Environmental monitoring based on aerospace and terrestrial researches

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SUMMARY

Remote sensing / GIS technologies and contact monitoring are the important parts of man-caused impact to natural and anthropogenic reservoirs rehabilitation capability database creating. The most reliable and precise results are obtained with primary data of multi-zonal space images of high-spatial resolution use.

Introduction

Researchers from different countries use data from remote sensing of the Earth from space to solve the problems of integrated environmental monitoring of territories. S ignificant advantages over ground-based methods are high territorial coverage and the ability to repeatedly re-survey the territory (*Trysnyuk et al., 2019*). To solve the problems of monitoring territories, space survey data is used in the visible, near (Near Infrared, NIR), middle (Short-Wave Infrared, SWIR) and far (Thermal Infrared, TIR) and infrared ranges of the electromagnetic spectrum To sensors that collect data from thermal surveys of average spatial resolution, including ETM+ (Landsat-7 satellite, prz 60 m), ASTER (Terra satellite, PR 90 m), TIRS (satellite Landsat-8, prz 100 m), TM (Landsat-5 satellite, prz 120 m), bird (bird satellite, prz 370 m), prz 548 m), MODIS (Terra, Aqua satellites, Prz 1000 m), AVHRR (NOAA satellites, prz 1100 m), and other satellite Data are used for solving temperature mapping tasks: determining the temperature of the earth's surface; identifying and mapping industrial, agricultural, and forest fires; mapping vegetation cover, thermal observations ;monitoring active fires; climate changes in megacities, and others (*Trofymchuk et al., 2017*).

Method

The purpose of the study is to solve the scientific and practical problem of environmental safety management under the influence of man-made dust pollution of soils and the development of specific technical solutions.

Existing information technology thematic processing of space images can be divided into the following categories: information technology software development of image processing, web technology, data visualization, satellite imaging, information storage technologies, information technology thematic processing of space images.

Operational satellite monitoring of the state of technogenic geo-systems – natural resource management, research of the dynamics of natural processes and phenomena, analysis of the causes of environmental pollution, forecasting of possible consequences and selection of ways to prevent emergency situations are an integral attribute of the methodology for collecting information about the state of the territory that is being studied (country, region, city). This information is necessary for making correct and timely management decisions. To assess the dynamics of ecosystems in the Carpathian region in the conditions of technogenic dust pollution of the air, a GEODATA database was formed, which included satellite images from Landsat 7 spacecraft (Fig. 1a); topographic maps, digital terrain models of various details. Solid particles from coal combustion (ash, coal dust) that were not caught by the gas cleaning equipment settle in a 30-kilometer radius around the station (Fig. 1b) For the Burshtyn TPP, the problem of storing and processing solid waste – fuel slag and ash – that remains after burning coal in the TPP furnaces is extremely urgent. The results of monitoring made it necessary to establish the actual conditions for the formation and manifestations of environmental hazards of this subspecies, taking into account the sources of secondary dust pollution of the air. Failure to take into account the sources of secondary dust pollution when monitoring the state of environmental hazards (which is currently observed everywhere) does not allow to objectively assess the contribution of this subspecies to the formation of environmental hazards at the regional level. Express assessment of the contribution of sources of air pollution to the formation of the level of man-made danger is based on the numerical values of the indicator

$$T = K_T \cdot K_{KM} \cdot K_p \cdot \left\{ \frac{\sum_{i=1}^{N} K_{ui} \cdot a_i \cdot M_i}{N} \right\}, \quad (1)$$

where T is an indicator of man-caused hazards generated by factors of dust pollution of atmospheric air;

T - regional coefficient of economic differentiation of the territory;

K_T - coefficient depending on the number of inhabitants exposed to man-made hazards;

K_{KM} - coefficient that takes into account the terrain;

K_p - coefficient, which depends on the characteristics of emission sources;

K_{ui} - an indicator that reflects the degree of negative impact of the unit of mass of a particular ingredient contained in emissions into the atmosphere on the environment;

a_i - annual mass of ingredients contained in emissions into M_i the atmosphere, t / year;

N is the number of ingredients.

a ***b***

Figure 1 *a - Satellite image from the Landsat 7; b –Nitrogen dioxide from the Burshtyn TPP causes smog*

The methodological approach to the study of the impact of dust pollution factors on the health of the population is that a quantitative spatio-temporal characterization of the manifestations of environmental hazards in the areas under study and the study of public health.

In order to establish the main characteristics of previously unrecorded sources of dust pollution, experimental studies were conducted in the laboratory and by field observations. The most significant factors affecting the quantitative indicators of the volume of dust intake from these sources of pollution are the dispersion of dust particles, wind speed, atmospheric humidity, precipitation (in the form of rain and sleet) (*Trofimchuk et al., 2013*).

At wind speeds of 7-10 m / s, the time required to restore dust blowing from the surface of storage areas varies slightly and is about 3 hours. At a relative humidity of 99%, the intensity of dust blowing is reduced by 25%.

