Impact of motor transport on the ecological and geochemical state of soils in the Black Sea resorts

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Abstract. The work shows how the average content of elements changes under the impact of motor transport with an increase in the intensity of their movement. For this, the concentration clarkes (coefficients) proposed by V. I. Vernadsky are used. The accumulation of elements is considered using indices of absolute (IAA) and relative (IRA) accumulation (IAA is expressed in t/km²). This makes it possible to plan the improvement of the ecological and geochemical situation in the recreational and tourist centers (RTC) of the Black Sea coast. The IAA values relative to the clarke of soils reach 300 t/km² (Sr in the soils of the Massandra settlement in comparison with the clarke content in soils). Most often, in the soils of the RTC of the Black Sea coast, in addition to Sr the contents of Cu, Zn and, somewhat less often, of Li and V are also increased. It was found that the following elements, the increased content of which are associated with the movement of vehicles, had the greatest influence on the current ecological and geochemical state of the soils of the RTC of the Black Sea coast and on the conditions for the development of living matter in them: Cu> Zn> Sr> Li.

1. Introduction

Soils of settlements belong to bioinert regional geochemical systems [1-4]. In them, as in planetary systems, the distribution of the content of chemical elements depends on a large number of equally probable, random and independent reasons. In this regard, the distribution of chemical elements in such large systems usually approaches (approximates) the normal law. In these cases, the arithmetic mean (\(\bar{x}\)) coincides with the most common value (mode) and with the average in the ranked series of values (median).

It is this value that is the clarke of the corresponding planetary or regional system. For the geochemical characterization of systems, a number of further considered indices are used, which are usually established during the statistical processing of the results of sample analyzes. With a normal distribution, the content of elements that go beyond the limits limited by the values \(\bar{x} \pm 3\sigma\) (where \(\sigma\) is the standard deviation) are referred to as anomalous. Out of 1000 values, no more than 3 can belong to them. In local, smaller geochemical systems, it is not the clarke that is established, but the local geochemical background.
To date, more than 40 chemical elements have been identified in settlements soils [5]. To characterize local geochemical systems (and these include soils of individual settlements and their groups), statistical processing of analyzes of uniformly selected samples is carried out.

2. **Scope and methods of the studies**

To establish the influence of vehicles on the ecological and geochemical state of the soils of the recreational and tourist centers (RTC) of the Black Sea coastal resorts, the authors carried out soil sampling in six settlements: Feodosia, Sudak, Koktebel, Massandra, Yalta, Alupka. In addition, the work used the results of analyzes of specially tested soils of the recreational and tourist centers of the world [5]. All samples were taken from the upper humus horizon, which, according to A.I. Perelman [6], is the "geochemical center of soils" with the maximum energy of geochemical processes in the landscape. Thus, soil samples were taken from a depth of up to 30 cm from the day surface. The tested RTCs are remote from industrial enterprises. This allows us to believe that the main technogenic changes in the soils in the centers under consideration are associated (except for those caused by the usual processes of normal life of local residents and tourists) with vehicles, or rather, with the intensity of traffic. In this regard, in each RTC, when sampling, its location relative to the movement of vehicles with different intensities was taken into account. In this work, for comparison, the results of analyzes of samples taken in areas with a practical absence of traffic and with its greatest intensity in this center are used.

The mass of one lithochemical (soil) sample averaged about 400 g. In total, during the preparation of this information, over 1000 samples taken at the RTCs were used for various calculations: of these, about 300 were taken in the main centers of Crimea. The sampling control was 5% of the number of ordinary samples.

All samples were subjected to standard processing and spectral analysis by the "spilling" method in the certified and accredited Central Research Laboratory of the Federal State Unitary Enterprise Kavkazgeosemka. Internal and external control of analyzes was 4%. The calculation of the error of analyzes and sampling was carried out for the logarithms of the contents. The values of systematic and random errors allow us to consider the work carried out as a good one [5].

