchatka | 49° 7'53.93" N 84°19'53.65" E | 49° 7'17.61" N 84°18'27.28" E | 10-15% | Along the road 2.2 km on the lake beach | 9,82 ha |
| 7) 2nd beach of Svinchatka | 49° 6'59.40" N 84°17'26.25" E | 49° 5'57.33" N 84°14'20.77" E | 5-10% | Along the road 4.5 km on the lake beach | 28,3 ha |
| 8) 3rd beach of Svinchatka | 49° 5'44.47" N 84°13'16.32" E | 49° 4'41.06" N 84° 9'14.33" E | 10-12% | Along the road 5.8 km on the lake beach | 35,5 ha |
| 9) 1st lake of Sibe, Khorjinlake | 49°25'24.95" N 82°39'6.21" E | 49°25'37.58" N 82°39'35.10" E | 40% | Along the road 0.7 km on the lake beach | 11,1 ha |
| 10) 2nd lake of Sibe, Shalkhar lake | 49°25'52.10" N 82°37'42.21" E | 49°25'29.77" N 82°38'50.40" E | 40-45% | Along the road 5.8 km on the lake beach | 96,8 ha |
| 11) Monastery ruins of Ablai king | 49°27'8.52" N 82°33'4.82" E | 49°27'47.56" N 82°33'54.67" E | 60-75% | Along the road 1.6 km on the lake beach | 20,7 ha |
| Total | | | | 55,3 km | 705,7 ha |

