STUDY OF NATURAL AND MAN-MADE ECOSYSTEMS BY METHODS OF ENGINEERING GEOPHYSICS (ON THE EXAMPLE OF THE CHECHEN REPUBLIC)

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Abstract*. A carbon landfill has been operating in the Chechen Republic since 2021. Among the studies carried out at the sites of the Carbon landfill, an important place is given to geophysical studies that have been widely used in solving environmental problems such as the study of the burial areas of various solid waste and other contaminated (including petroleum products) territories. This article is devoted to the methods of engineering geophysics carried out at the reference site "Carbon Farm", as well as at the experimental oil-contaminated site. The article presents the results of the research, the relevant conclusions are drawn.*

Keywords*: carbon landfill, electrotomography, seismic exploration, sludge storage, soil*

One of the operators of the Carbon landfill of the Chechen Republic is the Grozny State Oil Technical University named after academician M.D. Millionshchikov (GSTOU), whose scientists conduct scientific research at six reference sites [3, 4].

A wide range of environmental problems (landslides, landslides, pollution of the geological environment, etc.) have been solved for a long time and effectively by methods of engineering geophysics [1, 6-8]. Geophysical methods are also widely used in solving such environmental (geoecological) tasks as the study of landfills of solid household waste (MSW), tailings dumps of industrial enterprises and other polluted territories [5] that negatively affect the state of the environment and human health.

As part of the work carried out at the carbon landfill, employees of the Geophysical research laboratory of the Research Institute of Geoecology and Environmental Management of GGNTU conducted research on the site contaminated with petroleum products and the reference site "Carbon Farm".

Electrotomography (ET) on an oil-contaminated site

The objective of the study was to analyze the distribution of ER in the sludge storage bowl and evaluate the filtration properties of its sides. One of the effective methods for solving this problem is electrotomography [2, 7, 8].

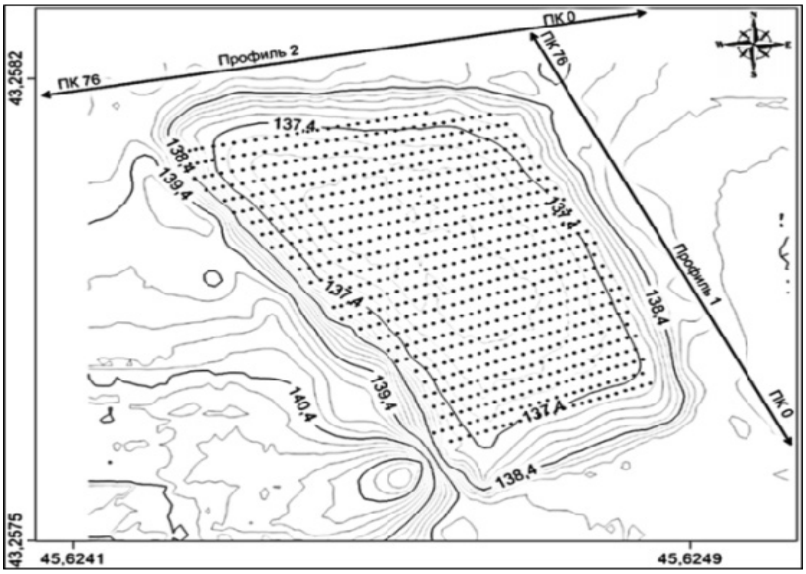


Fig. 1. Diagram of ET profiles and measurement points by the probe of the mini-installation of the VEZ.

To analyze the distribution of electrical resistivity (resistivity) in the sludge storage bowl and assess the filtration properties of its sides for possible leaks, an electrotomography and measurements of the ER were performed using the VEZ probe of a 4-electrode mini-installation Winner with an electrode pitch of 0.1 m. The range of the obtained values of the ER (at depths of 25 and 65 cm from the daytime surface) was 0.5-2 Omm, which is atypical for natural, but typical for man-made ground conditions.

