PROBLEMS OF IMPROVEMENT OF METJODS AND INSTRUMENTAL SUPPORT OF ECOLOGICAL DIAGNOSTICS

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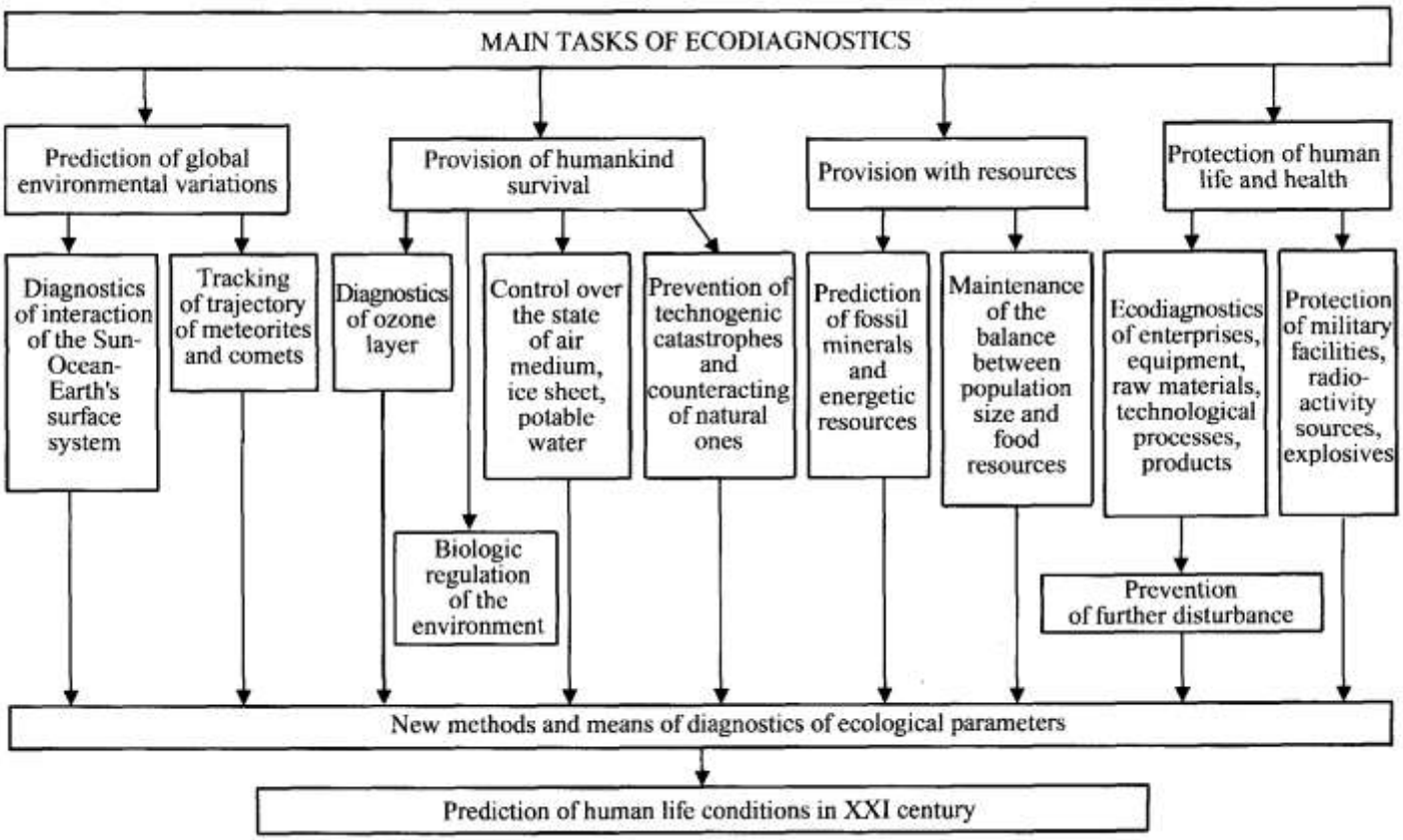
The present report is especially topical when in April 2010 the eruption of a volcano in Iceland seized the entire air traffic in Europe for two weeks. The event concurred with publication of the special reference book called "Ecological testing. Nondestructive testing volume 2" for 10th ECNDT 2010.Ecodiagnostics uses results of multiannual statistical ecological researches, which make it possible to determine the natural environment state favorable for ecosphere, as well as space and internal Earth processes, and to elaborate mathematical processes of these states.