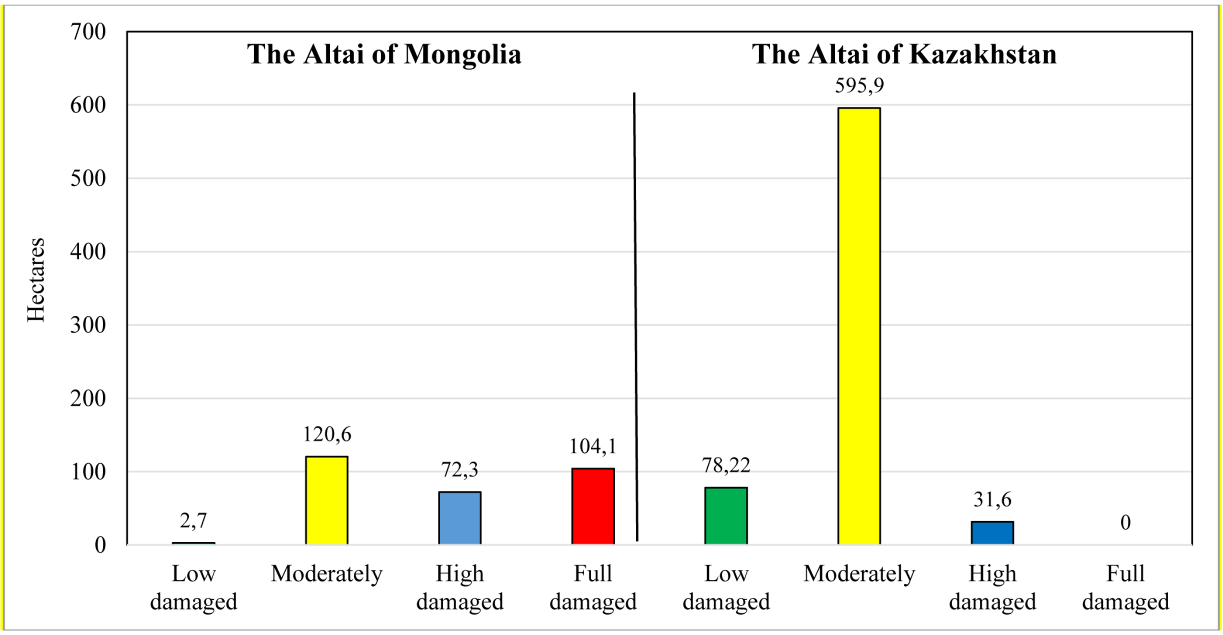
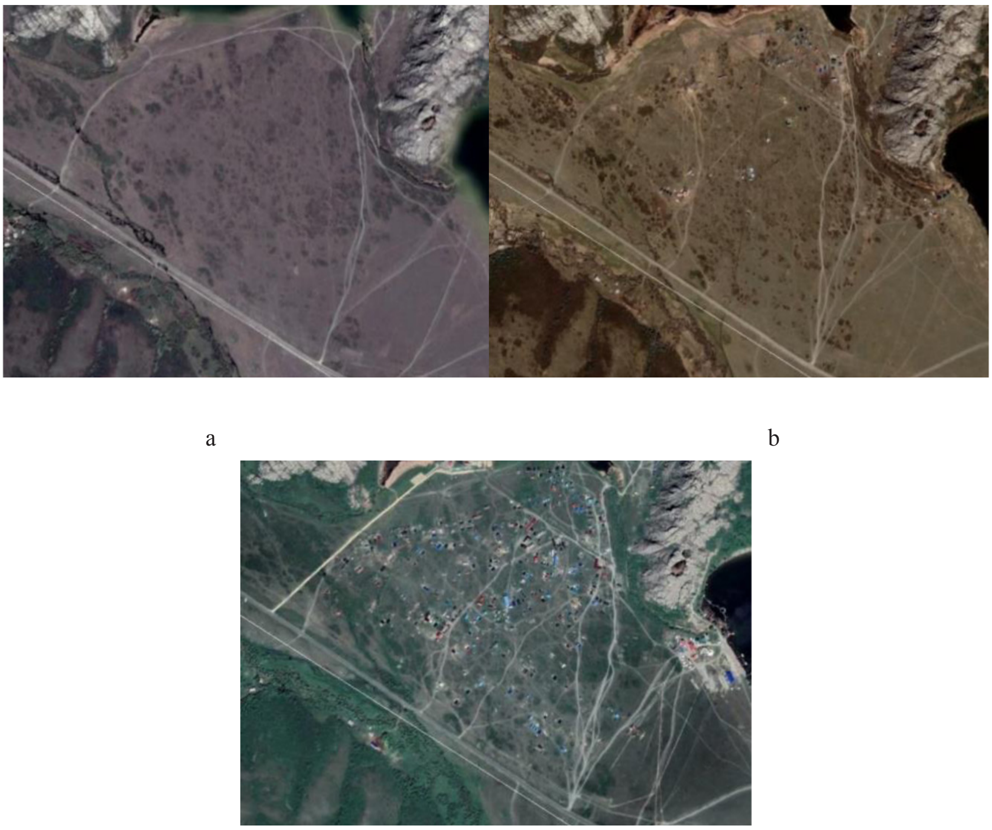



**Figure 3** – Level of damaged area (hectares)
(Low damaged = the soil is compacted, Moderately = plant, grass growth is reduced, High damaged = deteriorated into a stony or desolated area, Full damaged = No vegetation completely crushed

There are no very highly destroyed and damaged places along the route in the Altai of Kazakhstan. Approximately 84,4% of the total measured area is moderately damaged; the growth of plants and grasses has decreased. The soil of the area of 78,22 hectares was compacted on the beach of Svinchatka and Markakol lakes. In the Mongolian Altai, 56,9% were destroyed; 35,4% deteriorated into rock or desert.

In the third step, we tried to monitor the change of the damaged areas from the satellite images according to the above methodology. If the change of the vegetation layer covers a large area, the remote sensing method can show the areas affected by the change through satellite images of each year. Therefore, we concluded that it is possible to map the damage process by changing the vegetation layer of 18 areas every 5 years.