The diagram of the profiles and measurement points is shown in Fig. 1

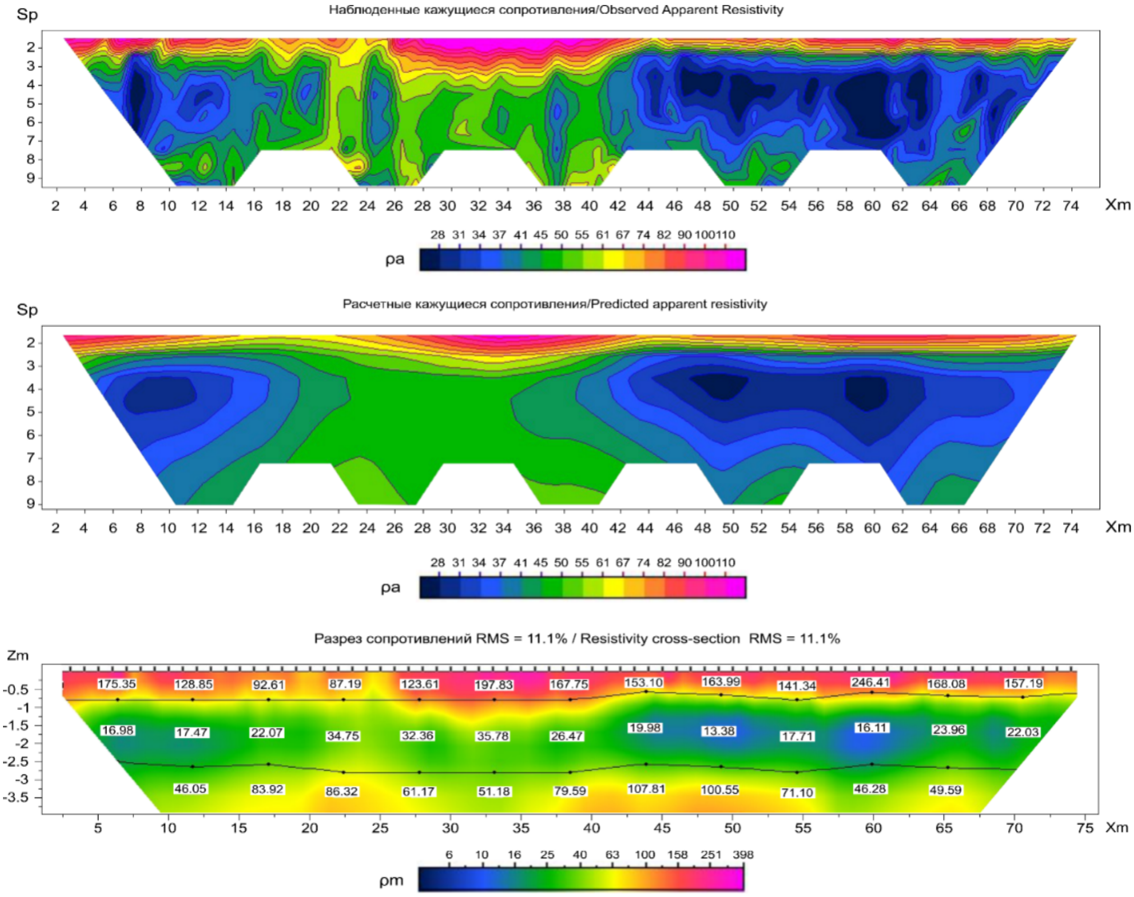
Analysis of the compiled cross-section maps of the distribution of ER at the designated depths revealed a linearly elongated anomaly from the SWW to the NEE in the middle of the bowl of the studied sludge storage (about 1 Omm at both depth levels). This anomaly is more pronounced in contrast at a depth of 65 cm from the daytime surface. Higher (relative to the obtained range, about 1.2-1.6 Omm) ER are confined to the subsurface part, and at a depth of 65 cm are localized in the area of a linearly elongated anomaly. The observed anomaly is probably confined to the internal partition dividing the sludge storage bowl into two almost equal parts, and made, most likely, of clay material.