I. DIAGNOSTICS OF EARTHQUAKES

Seismic risk grows constantly due to unrestrained industrialization and urbanization of seismically active territories. Reduction of the damage from earthquakes is related closely with solution of the earthquakes diagnostics problem - prediction of their place, time and intensity. Problem of the earthquake prediction is stated as an estimation of probability that earthquake of magnitude exceeding some threshold M_0 will occur in the given area S within the time $t,t+T$. Depending on length of the period of time T, following types of forecast are distinguished: long-term (years); medium-term (months); short-term (weeks, days). Earthquakes were preceded by squally wind, fog, drought, airglow, special behavior of animals, variations of the output of springs and water taste.

There were more than 150 methods of revealing individual precursory effects, approximately 30 ones were selected by the results of experiments and recommended for introduction into the Federal system of seismologic observations and earthquake prediction**.**

General requirements to observation points are as follows: low noise level of surface sources; high sensitivity to the earthquake preparation processes.
Instrumental equipment of combined observation point includes:
• seismic and acoustic sensors;
• equipment for precision geodetic measurements;
• tiltmeters and deformographs;
• gravimeters;
• magnetometers and sensors of natural electric field;
• sensors for borehole measurements of the water temperature level;
• geochemical sensors.

Efficient methods of the long-term prediction of earthquakes are developed with the series of successful forecasts implemented. Medium-term prediction is also performed efficiently. It is confirmed by successful forecasts in regions with dense network of seismic and special combined geophysical and hydrogeochemical observations-domestic and global seismology possesses with positive experience.

Short-term prediction represents maximal difficulty. It is related in considerable degree with the fact that short-term precursors of earthquakes are mostly volatile in spatial manifestation.

II. RADIATION ECOLOGICAL MONITORING

Radioactivity means spontaneous transformation of the substance nuclei accompanies by emission of ionizing radiation in the form of corpuscular particles of photons.

All main problems of radiation control are resolved by measurements of two types:
1) monitoring - regular (constant) observations over radiation situation in order to determine (control) the dynamics of its variation, reveal abnormalities for operative intervention and estimate the state of radiation safety for territories and population;
2) measurements in order to prevent exceeding of norms (control levels).

The most important characteristics of a dosimeter are: operation range of gamma-radiation energies; range of measured doses; and main error.

III. CHEMICAL-ANALYTICAL ECOLOGIC DIAGNOSTICS (CAED)

Application stages and a field of chemical products are presented below:

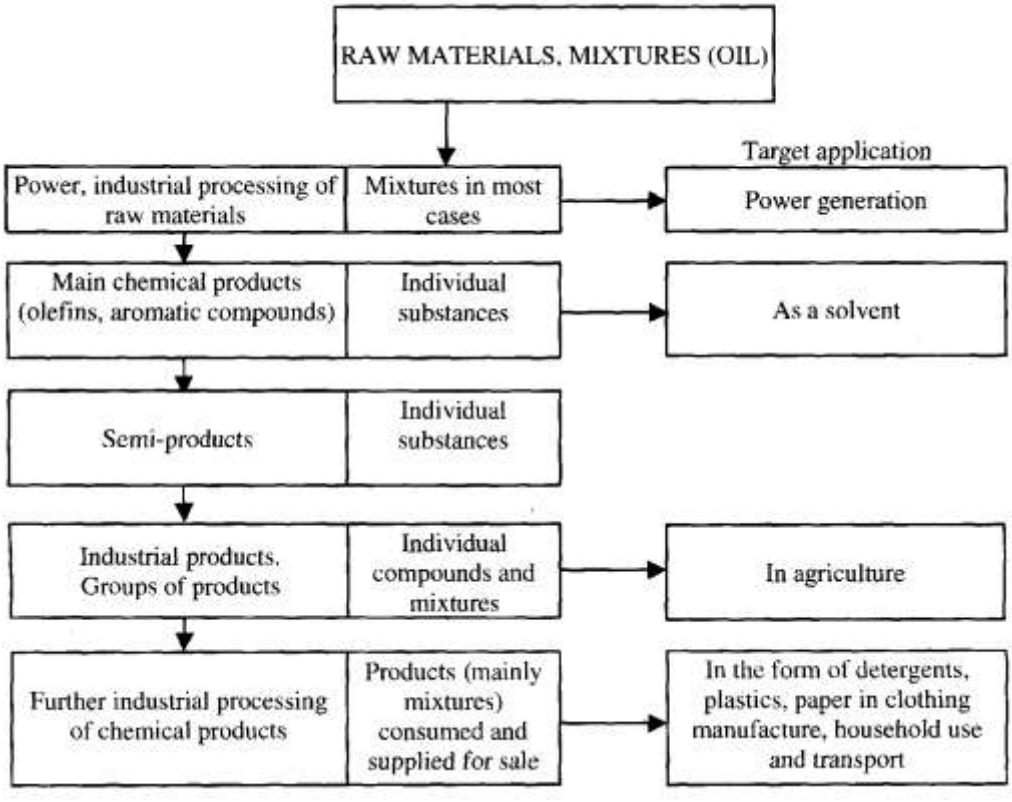
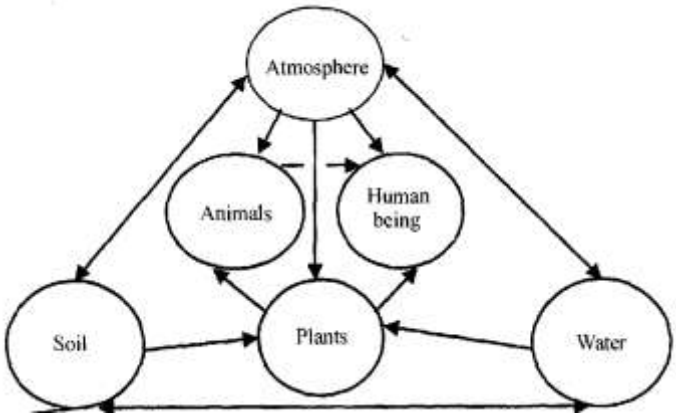


Diagram of substance transfer processes in the ecosphere. Chemical compounds are distributed between air, water and soil in accordance with their physic-chemical properties; moreover, environmental factors play, of course, the decisive role.



Today, CAED direction possesses in general with more than 1,000 types of instruments and measurement channels, as well as more than 2,000 diagnostic techniques and methods.
CAED is used for solution of problems of two types: control of micro-components of national and global importance (high-priority components) and control of micro-components of regional (local) importance (low-priority components).

Main CAED media, diagnostic parameters and methods

Diagnostics parameters	CAED method
Soil	
Pesticides, petroleum products, benzene, betanol, copper, zinc, radionuclides, lead, chromium, cadmium, phenol, etc	Atomic absorption spectroscopy; liquid and thin-layer chromatography; inversion volt-ammetry; polarographic method.
Atmosphere	
Sulfurous anhydride, nitrogen dioxide, nitrogen oxide, barium carbonate, benzapyrene, butyl chloride, hexene, cadmium oxide, phenol, chlorine, copper oxide, etc	Electrochemical method; gas and ionexchange chromatography; luminescent, photometric and photocalorimetric methods
Hydrosphere	
Benzene; ethyl benzene; propyl benzene; hexahydrophenol; phenol; radionuclides; oil and petroleum products; ethylbenzene lano-lin; toluene; coliphages; coliform bacteria in general; mobility, temperature certification, transparency, salinity, acidity of aquatic medium; microbiogenic parameters, etc	Infrared and ultraviolet spectroscopy; roent-genofluorescent, optic-acoustic, atomic emission and atomic-absorption spectroscopy; mass-spectrometry
Biotics	
Disturbance of luminous balance; moisture deficit; availability of atmospheric precipitations; wind streams; microbiogenic and zoogenic factors.	Titrimetric, gravimetric, turbidimetric, con-ductometric, densitometric methods; NMR-spectrometry; bioluminescent and nephelometric methods

