# GIS for Environmental Monitoring and Assessment in Mining Regions of Ukraine

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## SUMMARY

Mining regions of Ukraine differ in high indicators of industrial and domestic waste volumes formation as a result of densely located reprocessing (metallurgical, coke, energetic, etc.), industrial and residential objects. Results of the monitoring studies showed that at the current stage military factors increase their destabilizing impact on industrial and domestic waste polygons, potentially hazardous objects (disruption of electricity supply, mine water drainage and ventilation of mines, destruction of defensive hydro-technical constructions, etc.) alongside with the technogenic and natural factors. Authors consider an accelerated improvement of ecological monitoring of the Donbas region and adjacent territories to be possible if, first of all, a complex of the Earth remote sensing technologies (ERS-interferometry, spectrometry, etc.) and operational compilation of eco data through GIS are used. Examples of spreading of the near-earth atmosphere pollution in industrial cities located within the mining regions are shown.

**Introduction**

Donbas territory (Donetsk and Luhansk regions) is one of the biggest in the world complex regional natural and technogenic geosystem in ecological and technogenic terms. Long period of the coal output (more than 150 years), big areas of the subsoil imbalance (up to 15 000 $km^2$.), coal and rocks exemption volumes (9,5-10 bln $m^3$) and sources of explosive methane (up to 6 bln cubic metres per year) under the conditions of spatial distribution up to 4000 of potentially hazardous objects (chemical, metallurgical, etc.) have created a spatial-temporal instability of the environment, which requires quick mapping generalization of ecological parameters of the livelihood.

Furthermore, there are more than 5 bln tons of stored waste in the Donbas mining zone concentrated in tens of polygons, 1570 filtering storage ponds, 1300 waste piles (up to 340 of which burn). In the current circumstances of unregulated mines decommissioning (more than 80%) mostly by the method of "wet conservation" (auto-rehabilitation flooding during the mine water drainage elimination), there is an increase of areas of technogenic lands flooding, activation of the surface subsidence, acceleration of pollution migration in the groundwater flows and the hydrographic network. The specified changes in the engineering-geological conditions at the polygons of industrial and domestic waste degrade exploitation characteristics and increase the risk of emergencies of objective, territorial and regional level.

**Method and Theory**

As can be seen from the monitoring research, at the current stage military factors increase their impact on the polygons of industrial and domestic waste, potentially hazardous objects (disruption of water supply, mine drainage and ventilation of mines, destruction of hydro-technical constructions, etc.) alongside with technogenic and natural ones (storms, high water, flooding, etc.). In our opinion, this requires accelerated improvement of the ecological monitoring of the Donbas region and adjacent territories primarily with the Earth remote sensing technologies (ERS-interferometry, spectrometry, etc.) with an operational compilation of eco data using GIS.

We consider it necessary to note that the above mentioned geospatial impact of the flooding of the mines can significantly worsen the ecological-technogenic state of the industrial and domestic waste polygons and toxic compounds storages (water purification plants with liquid chlorine stock, coke plants, etc.). Additionally, over the recent years, there is an increase of a negative impact of the global climate changes (warming, storms, extensive water saturation and increase of filtrated water, etc.) on the ecological-technogenic balance of the natural-technogenic geosystem (NTGS) "waste polygon-environmental constituents".

**Examples**

Research experience of the Institute of Telecommunications and Global Information Space of the NAS of Ukraine shows that use of the ERS data can facilitate a significant increase of reliability of estimates of the ecological-technogenic conditions of the NTGS "waste polygon-environmental constituents" on the condition of reduction of the geological environment defensive ability as a consequence of the mines and pits flooding (Anpilova et al., 2020; Lukianova et al., 2020; Trofimchuk, 1996; Myrontsov, 2020a, 2020b). These data are characterised by a wide complex of processing and interpretation of images (Trofymchuk et al., 2019a, 2020), among which the following ones can be distinguished for the conditions of mining regions with the mines and pits flooding:

- binding to the relief changes (base maps);
- evaluation of the hydrographic network changes;
- analysis of the water-balance conditions at the boundaries of hydrogeological structures and in the frontiers of the minefields, in the zones of surface and groundwater technogenic nourishment, a connection of tectonic structures and hydrographic network, etc.;
- identification of pollution migration ways in the near-earth air and the hydrographic network.

Review and analysis of various methods of identification of anthropogenic anomalies development processes showed that their dynamics forecasting and complex analysis of heterogeneous data of space-based monitoring of soil pollution by technogenic dust require an approach based on a unified, functionally complete mathematical device, which realises all stages of processing in complex, from

analysis of initial information to receiving the forecast of the researched object further development (Trofymchuk et al., 2019,2019b). At specifying the area boundaries of pollution of the zone of the waste polygons impact and defining tendencies of its geometric characteristics possible changes, as well as pollution concentration measure at receiving forecast it is advisable to use soot in the near-earth air as a decrypting indicator, in particular changes in the colour characteristics of a picture in the area of localized industrial enterprises.

