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MODERN COMPREHENSIVE INFORMATION SYSTEM FOR ENVIRONMENTAL QUALITY MONITORING

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Abstract. The threat to ecological balance can turn into a global problem, and we observe its deviations, which arise as a result of complex relationships between natural and social environments. Direct and indirect human impact on Earth's ecosystems together and interdependently form the planet's ecosystem, resulting in changes in the social environment of a human. Today's global problems are increasingly shifting to the side of developing countries, where environmental pressure is increasing because along with "pre-industrial" pollution, a new one is emerging, related to the invasion of multinational corporations and "exports" of polluting industries to "third world" countries. Modern "industrial" pollution in developing countries is the result of the transfer of many polluting industries to the "third world", such as the construction of enterprises, chemical plants, chemicalization of agriculture. Due to this, the concentration of the population in the largest agglomerations is growing.

Keywords: ecosystem, environmental problem, pollution, ecological monitoring, anthropogenic factors, eco-business.

1. Introduction

In developed countries, awareness of the environmental problem has led to the greening of economic development in industry. This is reflected in the fact that the costs of the state and monopolies on environmental protection have increased sharply; the production of cleaning equipment was established. "Ecoindustry", "eco-business" arose as the concepts of the international market of environment-friendly equipment and environment-friendly products. The system of laws and organizations on environmental protection is formed, the design of the program of ecological development of separate countries and regions is developed; international coordination in environmental protection has intensified (Delden, Whigham, 2013; Palaniappan et al., 2021).

Sustainable industrial development is impossible without the creation of a system that monitors the safe operation of hazardous industrial facilities, especially biotechnology facilities, and the state of the environment in their areas. This system is called the system of environmental monitoring and provides the accumulation, systematization and analysis of information on the condition of the environment; the reasons for the observed and probable changes in its condition (i.e. the sources and factors influencing the environment); permissibility of changes and loads on the components of the natural environment; existing biosphere reserves (Zheng, Hong, 2014; Jenifer et al., 2012).

The traditional way to get the prerequisite knowledge for PA depends on labor intensive and subjective investigation, which consumes a large amount of human time and financial resources. Since remote sensing (RS) allows for a high frequency of information gathering without making physical contact at a low cost (Spong et al., 2016), it has been widely used as a powerful tool for rapid, accurate and dynamic agriculture applications (Arasteh,et al., 2016; Augusto, McCullagh, J., 2007). RS data are mainly collected by three kinds of platforms, i.e., spaceborne, airborne, and ground-based (Spong et al., 2016). Spaceborne includes satellite RS and can provide large-scale spatial coverage, but can suffer from fixed and long revisit periods and cloud occlusion, limiting its application for fine-scale PA (Baggio 2005; Bahrepour et al., 2010). Additionally, relatively low

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spatial and temporal resolution and high equipment costs become critical bottlenecks (Srinivas,et al., 2019). Ground-based remote sensors (onboard vehicles, ships, fixed or movable elevated platforms) are suitable for small scale monitoring. In comparison, airborne platforms can collect data with high spatial resolution and flexibility in terms of flight configurations such as observation angles, flight routes (Augusto, McCullagh, J., 2007). An unmanned aerial vehicle (UAV) is a powered, aerial vehicle without any human operator, which can fly autonomously or be controlled remotely with various payloads (Jhansi Rani, et al., 2020). Due to their advantages in terms of flexible data acquisition and high spatial resolution (Anitha et al., 2020), UAVs are quickly evolving and provide a powerful technical approach for many applications in PA, for example, crop state mapping, crop yield prediction, diseases detection, weed management rapidly and nondestructively.

Ecological monitoring is carried out in order to monitor the condition of the environment, including the areas of sources of anthropogenic impact; assessment and forecast of changes in the condition of the environment under the influence of natural and anthropogenic factors; ensuring the needs of the state, legal entities and individuals in reliable information about the condition of the environment and its changes, which is necessary to prevent and (or) reduce the adverse effects of these changes.

Particular attention in the organization of environmental monitoring is paid to biological methods. In its essence, monitoring is a high-tech, intelligent (in modern terminology) system that involves optimization and allows to get the most complete and reliable information about the state of the environment for a minimum of funds involved.