The analysis results were subjected to standard statistical processing. Soil samples taken in the RTCs of the Black Sea coast were combined into separate samples depending on the traffic intensity. In addition to the standard statistical processing of the analysis results, the indices of absolute and relative accumulation (IAA and IRA) were calculated [7]. The absolute accumulation index was determined by the formula:

$$IAA \ (t/km^2) = (C_{b2} - C_{b1}) \cdot C,$$

where

- $C_{b1}$ – the background content of the element in the considered geochemical systems before the beginning of the studied processes. Clarke or local background contents are sometimes used instead of this value. Which of these values is used by researchers is indicated in the text or in the heading of the table;
- $C_{b2}$ – the content of the same element in the same system after the end of the process under study;
- $C$ – the coefficient showing what mass of an element corresponds to an increase (decrease) in its content by a certain amount in the system under consideration.

With a technogenic input of an element, geochemical changes in soils usually occur in the upper layer with a thickness of 30 cm. Calculations and available experimental data show that in some soil layers with a thickness of 30 cm, with an increase in the abundance of an element by $1 \cdot 10^{-3}$%—there is an increase (decrease) its mass by 6 t/km². It is advisable to use this value as the corresponding coefficient in the study of the geochemistry of soil processes.

The ratio of IAA to local background or clarke content is called the index of relative accumulation (IRA). It can be used for a relative assessment of the ecological and geochemical significance of the changes that have occurred in comparison with those that existed before the process under consideration.

The clarke (coefficient) concentration (C.C), proposed in 1937 by V. I. Vernadsky was also determined [8,9]. It represents the ratio of the local background (clarke) content to the corresponding crustal clarke. In our case, instead of the clarke of the earth's crust, we used the average content of the
chemical element in the soils of the recreational and tourist centers (RTC) of the world [1]. When the value of C.C is less than "1", this is usually referred as the coefficient of dispersal (C.D).

To process the analysis results, the samples were combined into samples characterizing the following soils:
- individual RTCs without taking into account any technogenic load;
- individual RTCs, taking into account the traffic intensity.

Thus, in this study, soil samples were combined into separate samples in each RTC in areas with no vehicles, with a practical absence of vehicle traffic and with heavy traffic. The first samples combine those taken from pedestrian zones away from highways. Samples with a virtual absence of vehicles included RTC samples on streets with infrequent car traffic (up to about 20 vehicles per day). Intensive traffic was understood as corresponding to tens and hundreds of cars per day. The authors understand a conventionality of this classification. However, in RTCs occupying a small area, such a division makes it possible to more accurately establish the influence of vehicles on the geochemical state of the soils of the resorts.

3. Results
As one can see in tables 1, 2, no significant and clearly pronounced increase in the average contents of the studied chemical elements in the soils of the RTCs on the southern coast of Crimea, as compared to the soils of the RTCs of the world, has been established. However, for a number of elements, an insignificant increase in the average contents is still revealed.

These elements include, first of all, tungsten. For this metal, judging by the C.C values, the average content in the soils of all the studied centers increased by no less than 1.3 times (Table 1). In two cases (in the villages of Koktebel and Massandra), the W content in the soils exceeds its average content in the soils of the RTCs of the world by more than 1.5 times. Almost as often, the average content of nickel and vanadium in the soils of the Crimean resorts is 1.3 times higher than their average content in the soils of the RTCs of the world.

The above allows us to preliminarily assume that W, Ni, and V constitute a kind of association of chemical elements found in (usually slightly) higher concentrations in the soils of settlements of the Crimean geochemical province. The formation of this association, in general, can be associated not with later impacts, but with the processes of soil formation in specific geological and geomorphological conditions. In cases of both natural and man-made (including by means of motor transport) input of elements into already formed soils, all three elements should not have been concentrated together. This can be judged by the fact that during mechanical (air and water) migration due to different atomic masses of the elements under consideration (from 184 to 59), they should be concentrated in different areas. When migrating in the form of aqueous solutions, the joint concentration and even the migration distance of the three considered elements are hindered by the sizes of ionic radii (from 0.6 to 0.8), as well as the values of energy coefficients (from 2.18 to 19.4), ionization potentials, and Cartledge ionic potentials.

In some areas (the village of Koktebel, Massandra, etc.), regardless of the traffic intensity, the average contents of Ga, Ge, Cu, Li are increased, which, as well as increased contents of W, Ni and V almost everywhere, can be considered one of the geochemical features of the RTC soils in the southern part of Crimea. These geochemical features of the RTC soils on the southern coast of Crimea must be taken into account when planning the development of the region, as well as when carrying out various environmental measures and, first of all, when distributing the flow of cars in Crimea.