In the northern part of the bowl, a locally limited anomaly (1 Omm or less) is also recorded, the nature of which can be determined only after drilling holes and sampling for chemical analysis.

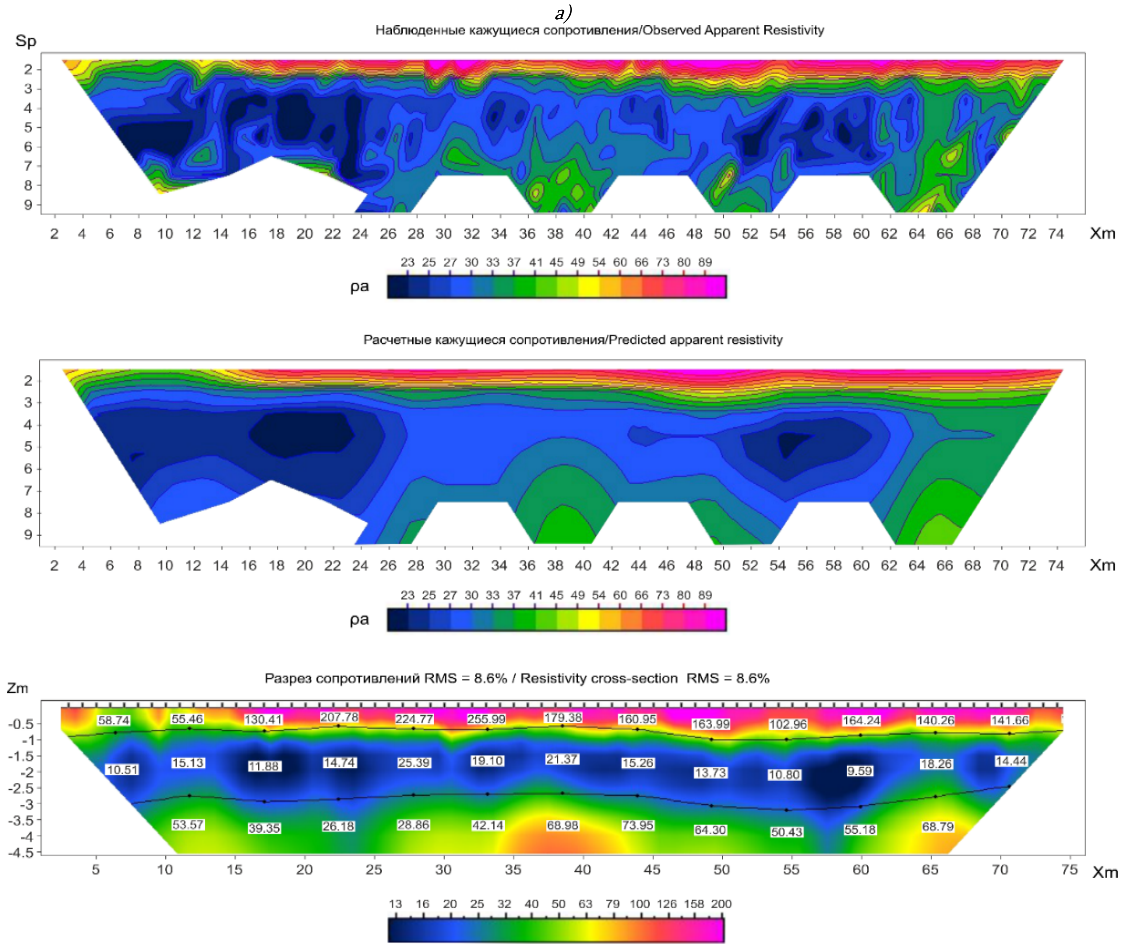
As a result of the inversion of the field data of the electrotomography method, geoelectric sections were obtained (Fig. 2).

On the profiles along the ridges of the eastern and northern sides enclosing the sludge storage bowl, the sections are structurally almost identical to each other. The first layer from the daytime surface of the geoelectric section of the eastern side (Fig. 2, a) has a power of about 0.7-1.0 m. and a ER in the range of 60-250 Omm, the second layer is characterized by a range of ER from 10-35 Omm and a power of about 1.7-2.0 m., the ER of the third layer is in the range of 25-110 Omm. The depth of the study on the eastern side is about 4 m. and on the northern side is about 4.5 m. from the daytime surface.