Recently, scientific and technological progress has had an extremely negative impact on the environment. Various types of environmental pollution are of concern to environmentalists. The problem of environmental protection has become very relevant for many industrialized countries. In such a situation, it is necessary to establish large-scale and effective control of nature in megacities, near environmentally hazardous facilities, and this will be the basis for environmental safety and sustainable development.

Information about the state of the natural environment is necessary for our daily life, for farming, construction, and in case of emergency. Moreover, the change in the state of nature occurs not only under the influence of natural processes but also human activity has a negative impact on nature. The need to predict anthropogenic changes in nature is a very specific task.

In the modern world, climate change is regularly monitored. These are meteorological, phenological, seismological and other types of environmental observations. The range of nature observations has expanded, the number of measured parameters has increased, and more observation stations have appeared. The problems of environmental monitoring have become more complex.

Environmental monitoring is a regular observation of the natural environment according to a given program, observation of natural resources, flora and fauna, which allows determining their condition and changes that occur under the influence of anthropogenic activities..

The idea of the need for systematic collection, storage and processing of data on the condition of the environment was finally formed in the late 1960s. The concept of "monitoring" is interpreted as a comprehensive system of observation, assessment and forecasting of changes in the state of the environment under the influence of anthropogenic factors at a conference on environmental protection under the auspices of the UN in Stockholm in 1972. Now it is interpreted as a set of territorially and chronologically organized observations of the components of the biosphere.

The creation and operation of a monitoring system to integrate environmental information systems covering certain areas are based on the principles of:

– consistency of regulatory, legal, organizational and methodological support, compatibility of hardware, information and software of its components;

– systematic observations of the condition of the environment and man-made objects that affect it;

– timeliness of receipt, the complexity of processing and use of environmental information received and stored in the monitoring system;

– objectivity of primary, analytical and forecast environmental information and the efficiency of informing public authorities, local governments, public organizations, mass media, the population of Ukraine, stakeholders among international organizations and the world community.

The monitoring system is aimed at:

– increasing the level of study and knowledge about the ecological condition of the environment;

– improving the efficiency and quality of information services to users at all levels;

– improving the quality of justification of environmental measures and the effectiveness of their implementation;

– promoting the development of international cooperation in the field of environmental protection, rational use of natural resources and environmental safety.

2. Research results

Monitoring includes the following procedures: identification of the object of observation; inspection of the object of observation; compilation of an information model for the object of observation; measurement planning; assessment of the state of the object and identification of its information model; forecasting changes in the state of the object; providing the users with information in a convenient form, as well as informing the consumer.

The nature and mechanism of generalization of information about the ecology of the environment are determined using the information portrait of the ecological situation. An information portrait of the ecological situation is graphically presented, spatially distributed data that characterize the ecology of a certain area, with a map of the area.

The Global Environment Monitoring System (GEMS) under the auspices of the United Nations consists of 5 subsystems: the study of climate change, long-distance transfer of environmentally harmful substances, hygienic aspects of the environment, exploration of the oceans, and land resources. The main purpose of monitoring is a new level of competence in decision-making at the local, regional and global scales.

Given the above issues, an important role is played by environmental quality monitoring systems, methods of control and management of environmental conditions. Modern capabilities and development of information and analytical, software, hardware and methodological support of multilevel environmental monitoring systems are the most important and effective mechanisms for comprehensive structural assessment of environmental quality and forecasting the scale and levels of man-made impact on natural objects, architecture and infrastructure, living creatures and territories. Many countries, especially the highly developed ones, have realized the danger of environmental catastrophe and are investing in improving the environmental safety of industry, agriculture and utilities, although none of these countries has achieved this goal: the impact of high-tech economies on the environment is changing. In any case, it does not decrease, but more often becomes more dangerous, including the population of the planet growth, causing the growth of consumption and the need for quantitative growth of all types of production, which serves as a basis for a new impetus to population growth.

The article focuses on considering the methodologies, scientific basis, IT background of implementation and functioning of information complex systems for monitoring the condition of environmental quality.

It is necessary to point out that the system of monitoring anthropogenic changes in the natural environment is not a new system that requires the organization of new observation stations, telecommunication lines, data centres, etc. It is an integral part of the universal system of observation and control of the environment. The system is already quite developed in many countries. The study considered by the authors is a superstructure over all existing systems and algorithms.