Over the long evolutionary processes of the Earth, its living matter has adapted to certain geochemical conditions. To date, one of the most objective geochemical indicators of the comfort of the existence of organisms on land is the clarke content of elements in such a depositing bioinert system as soils.
Table 1. Ecological and geochemical characteristics of the soils of the coastal RTCs of Crimea and the impact of motor transport (Ag - Mn)

|     | Ag  | Ba  | Co  | Cr  | Cu  | Ga  | Ge  | Li  | Mn  |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     | Clarke's of the Earth soils\textsuperscript{a} |
|     | 0.05| 50.0| 0.8 | 20.0| 2.0 | 3.0 | 0.5 | 3.0 | 85.0|
|     | 0.04| 98.3| 1.8 | 8.8 | 5.6 | 1.6 | 0.1 | 5.1 | 112.5|
|     |     |     |     |     |     |     |     |     |     | Average content in soils of RTCs of the world\textsuperscript{b} |
|     | 0.02| 63.3| 1.7 | 8.7 | 4.7 | 1.5 | 0.2 | 4.0 | 93.3|

Feodosia, the average content of elements in the soils of the RTC

|     | 0.5 | 0.6 | 0.9 | 1.0 | 0.8 | 0.9 | 1.1 | 0.8 | 0.8 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.02| 60.0| 1.65| 9.4 | 4.5 | 1.6 | 0.2 | 4.0 | 95.0|

Feodosia, C.C. in the soils of the RTC relative to the soils of the RTCs of the world

|     | 0.5 | 0.6 | 0.9 | 1.0 | 0.8 | 1.0 | 1.1 | 0.8 | 0.8 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.03| 80.0| 1.5 | 8.0 | 6.0 | 1.0 | 0.2 | 4.0 | 100.0|

Feodosia, C.C. in the soils of the RTC relative to the soils of the RTCs of the world

|     | 0.75| 0.8 | 0.8 | 0.9 | 1.1 | 0.6 | 1.1 | 0.8 | 0.9 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.02| 64.4| 1.7 | 9.5 | 6.0 | 1.3 | 0.2 | 3.7 | 84.5|

Sudak, the average content of elements in the soils of the RTC

|     | 0.5 | 0.7 | 0.9 | 1.1 | 1.1 | 0.8 | 1.1 | 0.7 | 0.8 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.02| 63.3| 1.9 | 9.7 | 6.2 | 1.2 | 0.2 | 3.0 | 83.4|

Sudak, C.C. in the soils of the RTC relative to the soils of the RTCs of the world

|     | 0.5 | 0.6 | 1.0 | 1.1 | 1.1 | 0.7 | 1.1 | 0.6 | 0.7 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.02| 66.7| 1.3 | 9.3 | 5.7 | 1.5 | 0.2 | 5.0 | 86.7|

Sudak, C.C. in the soils of the RTC relative to the soils of the RTCs of the world

|     | 0.5 | 0.7 | 0.7 | 1.1 | 1.0 | 0.9 | 1.1 | 1.0 | 0.8 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.015| 62.5| 1.9 | 10.0| 9.8 | 2.0 | 0.2 | 12.5| 85 |

Koktebel, the average content of elements in the soils of the RTC

|     | 0.4 | 0.6 | 1.0 | 1.1 | 1.7 | 1.2 | 1.1 | 2.4 | 0.8 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.015| 70.0| 1.8 | 10.0| 6.5 | 2.0 | 0.2 | 6.0 | 90.0|

Koktebel, C.C. in the soils of the RTC relative to the soils of the RTCs of the world

|     | 0.4 | 0.7 | 1.0 | 1.1 | 1.1 | 1.2 | 0.8 | 1.2 | 0.8 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.02| 55.0| 2.0 | 10.0| 13.0| 2.0 | 0.3 | 7.0 | 80.0|

Koktebel, C.C. in the soils of the RTC relative to the soils of the RTCs of the world

|     | 0.5 | 0.6 | 1.1 | 1.1 | 2.3 | 1.2 | 1.3 | 1.4 | 0.7 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.01| 70.0| 1.8 | 9.0 | 4.3 | 2.3 | 0.175| 6.0 | 90.0|