IV. OPTICAL ECOLOGICAL MONITORING

Two features are common for all optical methods employed in the ecological monitoring practice. Firstly, optical cross-sections of radiation interaction with aerosol/gas components in the earth atmosphere in many cases are of extremely high values, therefore the optical methods have the exclusively highest sensitivity rating. Secondly, interaction of optical radiation with the environment does not affect the environment, therefore the optical methods relate to non-destructive atmospheric pollution monitoring techniques.

The **LIDAR** (Light Detection and Ranging) is a remote sensing laser system. The lidar methods of atmospheric air pollution monitoring are considered active optical remote sensing techniques. They use the effect of laser radiation scattering and absorption on the air components. To this end a laser pulse is transmitted into the atmosphere to receive a backscattered pulse after its interaction with the air components. Since the atmosphere is a spatially distributed medium the propagating laser light wave interacts with the air components continuously.

To this end, single- and double frequency polarization are the most common practice.
Among the standard atmospheric parameters measured with rawinsondes and meteorological rockets The parameter of moisture content m the atmosphere is measured the least accurately especially at negative ambient temperatures that are characteristic of the upper atmosphere.
Lidar wind speed measurement technologies are progressively developed. Laser wind speed remote sensing techniques provide for detecting the movements of natural optical scatters (aerosols, molecules and in-homogeneities of their properties) blown away by the wind.
Currently two laser wind-speed measuring methods are developed in parallel, viz.

Photoelectric methods and instruments are based on measuring the light scattering properties of certain aerosol particles. The established relationships provide transition to basic characteristics of aerosols (concentrations, size distribution function, average size, etc.). Instruments employing this approach are called aerosol photoelectric spectrometers.

During remote sensing, the spectra of electromagnetic radiation received from the monitored atmosphere volume are the carriers of information on the quality and amount of pollutant gases in the air. There are various types of this kind of spectra: absorption spectra (electronic, vibration-rotation and rotation), combination scattering spectra, fluorescence spectra and emission spectra.
Measurements are taken in spectral intervals corresponding to atmospheric relative and transparency windows covering the range from 200 nm to several microwaves.

The remote-sensing method plays an important role in ecological monitoring of land surface including geological and urban land use survey, crop salvage, crop forecasts, and assessment of flood, earthquake, volcanic eruption, forest and subsurface fire consequences.
There are three land surface ecological monitoring methods:

1. monitoring of natural radiation of the studied land surface;
2. monitoring of scattered solar radiation;
3. use of active emission of lidars, lasers, etc.

The remote sensing of water pollution should tackle the following problems:
- detecting pollution, i.e. establishing the fact of pollution existence. In this case, it is desirable to document the pollution fact to be able to lodge a claim with the polluter;
- mapping pollution, i.e. establishing the boundaries and area of a polluted section;
- determining the pollution film thickness;
- determining the film age, i.e. the time which passed from spillage to detection; and
- identification, i.e. determining the type of the spilled oil product or any other pollutant.

V. ULTRAVIOLET ENVIRONMENTAL DIAGNOSTICS

Ultraviolet radiation accounts for less than 5 % of total solar radiation; however, its role in the vital activity processes is disproportionately big. This is due to the fact that UV radiation has a profound impact on diverse biological and chemical processes, with the effectiveness of such impact depending on the wave length.

The monitoring of UV radiation flows should take into account the aerosol abatement effect. In individual regions, industrial aerosols and gases may affect the UV climate.

The optical ozone measurement techniques are based on the ozone molecule being capable of absorbing radiation in the UV region of the spectrum.

VI. THERMAL ECOLOGICAL MONITORING (TEM)

TEM is based on the registration of the temperature field anomalies in the ecological system entities caused by deviations from their standard existence conditions in a natural environment.