It should be noted that the ER of the second (10-35 Omm) and third (45-110 Omm) layers on the ET section along the northern side (Fig. 2, b) are on average 1.7 times less than the values of the ER of the same layers (10-20 Omm and 25-75 Omm, respectively) on the ET section of the eastern side.



a)



b)

Fig. 2. Geoelectric sections: a - eastern side; b - northern side.

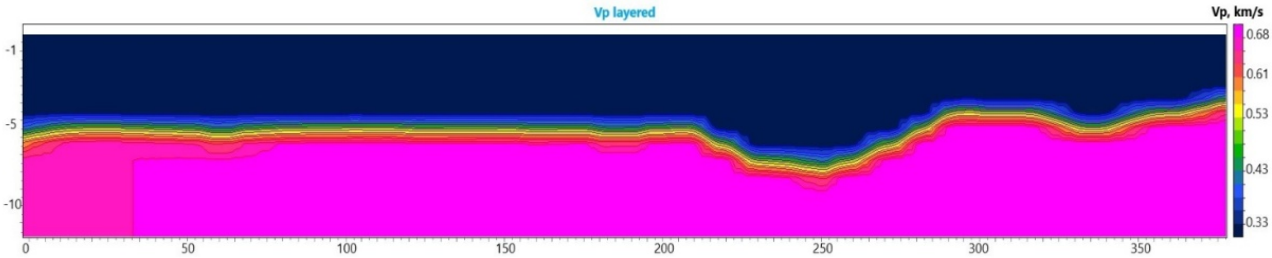
As a result of a visual examination of the physical condition of the sides and the bowl of the studied sludge storage, subsidence of soil was recorded in the storage bowl and on the inside of its sides – along PK 44-65 of the eastern ET profile and along PK 23-57 of the northern ET profile. Taking into account the low values of the ER of the second layer on both ET sections on these pickets, it can be assumed that the water-proof screen in the bodies of the enclosing sides is broken and fluids are migrating from the bowl outside the storage.

Seismic exploration of MRW at the "Carbon farm"

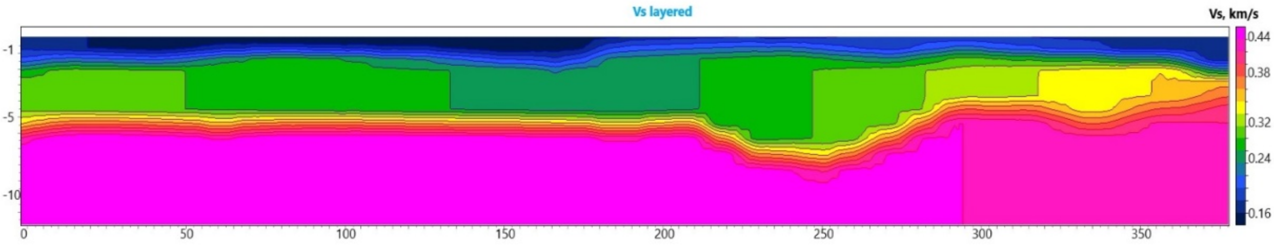
The research site is located on the territory of a former landfill, recultivated by filling waste with soil and planting trees. The objective of the study is to clarify the boundary of the sole of the technogenic soil in order to determine its thickness later. To solve it, seismic exploration by the method of refracted waves (MRW) was carried out. The choice of the method is due to the efficiency of the MRW in solving the problems of identifying shallow boundaries and determining the velocity of individual layers [6].