Massandra, the average content of elements in the soils of the RTC

|     | 0.25| 0.7 | 1.0 | 1.0 | 0.8 | 1.4 | 0.9 | 1.2 | 0.8 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.01| 60.0| 2.0 | 10.0| 4.5 | 2.5 | 0.2 | 6.0 | 80.0|

Massandra, C.C. in the soils of the RTC relative to the soils of the RTCs of the world

|     | 0.25| 0.6 | 1.1 | 1.1 | 0.8 | 1.5 | 1.1 | 1.2 | 0.7 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.01| 80.0| 1.5 | 8.0 | 4.0 | 2.0 | 0.2 | 6.0 | 100.0|

Massandra, C.C. in the soils of the RTC relative to the soils of the RTCs of the world
According to V. A. Alekseenko, the average content of elements in the soils of the RTC

Table 1. Ecological and geochemical characteristics of the soils of the coastal RTCs of Crimea and the impact of motor transport (Ag - Mn)

|       | Ag  | Ba  | Co  | Cr  | Cu  | Ga  | Ge  | Li  | Mn  |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Massandra, C.C in the soils of the RTC with heavy traffic relative to the soils of the RTCs of the world | 0.3 | 0.8 | 0.8 | 0.9 | 0.7 | 1.2 | 0.8 | 1.2 | 0.9 |
| Yalta, the average content of elements in the soils of the RTC | 0.04 | 80.0 | 2.0 | 10.0 | 30.0 | 2.0 | 0.15 | 6.0 | 80.0 |
| Yalta, C.C in the soils of the RTC in the absence of traffic relative to the soils of the RTC of the world | 1.0 | 0.8 | 1.1 | 1.1 | 5.3 | 1.2 | 0.8 | 1.2 | 0.7 |
| Alupka, the average content of elements in the soils of the RTC | 0.01 | 80.0 | 0.6 | 5.0 | 3.0 | 0.6 | 0.1 | 3.0 | 100.0 |
| Alupka, C.C in the soils of the RTC in the absence of traffic relative to the soils of the RTC of the world | 0.3 | 0.8 | 0.3 | 0.6 | 0.5 | 0.4 | 0.5 | 0.6 | 0.9 |

a According to A. P. Vinogradov (1957) [10], b According to V. A. Alekseenko, A. V. Alekseenko (2013) [5]

Table 2. Ecological and geochemical characteristics of the soils of the coastal RTCs of Crimea and the impact of motor transport (Mo – Zn)