However, from the Landsat-8 and Landsat-9 satellite images, the nomenclature fields of Mongolia M45-105, 118, 129, Kazakhstan M45g, and M45b are mostly cloudy images. At these sites, 70-80% of the images taken in a year are full cloud and very few images are taken. In some nomenclature, the number of pictures does not reach 20 in July and August. Therefore, without limiting the annual interval to 5 years, we considered Landsat-7 satellite images from 2000, and Landsat-5 satellite images from 1984-1995 from some areas. Due to drought in 2004, 2014, and 2022, only cloudless pictures taken in May and June were found. We couldn't find any satellite images for August that we wanted. Although we downloaded the images of May and June and prepared the main image by overlaying bands 1-4, no change in the vegetation layer was observed. In a word, in 17 out of 18 sites marked during one expedition, no trampled, crushed (other) traces were found. It has been fully proven in practice that no damage to the vegetation layer can be seen from the satellite images of May and June. And there was no chance to overlap with Resolution 15-meter "Band-9". Tertiary studies failed 95%. The only successful image shows clearly how tourism affects the soil cover (figure 4).



a b

c

**Figure 4** – The soil layer of the shore of Lake Sibe under the influence of tourism damage
a) 2004 b) 2014 c) 2022

Sibe's 5 lakes are one of the main visiting areas for locals of Ust-Kamenogorsk during the summer. The figure-4 clearly shows how the 96,8 ha area on the Korzhynkol coast has changed. In this area, the growth of the plant layer decreased by 30-40%, and the grass grew low and barren. Such areas can be seen near Lake Shalkar.

In general, due to the emergence of a settlement with a lot of resorts and rental houses near Korzhynkol, the open fields in the middle of the resorts and the beach of the lake have especially deteriorated and the vegetation layer has been damaged. Although there are many branches near Tortkara Lake, but the soil layer is not damaged. One of the tourist objects near the 5 lakes of Sibe is the ruin of the Buddhist temple named Ablaikit. To get to this object from the main way, the 1.6-km road has been particularly narrowed and the soil layer damaged to cross the muddy areas of the river. In recent years, crops have been planted here, but in some places, crops have been damaged to the extent that they cannot grow.

Environmental impact: We have seen that the soil has been compacted in the areas marked in the green category in figure 4 above. As a result of soil compaction, the following environmental damages will occur.

1) During compaction, the volumetric mass will increase and the porosity will decrease, which inhibits the development of the root system of the plant, supply of moisture to plants decreases;

2) Deterioration of water-physical properties of the soil such as moisture capacity, porosity, rate of water absorption, and water permeability is observed;

3) Aeration and biological processes will decrease;

4) Surface flow of water and washing of fine soil will increase; Soil fertility decreases on average by 5-20% or even more.

The compaction of the soil (even deep in black soil) may exceed 1,3-1,35 g/cm when the vehicle passes through it. This is the upper limit of optimal compaction for the growth of many crops. When the hardness reaches this upper limit (that is, 20 kg/cm), the amount of air in the field layer decreases by 15% from the critical level, and the water permeability of the soil decreases to 40-30 mm/h.

During the months when there are a lot of tourists, several people walk through these places. In some places, tourists choose the best place and create a new branch road. As a result, important properties of the soil for the growth and development of plants, such as density, hardness, air, and water permeability, deteriorate sharply. The degree of this deformation depends on its initial state. That is, the density and humidity during the passage of the equipment, the amount of contact pressure on the soil, and the frequency of exposure are important. Soil compaction is most dangerous when the soil is saturated with water in autumn and spring. The degree of compaction in summer depends on the amount of precipitation. Soil moisture at the time of technology exposure is an important factor that determines the degree of compaction under that load. The depth of deformation determined by the above-mentioned factors, as well as the unit mass of the equipment, axial pressure, and tension at a depth of 50 cm varies from 20-30 to 50-60 cm. As a result, the growth of plants decreases by 15-30%.