The seismic survey was carried out in the form of separate seismic sounding according to the profile system. The development of each profile included from three to four arrangements of seismic receivers of 94 meters each. The waves were recorded using a 48-channel linear seismic station LACCOLIT-48M4. The pitch of the seismic receivers was 2 meters, and the total length of the hodograph was 94 m., which made it possible to study the section to a depth of 20 m. In total, 11 physical observations were performed at the pickets of the excitation points. Longitudinal and transverse waves were recorded sequentially. The excitation of seismic waves was carried out by blows of a sledgehammer weighing 8 kg on a metal plate mounted on the ground. Transverse waves were excited by multidirectional impacts on the +YY and –YY system.Observation system – counter and catching up hodographs.

Based on the results of processing, seismic sections of longitudinal (fig. 3, a) and transverse (Fig. 3, b) velocities (Vp and Vs) for each profile are constructed.



a)



b)

Fig. 3. Example of seismic sections of longitudinal (a) and transverse (b) velocities.

The resulting sections clearly reflect the sole of the bulk and the roof of the untouched soil. This boundary is uniquely distinguished by the differentiation of velocities. The boundaries are distinguished by both longitudinal *Vp* and transverse *Vs* velocities, are identical and are observed at the same depth. This, in turn, indicates that the groundwater is located at depths below those studied. On the section constructed according to the transverse velocity data, a bulk layer is also allocated, which was used to seal the waste.

According to the results of the conducted studies, seismic sections were obtained according to the data of registration of longitudinal and transverse velocities, a map of the bulk soil capacity was constructed (Fig. 4).

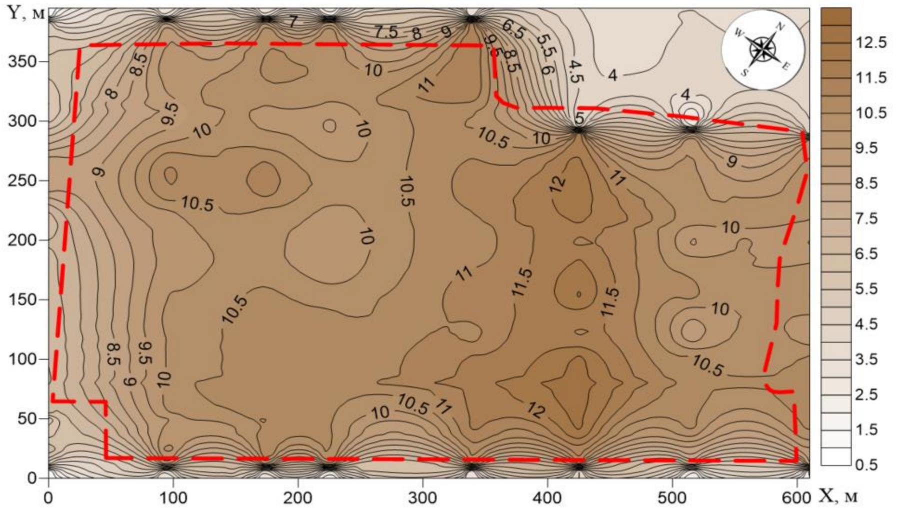


Fig. 4. Map of bulk soil capacity.

Conclusions

Based on the results of electrotomography, the following conclusions were made: 1. The registered values of the ER are typical for sites contaminated with waste from petrochemical production; 2. Two anomalies were identified – a large (linearly elongated) one crossing the storage of waste from petrochemical production in the middle, and a small (locally limited) one in the northern part of the site. The first anomaly with a high degree of probability indicates the presence of a clay partition under the technogenic soil; 3. Subsidence of the soil indicates a violation of the water-proof screen, as a result of which contamination is likely to spread beyond the sludge storage.

The results of seismic studies allow us to draw the following conclusions: 1. The boundaries of undisturbed and man-made soils are confidently distinguished at all sections by the difference in speeds. The velocities of longitudinal waves from 240 to 330 m/s in the field of transverse waves from 110 to 240 m/s are characteristic of technogenic soil; 2. According to the ratio of the magnitude of the velocities to a depth of 11-12 meters, the section appears to be waterless; 3. Comparison of the obtained values of the velocities of technogenic nature with literary sources and the experience of previously performed works indicates the compaction of the layer waste recently, almost to the state of natural soil.

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