|       | Mo  | Ni  | Pb  | Sn  | Sr  | Ti  | V   | W   | Zn  |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Clarke's of the Earth soils | 0.2 | 4.00 | 1.0 | 1.0 | 30.0 | 460 | 10.0 | -   | 5.0 |
| Average content in soils of RTCs of the world | 0.2 | 3.98 | 5.52 | 0.65 | 55.07 | 479.4 | 11.5 | 0.24 | 20.0 |
| Feodosia, the average content of elements in the soils of the RTC | 0.2 | 4.0 | 5.7 | 0.4 | 46.7 | 333.3 | 6.7 | 0.3 | 18.3 |
| Feodosia, concentration coefficient (C.C) in the soils of the RTC relative to the soils of the RTCs of the world | 1.0 | 1.0 | 1.0 | 0.6 | 0.8 | 0.7 | 0.6 | 1.3 | 0.9 |
| Feodosia, the content of elements in the soils of the RTC in the absence of traffic | 0.2 | 4.25 | 4.0 | 0.5 | 45.0 | 375.0 | 7.0 | 0.3 | 23.8 |
| Feodosia, C.C in the soils of the RTC in the absence of traffic relative to the soils of the RTC of the world | 1.0 | 1.1 | 0.7 | 0.8 | 0.8 | 0.8 | 0.6 | 1.3 | 1.2 |
| Feodosia, the content of elements in the soils of the RTC during heavy traffic | 0.2 | 3.0 | 10.0 | 0.5 | 50.0 | 200.0 | 6.0 | 0.3 | 30.0 |
| Feodosia, C.C in the soils of the RTC with heavy traffic relative to the soils of the RTCs of the world | 1.0 | 0.8 | 1.8 | 0.8 | 0.9 | 0.4 | 0.5 | 1.3 | 1.5 |
| Sudak, the average content of elements in the soils of the RTC | 0.2 | 5.2 | 3.5 | 0.5 | 54.8 | 544.4 | 12.8 | 0.3 | 15.6 |
| Sudak, C.C in the soils of the RTC relative to the soils of the RTCs of the world | 1.0 | 1.3 | 0.6 | 0.8 | 1.0 | 1.1 | 1.1 | 1.3 | 0.8 |
| Sudak, the content of elements in the soils of the RTC in the absence of traffic | 0.3 | 5.6 | 3.5 | 0.6 | 51.7 | 550.0 | 14.2 | 0.3 | 15.0 |
| Sudak, C.C in the soils of the RTC in the absence of traffic relative to the soils of the RTC of the world | 1.5 | 1.4 | 0.6 | 0.9 | 0.9 | 1.1 | 1.2 | 1.3 | 0.8 |
| Sudak, the content of elements in the soils of the RTC during heavy traffic | 0.2 | 4.7 | 3.7 | 0.5 | 60.0 | 533.3 | 10.0 | 0.3 | 16.7 |
| Sudak, C.C in the soils of the RTC with heavy traffic relative to the soils of the RTCs of the world | 1.0 | 1.2 | 0.7 | 0.8 | 1.1 | 1.1 | 0.9 | 1.3 | 0.8 |
| Koktebel, the average content of elements in the soils of the RTC | 0.2 | 4.7 | 4.0 | 0.47 | 55.0 | 475.0 | 15.0 | 0.3 | 21.2 |
| Koktebel, C.C in the soils of the RTC relative to the soils of the RTCs of the world | 1.0 | 1.2 | 0.7 | 0.7 | 1.0 | 1.0 | 1.3 | 1.3 | 1.1 |
| Koktebel, the content of elements in the soils of the RTC in the absence of traffic | 0.2 | 4.5 | 4.0 | 0.45 | 60.0 | 500.0 | 15.0 | 0.3 | 20.0 |
| Koktebel, C.C in the soils of the RTC in the absence of traffic relative to the soils of the RTC of the world | 1.0 | 1.1 | 0.7 | 0.7 | 1.1 | 1.0 | 1.3 | 1.0 | 1.0 |
Table 2. Ecological and geochemical characteristics of the soils of the coastal RTCs of Crimea and the impact of motor transport (Mo – Zn)

|    | Mo | Ni | Pb | Sn | Sr | Ti | V  | W  | Zn  |
|----|----|----|----|----|----|----|----|----|-----|
| Koktebel, the content of elements in the soils of the RTC during heavy traffic |
| 0.2 | 5.0 | 4.0 | 0.5 | 50.0 | 450.0 | 15.0 | 0.4 | 22.5 |
| Koktebel, C.C in the soils of the RTC with heavy traffic relative to the soils of the RTCs of the world |
| 1.0 | 1.3 | 0.7 | 0.8 | 0.9 | 0.9 | 1.3 | 1.5 | 1.1 |
| Massandra, the average content of elements in the soils of the RTC |
| 0.2 | 5.3 | 6.5 | 0.6 | 57.5 | 575.0 | 12.5 | 0.3 | 16.3 |
| Massandra, C.C in the soils of the RTC relative to the soils of the RTCs of the world |
| 1.0 | 1.3 | 1.2 | 0.9 | 1.0 | 1.2 | 1.1 | 1.3 | 0.8 |
| Massandra, the content of elements in the soils of the RTC in the absence of traffic |
| 0.2 | 5.5 | 3.0 | 0.5 | 35 | 550 | 15 | 0.4 | 12.5 |
| Massandra, C.C. in the soils of the RTC in the absence of traffic relative to the soils of the RTC of the world |
| 1.0 | 1.4 | 0.5 | 0.8 | 0.6 | 1.1 | 1.3 | 1.5 | 0.6 |
| Massandra, the average content of elements in the soils of the RTC during heavy traffic |
| 0.2 | 5.0 | 10.0 | 0.6 | 80.0 | 600 | 10.0 | 0.3 | 20.0 |
| Massandra, C.C in the soils of the RTC with heavy traffic relative to the soils of the RTCs of the world |
| 1.0 | 1.3 | 1.8 | 0.9 | 1.5 | 1.3 | 0.9 | 1.3 | 1.0 |
| Yalta, the average content of elements in the soils of the RTC |
| 0.2 | 5.0 | 6.0 | 0.6 | 80.0 | 500.0 | 15.0 | 0.2 | 30.0 |
| Yalta, C.C. in the soils of the RTC in the absence of traffic relative to the soils of the RTC of the world |
| 1.0 | 1.3 | 1.1 | 0.9 | 1.5 | 1.0 | 1.3 | 0.8 | 1.5 |
| Alupka, the average content of elements in the soils of the RTC |
| 0.1 | 2.0 | 3.0 | 0.4 | 60.0 | 200.0 | 5.0 | <0.2 | 8.0 |
| Alupka, C.C. in the soils of the RTC in the absence of traffic relative to the soils of the RTC of the world |
| 0.5 | 0.5 | 0.5 | 0.6 | 1.1 | 0.4 | 0.4 | 0.4 | 0.4 |