If the compaction of the soil is up to 1,0-1,1 g/cm "normal" or weak, if it is 1,3-1,5 g/cm "medium", if it is 1,5-1,6 g/cm and more, compaction is considered strong. When the compaction reaches a strong degree, the growth of the plant cover decreases to 50-60%. The consequences of one-time intensive compaction remain for 2-5 years [25]. It is impossible for plants to grow in soil that is compacted after several years. Therefore, we can say that the soil is trampled and plant growth is reduced under the influence of tourism as "soil cover damage". And the situation of the places where the roads are broken and the clay swamps are completely overturned is understandable. It would be enough to show a picture and write that "tourism is damaging the soil cover" without conducting scientific research in such places.

Heavy metal pollution of the soil: Samples for determination of heavy metal pollution of the soil were taken along 5 coordinates along the last 13 km of the road going up to Tavanbogd, the most destroyed mountain in the Mongolian Altai. In Kazakhstan, it was taken from 1 coordinate up to Karakol, and from 2 coordinates up to the Rahman spring. The sample was taken over the road, 2 meters from both sides of the road, 5 meters from 1 coordinate, according to the "envelope" method, a total of 5 samples were taken from 1 coordinate in the Mongolian Altai, and 15 samples were taken in the Kazakhstan Altai.

Chromium (Cr), lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn), and nickel (Ni), all 6 elements were determined in the soil, according to atomic spectrometer absorption methods in "Nart" soil laboratory, Ulaanbaatar. The standard amount of heavy metal in the soil was compared according to the standard of Mongolia "MNS 5850:2008 named "Soil quality. Soil pollutants elements and substance". It was determined that the physical composition of the soil near Tavanbogd is 30-35% (<0.01 mm) and that it is clay-swamp soil.

"Coordinate-1,5" is a parking place for tourist cars in Mongolian Altai. The soil taken from the 4 ends of the area of about 1 ha was well mixed and compared with the clean soil indicator taken 20 meters away from the parking.

In figure 5 below, the standard indicator according to MNS5546:2005 [25] with a blue column is not considered to be at a critical level unless this line is exceeded. We have shown heavy metals in clean soil and normal levels in the white column. As the size of the band increases, it indicates the presence of heavy metal contamination. The amount of contamination is marked with a red column.

The amount of chromium in the clean soil of the Mongolian Altai is about 19,0-21,2mg/kg in 5 coordinates, while it is 17,3-22,4 mg/kg in some places along the road; 27,6-29,3 mg/kg at a distance of 5 meters below the road. That is, it is 8,1-8,6 mg/kg more than the amount of chromium in clean soil. This is proof of the accumulation of heavy metals in one place by soil layer leaching.

While the amount of lead in clean soil is 16,7-20,6, on the road it is 13,9-25,0 mg/kg at different levels; below the road, it reached 20,5-45,5 mg/kg. Even in coordinates 3 and 4, 2 times more lead was found than in clean soil. This indicates that there is heavy metal pollution. Cadmium metal contained in oil was not found in the soil.