Sulfurous anhydride in atmospheric air enters into chemical reactions with water and can already be shed with rain on the ground in the form of acids. Now, sulfur dioxide emissions are an acute problem and do not meet European standards (*Okhariev and Trysnyuk, 2019*). Carbon monoxide increases the greenhouse effect.

Remote sensing / GIS technologies and on-ground works are the important parts of anthropogenic impact to natural and anthropogenic reservoirs rehabilitation capability database creating (*Myrontsov, 2020a; 2020b*). The most reliable and precise results are obtained with primary data of multi-zonal space images of high-spatial resolution use. Dniester canyon limnological eco-system was used as an example for developing algorithms of identifying anomalies on satellite images (*Trysnyuk, et al., 2019)*. These algorithms were used for measuring ecological indicators of eutrophication in water reservoirs, ponds, lakes including those that relate to natural parks and recreational zones.

Based on the analysis of the state of pollution of the surface layer of the atmosphere within the zones of residential development, an unacceptable state of environmental danger in relation to this factor (on average, by years, the concentration of dust exceeds 1.3 times).

During comprehensive assessment of techno-natural geosystems pollution, regional specializations of pollution were researched. Also, medical-ecological parameters of pollution on the territory were characterized; statistical dependence between the concentrations of trace elements in soils, in water resources, population morbidity and mortality was established. Functional dependences simulating these relations, based on mathematical model, were found.

Environmental safety management system for geosystems is provided by creating rational "structures" which include:

- Establishing of territorial organization;

- Choice of forms and types with taking into account the peculiarities of environmental risks for ecosystems;
- Variable actions to prevent environmental threats.

For example, in agriculture drone using helps to save time and money by farmland monitoring. It is right technique to replace traditional land bypassing on their distance controlling. There are some advantages of remote sensing method for agricultural land monitoring:

- Higher accuracy. Ability to determine the spatial variability of soil indicators and their dynamics accurately and continuously, at each point of agricultural land; less significant loss of information during processing and mapping;
- Awareness. Ability of results to cover larger areas;
- Efficiency. Ability to make land monitoring quickly and operational; possibility to adjust the continuous monitoring of soil indicators.

At the regional level risk analysis involves analysis of threats which determine indicators of environmental safety of the region. As theoretical basis for environmental safety assessment we can choose theory of reliability, according to which emergency situations should be considered as "failure" of system element that leads to malfunction of their stability (*Trofymchuk et al., 2019*)

In general, environmental safety management is a complex, multi-stage process which requires proper technical equipment and theoretical justification. More details of its algorithm presented in Fig. 3. Determining hazardous factors is to identify and pre-assess the degree of pollution elements danger those are specific to a particular territory. These include the following: radiation, chemical substance, solid materials (cement, asbestos etc.). During the objects and source of danger inventory we must determine not only the source of pollution, but also the channels of their inflow into the ecosystem, separately into the atmosphere, soil, water reservoirs, and organic life. This is necessary for further effective monitoring, without which it is practically impossible to manage environmental safety. Receiving of the receptor monitoring points can be substantiated only on the basis of modeling, based on various methods.

The total number of monitoring points predominantly depends on the area of research, on concentration and exposures of pollution elements on different territories, on economic capabilities of monitoring organization (*Anpilova et al., 2020; Lukianova et al., 2020; Trofymchuk et al., 2019, 2020*).

Receptor points are differentiated according to criteria of carcinogenicity for evaluation of the morbidity and mortality from the individual and total influence of the contamination elements. This stage of research requires the large massive of information obtained on the previous stages. For some cases, additional research is necessary.

Proper objectivity during the classification is provided by a comprehensive synthesis of on-ground measurements, methods of mathematical modelling and remote sensing technologies in conjunction with active use of geographic information technologies. It should be attend to the implementation of remote sensing / GIS-technologies, as far as the methodology of space images decoding is universal. Use of these capabilities allows automating the process of assessment and forecasting the current ecological situation within a specialized geographic information system of a region (*Trofymchuk et al., 2014*). Analysis of information and methodological support structure shows that environmental monitoring is just one of the elements of data collection and processing units about the ecological situation and natural resources use. At the regional level, it is necessary to create an integrated information and analytical system for local authorities. It has to be including in its structure:

- System of environmental monitoring (both departmental and interdepartmental);
- Inventory system for different types of natural resources;
- Environmental forecasting system to prevent emergency situations of anthropogenic origin.

To solve problems related to environmental sustainability of territories, it is necessary to apply a system-wide approach which taking into account the presence lots of anthropogenic impact factors. A significant part of environmental problems associates with inefficient decision-making system, lack of information about key ecological indicators, lack of coordination between different sections of the environmental monitoring system.

Conclusions

Identification of the structure of causal relationship between anthropogenic impact and sustainable development of geosystems is the most important factor which determines a possibility of regional environmental management successful execution. Structure and nature of such causal relationships can be determined by ecological classification of the territories. They reflect unicity of natural conditions and economic features of social development in area of research.

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