According to A. P. Vinogradov (1957) [10], According to V. A. Alekseenko, A. V. Alekseenko (2013) [5]

Let us consider the features of the incidence of a number of chemical elements in the soils of recreational and tourist centers (RTC) of the Crimea in comparison with the abundance of elements in the soils of the Earth (Fig. 1) and taking into account the traffic intensity of motor transport. In the soils of all these centers, which are not susceptible to the likely impact of vehicles, the contents of Zn, Sr, and Cu are significantly increased. The contents of Li and V are often also increased. This, like the previously considered contents of V, Ni, W, is most likely associated with the processes of soil formation and characterizes the soils of the RTCs of the Crimean geochemical province. Compared to the soils of the Earth, the highest content of Sr in the soils of these centers in unpolluted areas was found for Sr (max 180 in Koktebel, and min - 30 t/km² in Massandra).

In the soils of the same RTCs, but exposed to heavy traffic, the content of all these elements increased. It should be especially noted that for those of the elements that were in the highest concentrations in soils that were not exposed to transport, the increase in the content under the influence of vehicles became large. I.e., the content of Zn in the soils of Koktebel increased by 15 t/km² from 90 to 105, and Ni - by only 3 - from 3 to 6 t/km². In the soils of Massandra, the content of the same metal increased from 45 to 90 t/km².

The accumulation series of these chemical elements in the soils of the Crimean RTC relative to the clarke of the Earth's soils have the following form in the absence of traffic (in parentheses, the content in t/km²):

Feodosia: Zn(113) > Sr(90) > Cu(15) > Li(6)
Sudak: Sr(130) > Zn(60) ≥ Cu(25, V)
Koktebel: Sr(180) > Zn(90) > V(30) > Cu(27) > Li(18) > Ni(3)
Massandra: Zn(45) > V, Sr(30) > Li(18) > Cu(15) > Ni(9)
Under the impact of motor transport, these series take the following form:

Feodosia: Zn(150) > Sr(120) > Cu(24) > Li(6)
Sudak: Sr(180) > Zn(70) > Cu(22) > Li(12) > Ni(4)
Koktebel: Sr(180) > Zn(70) > Cu(23) > Li(12) > Ni(4)
Massandra: Sr(300) > Zn(90) > Li(18) > Cu(12) > Ni(6)

As can be seen from the data presented (Table 1, Fig. 1), Sr, Zn, Cu, Li have accumulated in the largest amounts in the soils of the Crimean RTCs, regardless of the influence of vehicles. Thus, IAA (t/km²) for Sr in the soils of Koktebel and Sudak reached 180 and 130 t/km², respectively. For the soils of the majority of the Crimean RTCs under consideration, the constant accumulation of Sr, Zn, Cu, in comparison with the soils of the world, is common (Fig. 1).

With an increase in the traffic intensity, the mass of almost all the considered elements increased in the soils of the Crimean resorts relative to the soils of the world (Fig. 1). The increase in the content of chemical elements in the soils of various Crimean RTCs, of course, was influenced not only by the traffic intensity, but also by the local ecological and geomorphological features of the centers. However, the direction and scale of the accumulation process make it possible to consider the role of motor transport as the leading one.