In each country, the integrated monitoring system is based on existing monitoring systems, which often reflect, to some extent, the organizational structure of economic management in the country. However, the most important features of monitoring in different countries should be the same. There should be a single concept of monitoring, including observations, assessment and forecast of the environment, universalization of measurements, a single definition of priority in the observations of the state of the environment.

Monitoring systems are traditionally divided into subsystems by environments and territories.

The monitoring system works at the following levels:

• impact (study of strong influences at a local level);

• regional (problems of migration, the transformation of pollutants, joint action of various factors specific to the region's economy);

• background (in biosphere reserves, where economic activity is excluded).

Comprehensive monitoring is carried out in order to combine a number of programs of different types of monitoring for a comprehensive assessment of some problems of environmental pollution:

1) global, i.e. affecting most of the earth's surface; an example is the effect of the release of carbon dioxide and chlorofluorocarbons;

2) regional, i.e. those that affect neighbouring groups of countries, such as transboundary migration of pollutants through the air and rivers, marine pollution, degeneration of tropical forests;

3) local, i.e. those related to a relatively small area, although they may occur in many places. Urban air pollution, drinking water pollution, heavy metal pollution and the disappearance of the soil layer could be mentioned as an example.

Accordingly, the monitoring system can cover both local areas and the globe as a whole (global or background monitoring). The main feature of the global monitoring system is the ability to assess the state of the biosphere on a global scale based on the data from this system.

A monitoring system within one state is usually called national monitoring. Such a system differs from global monitoring not only in scale but also in that the main task of national monitoring is to obtain information and assess the state of the environment in the national interest. Thus, increasing the level of air pollution in individual cities or industrial areas may not be significant for assessing the state of the biosphere on a global scale, but is an important issue for action in this area, action at the national level.

Monitoring systems used in the interests of several states are sometimes called multinational or international monitoring. Such systems are often used when considering the transfer of pollution between states. Impact or local monitoring is carried out in areas of a high level of anthropogenic impact at a local level. Monitoring systems can also be classified by objects and methods of observation. The main types of monitoring systems and their characteristics are described in Table 1.

Table 1

Types of monitoring and their characteristics

Class	Type	Purpose
On the scale of generalization of information	Global	Monitoring of global processes and phenomena in the Earth's biosphere, including all environmental components. Prevention of emerging extreme situations.
	National	Monitoring of processes and phenomena within the country, including all environmental components. Gathering and analysis of information, forecasting the state of the environment and warning of possible extreme situations
	Regional	Monitoring of processes and phenomena within a region, where these processes and phenomena may differ in nature from the basic background characteristic of the biosphere.
	Local	Monitoring of anthropogenic impacts at the local level.
According to the methods of conducting	Biological	Monitoring with bioindicators.
	Aeronautical	Carried out from airplanes, helicopters, other aircrafts within the troposphere.
	Space	Monitoring with space surveillance.
	Remote	A set of aviation and space monitoring. Sometimes this concept includes observation of the environment with the help of devices installed in hard-to-reach places of the Earth, the data of which are transmitted by long-distance transmission of information (by radio, via satellites in computer networks).
According to the objects under observation	Monitoring of the environment and its objects: – atmosphere; – hydrosphere; – lithosphere.	Monitoring the state of the environment and warning of critical situations that are harmful or dangerous to human health and other living organisms
	Biological	Monitoring of biological objects, the presence of species, their condition, the appearance of random ingredients, etc.

Thus, monitoring is a multi-purpose information system. Its main tasks are monitoring the state of the biosphere, assessing and forecasting its state, determining the degree of anthropogenic impact on the environment, identifying factors and sources of such impact, as well as the degree of their impact.

The following information is required to develop an environmental monitoring project:

– sources of pollutants in nature. These include: emissions of pollutants into the atmosphere by industry, energy facilities, transportation facilities, and other facilities; discharges of wastewater into water bodies; surface washes of pollutants and biogenic substances into surface waters of land and sea; introduction into the earth's surface and soil layer of pollutants and nutrients with fertilizers and pesticides used in agriculture; burial and storage of industrial and municipal waste; man-made accidents that lead to the release of hazardous substances into the atmosphere and the spillage of liquid pollutants and hazardous substances, etc.;

– transfer of pollutants as the process of atmospheric transfer, as well as the process of transfer in the aquatic environment;

– the process of landscape-geochemical redistribution of pollutants, i.e. the migration of pollutants in the soil layer to groundwater; migration of pollutants by landscape-geochemical profile considering geochemical barriers and biochemical cycles; biochemical cycle, etc.;

– data on the state of anthropogenic emission sources, i.e. the capacity of emission sources, their location, hydrodynamic conditions of entry into nature.