Space images of the territory of Ukraine were made using the Earth remote sensing devices MODIS and used in the project to study the dynamics of the Donetsk region ecological state change. Wind directions schemes were configured in separate areas of the region, chosen as the most typical ones in terms of the ecological impact of the waste polygons (cities of Artemivsk, Donetsk, Kramatorsk, Kostiantynivka, Mariupol), with the help of information about the character of the wind force spreading in the region during the last four years. At that, we took into account that the pollution speed in the near-earth air is maximal (up to tens of kilometres per hour) as compared with the speed of the surface (1-3 km/hour) and underground (0.5-1 km/hour) ones.

As a result of such analysis atmospheric pollution areas were built around the cities, chosen for the research. The built areas are shown in the Fig. 1-4.

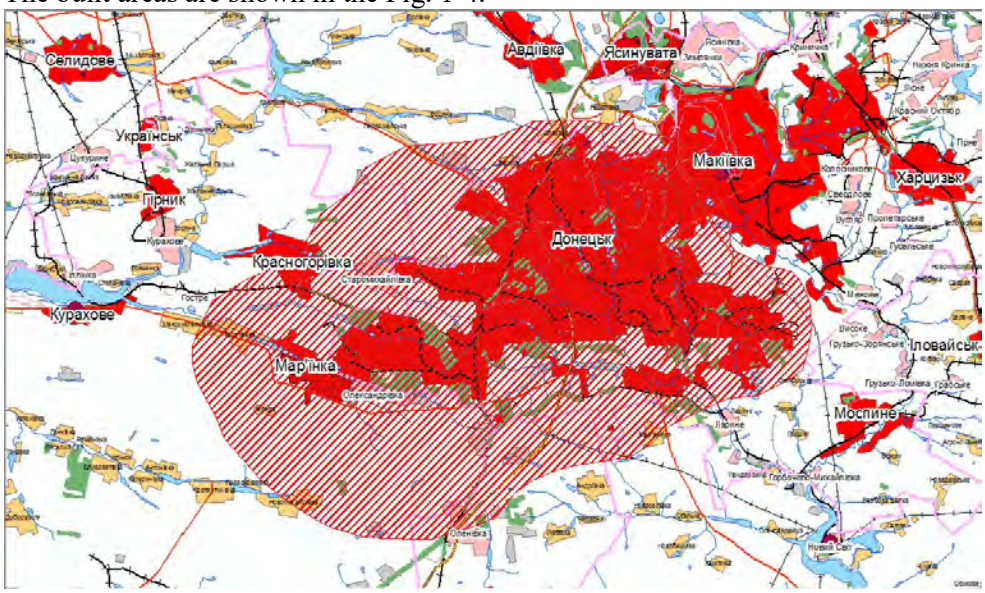


***Figure 1*** *Air pollution areas around the city of Donetsk*

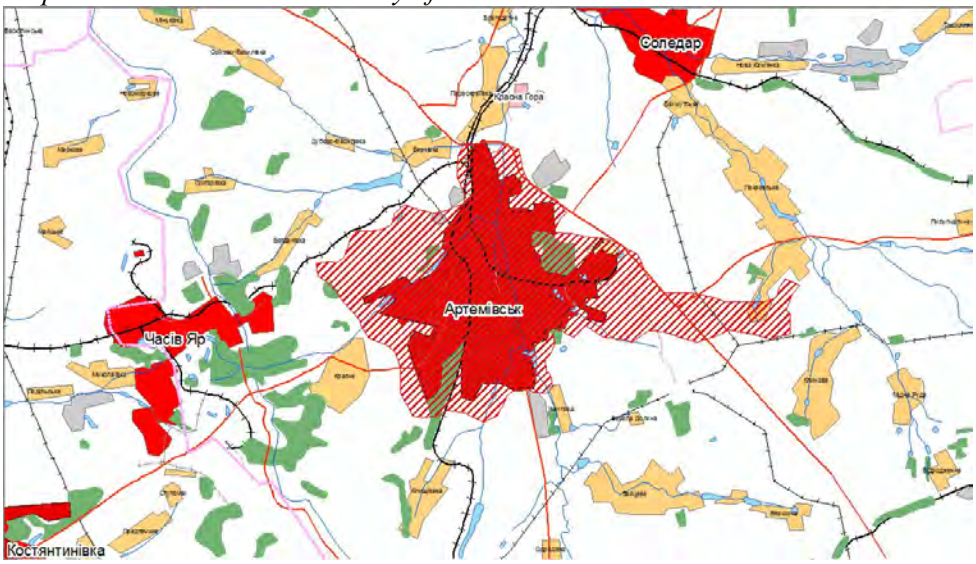


***Figure 2*** *Air pollution areas around the city of Artemivsk*

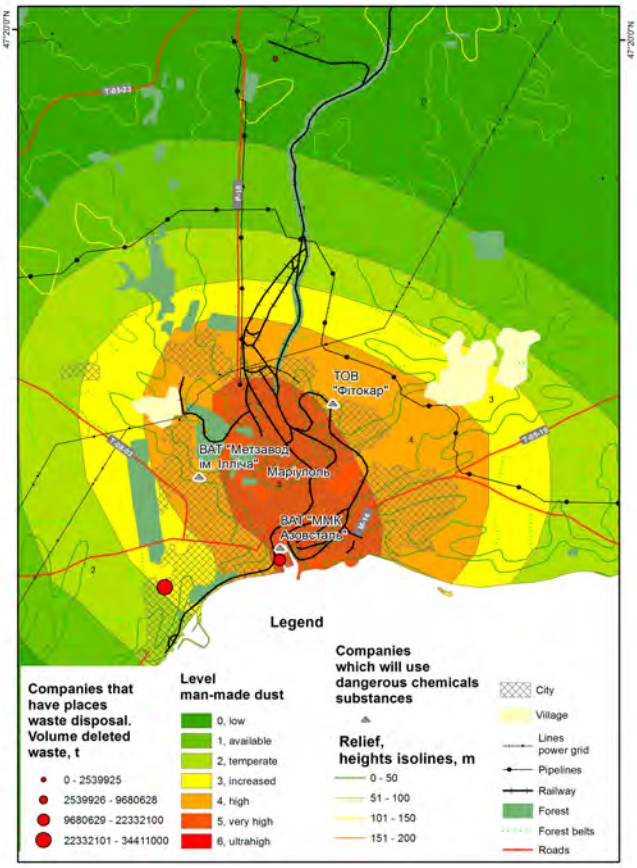


***Figure 3*** *Industrial impact on the region of the city of Mariupol*

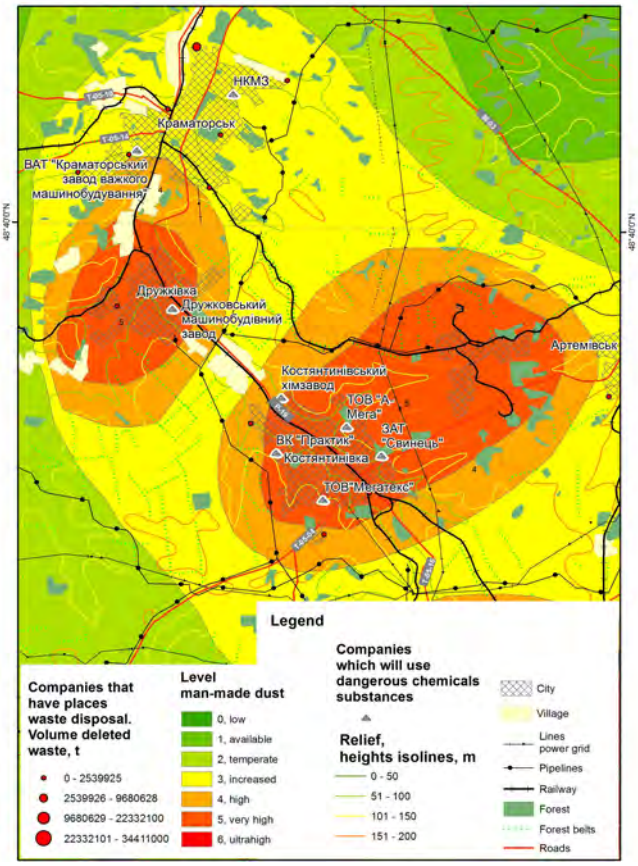


***Figure 4*** *Industrial impact on the region of the cities of Kramatorsk and Kostiantynivka*

**Conclusions**

As a result of the subsoil complex imbalance at the exemption of large volumes of ore-soil raw materials and creation of the "mass shortage", a larger part of ecological-defensive functions of the geological environment is lost. Thus the main task of the post-mining separate measures implementation, aimed at improving the local community safety in the mining regions of Ukraine with a large amount of ecologically hazardous IDWP, can be the following:

- improvement of the main life-support constituents (soil, atmosphere, hydrosphere, subsoil, etc.) changes forecast;
- long-lead development of compensatory models of the IDW polygons ecological-technogenic and social-economical risks reduction in the mining regions of Ukraine taking into account experience of restructuring mining complexes in the EU countries (Germany, Great Britain, etc.);
- improvement of the monitoring structure based on the expansion of evaluating parameters, implementation of mathematical models of a (technogenic-geological system) TGS in the mining regions, use of GIS and ERS (interferometry, spectrometry, etc.) technologies;
- the scientific basis for permissible changes in the ecological parameters of the environmental constituents and long-term safety.

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