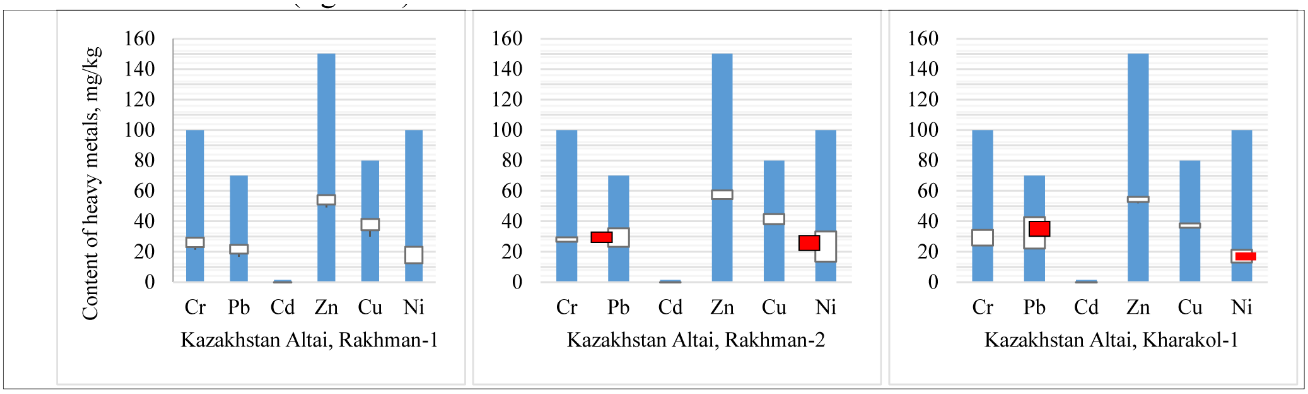



**Figure 5** – Heavy metal levels in soil in the Mongolian Altai
(Blue column is a critical level of heavy metals by MNS 5850:2008 Standard, White column shows a heavy metal level of clean soil. The red column shows the level of sampled soil. If the amount of heavy metals in the sampled soil is 2-3 times higher, it is colored red)

The level of zinc in clean soil was 42,0-42,8 mg/kg, while on the road it reached 42,7-76,2 mg/kg. The amount of zinc in coordinate 3 was 2 times more than in other coordinates. In coordinate-2, zinc was contaminated with 31,6 mg/kg, i.e. 2 times more than the normal level; it increased by 17,1 mg/kg in coordinate-1 and 15,6 mg/kg in coordinate-4.

The amount of copper in clean soil was 30,2-30,9 mg/kg, but on the road, it increased to 0,8-17,0 mg/kg. However, at the lower end of the line, coordinate-2 dropped to 14mg/kg.

Nickel is a type of heavy metal that pollutes the soil heavily. Although the amount of nickel in clean soil was 8,6-10,4 mg/kg, it reached 21,1-34,9 mg/kg-ha (excluding coordinate-1) on the road and increased by 2-3 times the normal amount. On the edge of the road, it reaches 16,1-33,7 mg/kg, that is, 2-4 times bigger.

Chromium (Cr), lead (Pb), zinc (Zn), and nickel (Ni) content is slightly or 2-4 times higher than the normal level in all 5 sampled coordinates, and most of them are collected below the road. 5 meters from the road means that the vegetation layer is taken from the undamaged areas, so it can be seen that the heavy metals that have entered through the vehicles are the result of the melting of the snow water, and the heavy metals that have fallen on the roads due to the wind are washed away and collected below the road. Below the road, the amount of heavy metal increased by at least 2,1mg/kg.

The following information was obtained from a sample taken from 3 coordinates in Kazakhstan's Altai (figure 6).