The main thermal monitoring problems are listed below:

- acquiring and integrating temperature mode data for ecological system entities specific to their normal existence; and
- establishing the reasons for ecosystem temperature regime deviations from the standard conditions, determining the degree of their danger and predictability of unfavorable ecosystem development scenarios based on such deviations, such as failure, breakdown, etc.

VII. RADIOWAVE METHODS OF ECOLOGICAL DIAGNOSTICS

Microwave remote sensing of the Earth's land layer, atmosphere and world ocean basins is based on recording intrinsic or reflected and scattered electromagnetic radiation.

Electromagnetic radiation waves (or frequencies) used for remote sensing in the environmental monitoring systems occupy a wide portion of the spectrum ranging from 0.3 μm to 1.3 m, which is further subdivided into the following ranges: near ultraviolet (UV, 0.3...0.4 μm), visible (0.4...0.76 μm), near infrared (IF, 0.76... 1.5 μm), medium and far (IR 1.5 μm...l mm), and microwave (1 mm... 1.3 m)

Remote monitoring is aimed at evaluating biological productivity, understanding interactions in the soil-plant-atmosphere system, calculating dynamics of biomes, modeling biogeochemical cycles with consideration for the role of vegetation and also at managing plant resources.

VIII. BIOLOGICAL DIAGNOSTICS

Biological systems are represented by biological objects of various complexities (cells and tissues, organs, systems of organs and organisms, biocenoses and ecosystems, including the biosphere in general) that have as usual several levels of structure-functional organization. Defined as the complex of interrelated and interconnected elements, the biological systems have the properties of integrity (do not reduce the system properties to a sum of properties of system elements), relative stability and adaptability to the environment, as well as development potency, self-reproduction and evolution ability.

Alongside with the biotesting there are special methods for complex habitat diagnostics that include morphogenic (gene analysis, morphological and biochemical measurements, etc.), biophysical and biochemical methods (bioluminescence, photosynthetic activity, etc.), bioenergy and immunodetection methods, toxicological and embryological methods, population and ecosystem methods. Since the biological methods provide for reliable evaluation of habitat quality and, what is

more important, its suitability for life, biodiagnostics should remain an obligatory component of the complex habitat appraisal procedure.

Many biological methods are sufficiently supported with instrumentation and software. They are successfully employed for monitoring of air, water and ground habitats.

A key technique of biological system state tracking is the monitoring.

The biological monitoring is a procedure used to track biological diversity, i.e. existence of species, their population and condition, emergence of species alien to the given ecosystems, etc.

The biomonitoring technique uses bio-indicators for habitat appraisal. *The bioindicators* are organisms or communities of organisms, which presence, quantity and development features tell us about natural processes, conditions and anthropogenic changes in habitats.

Bioluminescence is the phenomenon of live organism luminescence associated with the life activity in this organism, and predetermined by enzymic oxidation of special substances, i.e. luciferins, in the majority of species.

The bio-energetic methods are used to detect deterioration of environment quality whilst the pollution impact on the organism is not yet irrevocable. The bio-energetic methods are built upon a concept that any physiological process needs energy. The amount of energy spent by organisms on all physiological processes in a unit of time reflects the intensity of energy metabolism. This effect may be measured by a recpirometry technique.

There is a wide variety of instruments used for biodiagnostics. In many respects they are similar to those used by the analytical methods of habitat monitoring.

The test-System ECOLYUM is a set of special reagents (biosensors) prepared on the basis of sea luminescent bacteria cultivated in the laboratory conditions, and luminometers specially designed for this system. A parameter measured with this system is bioluminescence in the visible spectrum.

CONCLUSION

Solution of scientific and technical problems includes study of physical, chemical and analytical methods and creation of adequate means and system of ecological diagnostics, elaboration of technology designing of equipment, selection of delivery and communication means, creation of software and hardware for data acquisition, processing and recording, compilation of forecasts for natural disasters and evaluation the service life of ecologically hazardous-production facilities.

In the author’s opinion modernization of outdated equipment by means of development of new methods are application of informational technologies, recovery and development of ground-based seismic stations, systems of the remote sensing of the Earth, aerospace monitoring and creation of infrastructure for user access to satellite data ranges among problems of instrumental support of ecological diagnostics.