The increase in the content of chemical elements in the soils of the RTCs undoubtedly affected the comfort of the existence of many living organisms. However, the degree of influence of increased concentrations of various elements in the environment on organisms is often not proportional to changes in the contents of various elements [8-10]. To take into account the long-term “adaptation” of living matter to certain contents, to assess the “harmfulness” of an increase in the concentrations of elements under the influence of various processes, the index of relative accumulation (IRA) was used. In this work, the IRA, in relation to the clarks of the Earth's soils, is also established in order to compare the ecological and geochemical conditions prevailing at the present time in the RTCs with the conditions customary for living matter on a historical scale.

Data in Table 1, Fig. 1, Fig. 2 allow us to confidently assume that the following (accumulating) elements had the greatest influence on the current ecological and geochemical state of the soils of the Crimean RTCs and on the conditions for the development of living matter in these RTCs (in comparison with the soils of the Earth): Cu > Zn > Sr > Li. Moreover, this influence occurred both with and the heavy traffic of vehicles and without it. An increase in the traffic intensity increased the influence of the listed elements on the ecological and geochemical state of soils in various RTCs of Crimea.
Figure 1. IAA of a number of chemical elements in the soils of the RTCs of Crimea relative to the clarke of soils of the Earth: Feodosia: (a) - in the absence of traffic, (b) - with heavy traffic; Sudak: (c) - in the absence of traffic, (d) - with heavy traffic; settlement Koktebel: (e) - in the absence of traffic, (f) - with heavy traffic; settlement Massandra: (g) - in the absence of traffic, (h) - with heavy traffic.

Thus, the geochemical differences between the soils of the Crimean RTCs and the soils of the Earth, with the clarke content of elements, increase under the influence of vehicles. However, such an effect does not always lead to an increase in the content of elements.

The content of a small group of elements (Li in Feodosia, Cu in Sudak, etc.) in the soils of the RTC under the influence of intensive car traffic practically did not change. The average content of another part of the elements, and hence their IAA, decreased as a result of the increased influence of motor transport. These elements include V in the soils of Massandra, Ni in Sudak, etc.

The above suggests that, as a result of the impact of vehicles in the soils of the Crimean RTCs, significant changes in the contents of almost all studied elements occur (in comparison with the soils of the Earth). This, together with other factors, is the reason for the rather large impact of vehicles on the ecological and geochemical situation in the RTCs of Crimea. To establish the role of individual elements in such changes, the IRA calculated relative to the Earth's soils is used (Fig. 2).

The series, developed according to the values of the established IRA (taking into account the geochemical characteristics of the Earth's soils), is for the most common elements as follows: (Cu, Zn) > (Li, Sr) > V. Therefore, the content (input) of Cu and Zn in the resort centers deserves special attention. These metals, which are in higher concentrations than their content in the Earth's soils, can have a significant impact on the development of many organisms. Note again that copper and zinc are supplied in large quantities by vehicles (Fig. 1).
Figure 2. IRA of a number of chemical elements in the soils of the RTCs of Crimea relative to the clarke of soils of the Earth: Feodosia: (a) - in the absence of traffic, (b) - with heavy traffic; Sudak: (c) - in the absence of traffic, (d) - with heavy traffic; settlement Koktebel: (e) - in the absence of traffic, (f) - with heavy traffic; settlement. Massandra: (g) - in the absence of traffic, (h) - with heavy traffic.

When considering the influence of vehicles on the ecological and geochemical appearance of the soils of the RTCs on the southern coast of Crimea, it should be taken into account that the geochemical characteristics of the soils of the resorts differ not only from the soils of the Earth, but also from the soils of ordinary settlements.

On the territories of the RTC, not only a certain number of permanent residents live, but a much larger number of people come to restore their health. In this regard, the ecological and geochemical characteristics of the RTCs (objective data on it can be obtained from the study of soils), is of particular importance. Above, data were given on the ecological and geochemical changes in the soils of the Crimean RTCs (mainly due to the influence of vehicles) in comparison with the average contents in the soils of the Earth. Let us consider the same changes in comparison with the averaged geochemical data on the soil content of the RTCs located in various parts of the Earth.