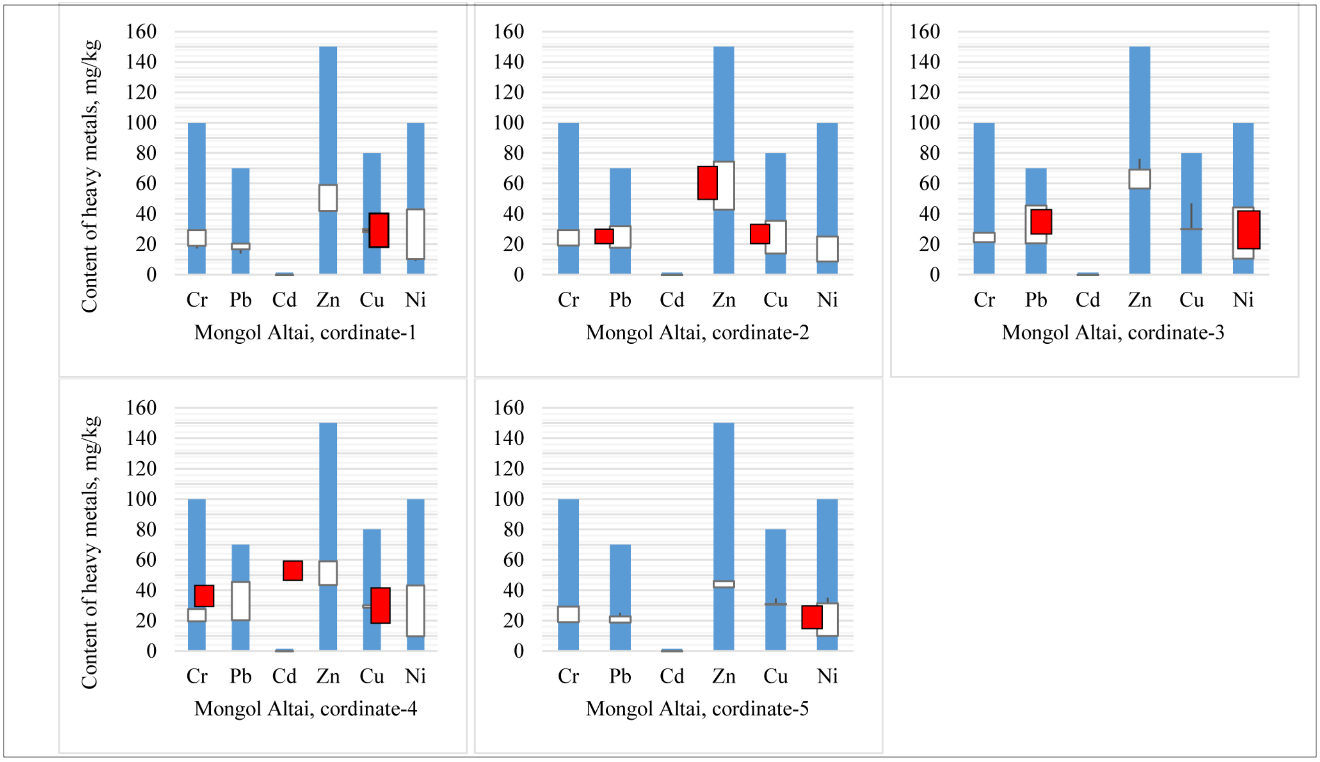



**Figure 6 –** The level of heavy metals in the soil of Altai, Kazakhstan
(Blue column is a critical level of heavy metals by MNS 5850:2008 Standard, White column shows the heavy metal level of clean soil. The red column shows the level of sampled soil. If the level of heavy metals in the sampled soil is 2-3 times higher, it is colored red)

Chromium level is 23-26,6 mg/kg in 2 coordinates taken along the road to Rahman spring, while on the road it is 21,3-28,7 mg/kg, i.e. at a normal level. Below the road, it is 3,3-6,3 mg/kg more than the normal level; cadmium metal was not found here either. The amount of zinc was 51,0-54,7 mg/kg, slightly decreased in coordinate-1 to 49,1 mg/kg, in coordinate-2 it reached 58,3 mg/kg, and on of road, it reached 60,4 mg/kg. The amount of copper in clean soil is 34,2-38,2 mg/kg, on the road it is 30,0-39,0, and below the road, it slightly increases to 41,5-44,8 mg/kg. This is evidence of heavy metal dissolution and accumulation here.

While the amount of lead in clean soil reaches 18,7-23,2 mg/kg, above the road it is 25,6 mg/kg, below the road it is 2 times higher, i.e. 12,5-15,8 mg/kg. If the amount of nickel is 12,4-12,8 mg/kg in clean soil, 14,7-17,1 mg/kg more on the road; below the road reaching 23,3-33,3 mg/kg indicates that there is pollution. Lead pollution of the soil is both in the Rahman spring and in Karakol.

In Karakol, the amount of nickel increased by 7,4 mg/kg below the road. Although the amount of lead, zinc, and chromium is normal, it can be seen that it has been washed away and collected below the road.

In general, the amount of lead and nickel in soil has increased by 2-4 times due to tourism in Mongolian Altai and Kazakhstan Altai. Cadmium element was not found at all. Other heavy metals such as chromium, copper, and zinc have slightly increased and accumulated below the road.

There is no mining or the metallurgical industry within 300 kilometers of this territory in either Kazakhstan or Mongolia. If we consider that these places are 60-120 km away from urban areas, only cars pollute the air and soil here. There are no large resorts to pollute the air and soil.

