Geoecological monitoring of the Khankal field based on thermal infrared imaging

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Abstract. The aim of the work is to review technology for assessing and modeling quality of the environment in industrial zones, the emission of pollutants into the atmosphere based on geographic information systems and environmental modeling taking into account environmental monitoring data. The article presents results obtained by using Geoscan 201 for simultaneous shooting with a Thermophrame-M thermal imager and a visible range camera.

1. Introduction
The Khankala thermal water deposit has been in operation since the 1970. To date, some of the wells have been abandoned or are not in operation. The surviving well stock is used for heating greenhouses. The field is located 10 km southeast of Grozny, the Chechen Republic (Fig. 1).

The thermal groundwater of the Khankala deposit is concentrated in the Middle Miocene Karagan-Chokrak deposits, composed of sandstones and clay interlayers and lenses. In total, there are up to 22 productive formations with a thickness of several to 50–60 m [4, 5].

In 2015, a pilot geothermal station was put into operation on the territory of the Khankal field. It was based on the circulation scheme for using the Earth deep heat (DCS).

The station with a capacity of 8 MW has been in operation since the beginning of 2016. It is based on the circulation system consisting of injection and production wells; recirculation involves the operation of the station with complete injection of water back into the reservoir; the greenhouse system acts as a heat consumer (Fig. 1) [6].

During the operation of thermal groundwater deposits using doublet technology, the main environmental threat is leakage and spills of fluid from the primary circuit. To solve this problem, it is necessary to monitor the field [3].

2. Methods and materials
Environmental monitoring is carried out by field and remote methods. Field (contact) methods include monitoring carried out at stationary observation posts and ground route studies. Remote methods are photo and video shooting, as well as lidar sensing (thermal, infrared, and other types of surveys) Remote methods are widely used to monitor the environment [1, 2, 4].
The dynamic development of unmanned aerial and ground technical equipment and geo-information technologies contributed to the development of alternative methods for monitoring vast territories. One of these methods is the use of unmanned aerial vehicles (UAVs) for aerial photography and creation of digital terrain models [8, 9]. In 2016, monitoring using an UAV equipped with a digital camera and a thermal imager was carried out at the Khankala thermal groundwater deposit and the adjacent territory. Results of photographic, thermal and infrared shooting and their analysis are presented below.

To monitor the Khankala field of thermal underground water, the UAV Geoskan 201 designed for shooting area and extended objects was used. This UAV can be offline for 3 hours, with an average flight speed of 80 km/h. Such parameters allow for observation of a large area. The launch of the drone is carried out using a catapult, the device lands on a parachute. The system is automatic, the ground control panel controls the process at each flight stage.

The UAV can carry up to 1 kg of load.

As a payload, a set consisting of a gyrostabilized optoelectronic system and a thermal imager of 640 × 480, 17 μm, 25 Hz was used.

The parameters are as follows: image expansion is MPEG or H.264, 2-axis stabilization, accuracy of 250 mrad, rotation range in azimuth, unlimited elevation + 10–100°.

Overall dimensions: the diameter of 110 × 144 mm, the weight of 620 g.

The Thermophrame-M thermal imager was used with the visible range camera; the shooting was synchronous. The shooting was carried out in accordance with the algorithms of the GeoScan Planner program, which is part of the UAV ground control station. The images were stitched together using the Agisoft PhotoScan program by the block editing algorithm. The total area of the monitoring site was 3710 m². Along with photographing, the thermal imaging survey of the area was carried out. It took two flights of 2.5 hours to capture the entire area.

3. Results

As a result of heat recording data processing, more than a dozen thermal anomalies were revealed (Fig. 2). Interpretation of the data (forms and temperatures) on the identified anomalies made it possible to determine their sources. [6].

Camera works were followed by the field study of the identified anomalies. The coordinates were determined using the Garmin GPSMAP 64ST GPS navigator. Assessment of reliability of the monitoring results using UAVs was presented below. The results were compared with the results of field studies at the site (Fig. 3).

The above anomaly is due to the spill of hot water. It has a temperature of 50–55 (conventional temperature units) and an isometric shape of 50 × 40 pixels [7].
Figure 2. The photo of the area obtained as a result of heat shooting. Circles mark wells, squares – heat anomalies

Figure 3. Comparative analysis of thermal survey results

4. Conclusion
Studies using UAVs conducted at the Khankal field identified 13 anomalies. The results of the experiment showed the possibility of monitoring exploited deposits of thermal groundwater using an unmanned aerial vehicle and a thermal imager to detect anomalies caused by leaks of old wells and pipelines, draining of used fluid, etc. In addition, the monitoring will allow for timely repair and cleaning works increasing the life of the systems.

Environmental monitoring of the area with operated wells of heat energy water using the UAV Geoskan 201 and a thermal imager showed that it is possible to sort out anomalies and determine the source by shapes and temperatures of the anomaly.

The development of thermal water deposits causes micro-earthquakes, release of hydrothermal steam, spills of thermal water and subsidence. Continuous monitoring of geothermal water deposits and the development of methods for timely assessment of the environment of industrial facilities using remote monitoring data can prevent possible environmental and other risks or eliminate them.

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