Let’s consider a universal scheme of information system for monitoring the condition of the environment, that is suitable for the system as a whole and any geophysical service included in this system (hydrometeorological service or pollution monitoring system, i.e. monitoring of pollution or monitoring of anthropogenic changes in the biosphere).

The most universal approach to determining the structure of the system for monitoring anthropogenic changes in the natural environment is its division into

blocks: “Observation”, “Assessment of the actual state”, “Forecast of the state”, “Assessment of the forecasted condition”. Existing geophysical services were built according to the same scheme (Fig. 1).

The “Observation” and “Forecast” blocks are closely related, as the forecast of the condition of the environment is possible only if there is sufficiently representative information about the actual state.

On the other hand, the direction of the forecast should largely determine the structure and composition of the observation network.

Data characterizing the state of the environment, obtained as a result of observations or forecasts, should be evaluated depending on the area of human activity where they are used (using specially selected or developed criteria). The assessment implies, on the one hand, the determination of damage from the impact, on the other hand, the choice of optimal conditions for human activity, the definition of existing environmental reserves. Such assessments imply knowledge of the permissible loads on the environment.

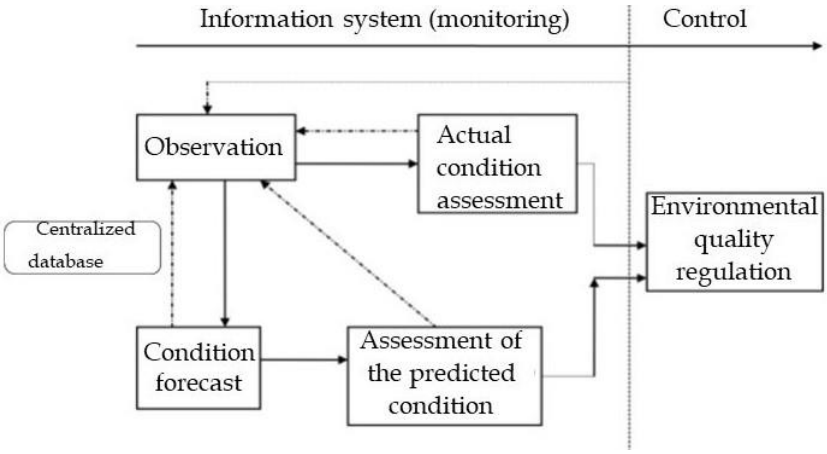

Fig. 1. Block diagram of the monitiring system

The system of ecological monitoring is a necessary condition for the correct organization of environmental quality management.

The developed system of robots includes embedded hardware, software and similar components of the Internet of Things (IoT). The system style in Fig. 1 shows a block representation of IoT and also has a built-in system of robots based on ARM. The whole automated system consists of 2 components:

• Preparation of the monitoring system: this system is designed to collect the relevant information coming from the sensor, as well as for sending the received information to the IoT system.

• Navigation and control of the system: the key function of a specific system is navigation and additional control of the automatic system according to the appendix.

Due to the low cost of implementation, IoT is a great innovation for monitoring the influence of harmful events or continuous problems on humans. Virtually any type of monitoring could be grouped into 2 types: event detection (ED) and spatial process estimation (SPE). Surprisingly, sensors are used to accurately detect an event (for example, a forest fire, an earthquake, a temperature change in a greenhouse, etc.). Attributes of excellent sensor evaluation include:

• Physical aspects: consists of light and resistant to ultraviolet radiation two-coordinate accelerometers, biaxial magnetometers of radiation levels, frequency waves and microwaves, humidity, temperature, air pressure, smoke and dust, area and speed measurement, audio, acoustics, online recording of video, as well as images, earthquakes, physical exertion, in addition to the blast wave.

• Measurement of entirely natural and chemical compounds: for example, maximum permissible standards or even measurement of the content of impurities of compounds or measurement of focuses on a particular composition.