Therefore, we can say without a doubt that the level of some heavy metals in the soil here has increased by 2-4 times directly due to tourist vehicles. Even if it has not yet reached a dangerous level, a

2-4 times increase in 5 years can be a full reason to say that it is “contaminated with heavy metal”.

The lead here consists of cheap, non-environmentally eco gasoline, which is widely consumed in Mongolia and Kazakhstan. A80 gasoline contains 0,17g/l, A93 – 0,37g/l of lead [27]. Most of the vehicles serving tourists here are UAZ cars that use A80 gasoline, or powerful cars that use A93. Driving slowly with maximum power causes gasoline to burn prematurely and emit even more toxic gases. A car traveling at a speed of 31,7 km/h emits 1,11 g/h or 0,035 g/km of lead. Zinc is abundant in electric batteries [28]. In Mongolia, nickel alloys are widely used for painting and masking cars. Therefore, we can say that the heavy elements here fell into the soil directly through cars.

If we take into account that there are a lot of tourists on this road only in July and August and that it is washed away by snow and rainwater, if it continues like this, it can be assumed that the pollution will exceed the standard indicator and reach a dangerous level in the next 4-5 years.

## Conclusion

Studies were conducted on the hypothesis that the soil layer may have been damaged by uncontrolled, careless tourism and that the soil may have been poisoned with heavy metals by vehicles. As a result, the volume of the damaged soil was measured, and it was found that the heavy metal in the soil is increasing. After summarizing the data, an accurate assessment of the environmental impact was given.

According to the expedition and laboratory work, it was found that the soil cover of 182,7 km long territory in Mongolian Altai was damaged by vehicles and trampling by tourists; 56,9% of these measured territories were destroyed, and 35,4% became rocky or desert.

In Kazakhstan, the soil cover was damaged due to the formation of branch roads on an area of 705,7 ha, which was 55,3 km long. There is no very high crushed and damaged area; 84,4% of the total recorded area is moderately damaged and the growth of plants and grasses has decreased; the soil of 78.22 ha area was compacted on the banks of Svinchatka lake and Markakol.

To monitor the change in these areas, the study of finding damaged areas from satellite images and measuring the change using remote sensing was unsuccessful. Many of the satellite images here are clouded, and very few stored satellite images fail for a variety of reasons, such as the timings of the stored images not matching the same time as the monitoring.

During the determination of heavy metal contamination of the soil, a total of 40 samples were taken from 8 coordinates, and 24 of them were tested in the “Nart” soil laboratory in Ulaanbaatar.

As a result, it was found that due to tourism in the Mongolian Altai, the surface of the soil is being polluted in a small amount by the fumes released from the tourist vehicles. Chromium (Cr)-6,4-8,1 mg/kg, lead (Pb)-0,1-24,9 mg/kg, and copper (Cu)-0,7-5,1 mg/kg are more than normal. higher with zinc (Zn)-0,8-11,5 mg/kg, nickel(Ni)-21,1-34,9 mg/kg. In general, lead has increased 2-3 times in 3 coordinates, zinc has increased 2 times in 2 coordinates, and nickel has increased 2-4 times in 4 coordinates. It is seen that the amount of heavy metals in the soil has changed due to leaching by snow and rainwater. However, this indicator does not apply to contaminated soil according to the Mongolian National Standard.

The l of heavy metals increased in soil samples in Kazakhstan. In samples from Rahman spring, Karakol, lead increased by 12,5-15,8 mg/kg, i.e. 2 times, compared to pure soil. And the amount of nickel increased by 8,6-16,21 mg/kg from clean soil.

Since there is no mining ore production within 300 km of this territory in Kazakhstan and Mongolia, we can definitely say that the pollution is directly caused by tourism vehicles. If this continues, in the next 5 years, the amount of lead, zinc, and nickel will increase by 2-4 times and reach dangerous levels.

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