As can be seen from Fig. 3, in the soils of individual Crimean resorts, the content of a number of metals differs significantly from the average content of the world resorts. In the soils of the Crimean RTCs, lower concentrations of the studied elements are often established. Thus, in the soils of Massandra, Sudak and Feodosia, in comparison with the soils of the RTCs of the World, the average content of Zn is reduced by 22, 26, and 50 t/km$^2$, respectively. At the same time, in Koktebel, the average content of the same metal increased by 7.2 t/km$^2$. The average Sr content varies from a lower one in comparison with the soils of the RTCs of the world (-10.2 t/km$^2$) in Feodosia to an increased (+14.6 t/km$^2$) in Massandra. Such a mosaic distribution of metals in the soils of the Crimean RTCs can be explained by the combined effect of the still dotty pollution from road transport with the local climatic, geological-hydrochemical and geomorphological features of the Crimean resort centers.

The distribution of Cu and Li in the soils of the resorts of the southern coast of Crimea, in comparison with the average contents in the soils of the RTCs of the world, is quite contrasting. The Cu content in Koktebel increased by 24.7 t/km$^2$ and decreased by 8.3 t/km$^2$ in Massandra. The Li content is increased in the soils of Koktebel (+44.3 t/km$^2$) and decreased in Feodosia (-29.4 t/km$^2$). A similar geochemical pattern is typical for other elements (Fig. 3).
Figure 3. IAA (t/km²) of a number of chemical elements in the soils of the RTCs of Crimea relative to the average contents of elements in the soils of the RTCs of the world (a) - Feodosia, (b) - Sudak, (c) - Koktebel, (d) - Massandra

Judging by the small fluctuations in the IRA values (Fig. 4), the isolation of any element that currently has the greatest impact on the ecological and geochemical state of the RTCs on the southern coast of Crimea is not yet a priority task. However, attention should be paid to the input of Cu and Li into the soils of Koktebel and Yalta (Fig. 4).

As already indicated, within the studied Crimean RTCs there are areas with no vehicles and with heavy traffic. Let us consider how the content of the considered elements changes in such areas within the same settlement. As can be seen from Fig. 5, with an increase in traffic intensity, the content of only Zn increased in the soils of all studied RTCs. In three of the four centers under consideration, the Sr content, in two of them – Cu and Li content increased.

Figure 4. IRA (t/km²) of a number of chemical elements in the soils of the RTCs of Crimea relative to the average contents of elements in the soils of the RTC of the world (a) - Feodosia, (b) - Sudak, (c) - Koktebel, (d) - Massandra

The number of elements that accumulate, mainly under the influence of vehicles in the soils of one center, changes, despite their small size. In Feodosia, due to motor transport, the content of Zn, Sr and Cu in soils increased by 37.3 and 9.0 t/km², respectively (Fig. 5).

In a larger mass, the Zn content increased due to motor transport in some areas of Massandra (45.0 t/km²). In the same center, the Sr content increased in the greatest amount (up to 270 t/km²). The maximum Cu content (39.0 t/km²) was found in the soils of Koktebel. The accumulation of other elements under the influence of vehicles increased in quantities less than t/km².
4. Conclusion
Regardless of the movement of vehicles in the soils of recreational and tourist centers (RTC s) of Crimea, the contents of W, Ni, V are increased (in comparison with the clarkes of the Earth's soils and with average contents in the soils of the RTCs of the world). In addition, in some areas of the southern coast, regardless of motor transport, the average contents of Ga, Ge, Cu and Li are increased. This created a peculiar geochemical background.

Under the influence of motor transport, the content of Zn, Sr, Cu, Li and V increased to 300 t/km² (Sr in the soils of Massandra). The greatest impact on living organisms could have an increase in the contents of the following elements Cu> Zn> Sr> Li. Under certain landscape-geochemical conditions, the current impact of vehicles did not lead to the usual increase in the content of certain elements in soils (Li - in Feodosia, Cu - in Sudak, etc.). In rare cases (Ni in Sudak) in areas, exposed to the impact of motor transport, the content of elements in soils has decreased (Ni in Sudak). With the development of automobile traffic, attention should be paid to the input of Cu and Li in the soils of Koktebel and Yalta.

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