• The scale of activities: for example, the size of the sanitary protection zone, life perspectives (corporate and environmental management), current activities or tasks of ordinary people's life (for example, cyber-level concerns, monitoring of internal and external factors, etc.). Although IoT is used in various fields, the planning of these networks for a particular of these uses improves or balances several important elements. In addition, the combination of styles of each element is combined with the corresponding functions used in many places. Compliance with the levels may exceed the extremely high environmental requirements of the Internet of Things.

Innovative monitoring systems are built using the achievements of the latest technical and industrial revolution in the IoT (Internet of Things – IoT). The use

of IoT in monitoring systems allows you to quickly obtain data from devices, stationary and mobile laboratories, instant real-time display and the ability to connect to any system and site.

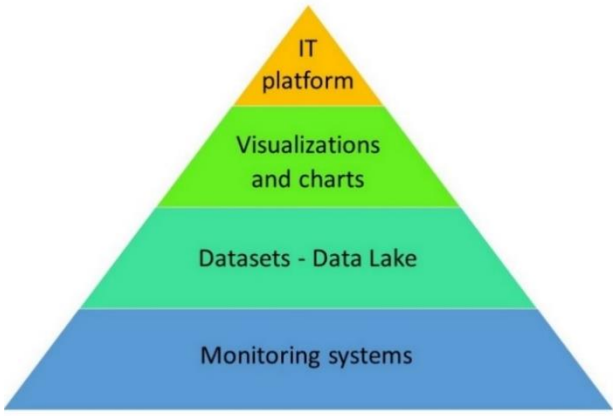

Fig. 2. Visual image of the hierarchy of the monitoring system

3. Conclusions

In fact, a change in temperature changes people and all pests; the resistance to organic threats increases due to changes in the atmosphere, such as cyclones, floods, droughts, landslides, forest fires, and specific earthquakes. Wireless sensor units detect various weather components, including temperature, CO_2 level, wind speed, wind orientation, ground heat level, light intensity, humidity, etc. The monitoring sensor on a temporary moving object is an advanced tool in mobile automated stations for monitoring the state of the environment. It performs preliminary operations together with existing remote detection files in combination with the added compilations of geospatial information (GPS and GTM and GSM spots) as details to determine the expected results and conditions of the environment (including pollution levels), as well as rapid notification strategies, especially when exceeding the permissible levels. For example, the GlacsWeb was organized to monitor icebergs in Norway using a one-hop sensor network of eight elements installed inside icebergs, on and under them. The method of monitoring the improvement of weather conditions can be extended to obtain a weather forecast in the city, as well as globally by studying the actual tracked files. Weather plays an important role in the development of animals, along with the strength and abilities of creatures that anticipate weather conditions, which, for example, are accompanied by a strong storm. For example, Ghobakhlou et al. introduced a standard for the use of IoT for farm administrations to limit problems with vegetable freezing.

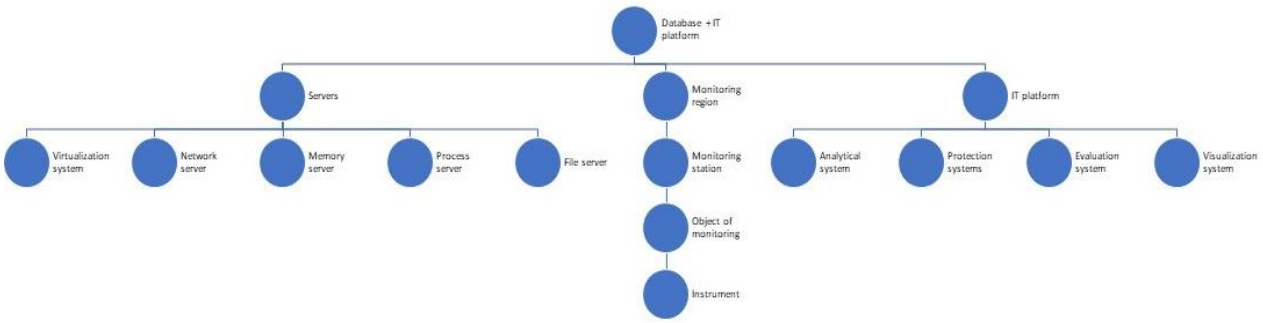

Fig. 3. The structure of the modern monitoring system

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