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# INFORMATION SUPPORT FOR AUTOMATIC INDUSTRIAL ENVIRONMENT MONITORING SYSTEMS

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*Abstract*—*Results of industrial environment monitoring system development with relative software are presented. Information and analytical support algorithms for automatic control for industrial environment monitoring were developed also. The analytical support system for continuous information receiving and processing on the base of indicators changes reflecting the environmental condition of the coal region was elaborated; some practical ecological proposals were done.*

**Index Terms**—Automatic control systems; analytical system; monitoring; emission sources; coal mining; environmental impact.

## I. INTRODUCTION

Coal industry is important branch of Ukrainian industry being the main source of domestic energy resources. Coal mines and related enterprises are localized predominantly at Donbas industrial region of Ukraine. From year to year the number of problems in coal industry there grows dramatically; a lot of them are linked with pollution of environment. Some of such problems are result of the low technical and technological level of this branch causing negative influence on environment [1]. Due to the fact that coal mining activities have significant environmental consequences, it requires constant monitoring of pollutant emissions (PE) in environment as well as monitoring of ecological state of surroundings aimed on the prevention of irreversible processes and negative influence on human health.

Law of Ukraine "On Protection of Natural Environment" (article 20, 22) allows the development of environmental monitoring system and carrying out of the environmental condition observations. According to this law environmental monitoring has to be performed at local, regional and national levels with centralized data storage.

Therefore, for the estimation of ecological environment state primarily it is necessary to ensure the continued receipt and processing of information about changes of some indicators that characterize negative anthropogenic pressure. Such indicators we defined in result of our analysis (see below), they reflect the situation with environment pollution of the region. Accordingly, there is a need for special information-analytical systems and software for processing and analysis of quantitative monitoring indicators of coal mines hazardous substances emissions and registering of the ecological state of environment.

## II. PROBLEM STATEMENT

*The purpose of research* is to determine the areas of information-analytical basis improvement of environment monitoring system during the removing of mines from service (by example of ambient air). In order to track the ambient air condition parameters and to determine substances harmful for the life of population we decided to develop technical system for pollution monitoring. So, we have to suggest information-analytical indicators monitoring system for control of environmental characteristics for regions with coal industry in Ukraine.

According to abovementioned, we set and solved following problems:

• coal industry state in general and its current problems were examined;

• problems of information and analytical support for monitoring system were studied;

• we suggested some grounds aimed on ecology defense in process of mines removing from service.

*The object of the study* is the mine and its surrounding as a chain of coal industry of Ukraine.

*The subject of the study* is a set of scientific, methodological and applied aspects for monitoring and environmental grounds of mines removed from service.

## III. PROBLEM SOLUTION

Atmospheric air is a vital component of environment, the quality of which influences significantly on the public health, especially in mining towns and settlements where 70% of Donbas population is concentrated. As impact indicators of atmosphere

quality monitoring during coal mine functioning and closure we picked up such pollutant emissions as ozone, sulfur dioxide, nitrogen dioxide, nitrous oxide, methane. Nevertheless of the decline of coal enterprises quantity, significant changes of coalmines impact on the atmosphere were not registered [1], [3].

Pollutant levels registration is fulfilled in manual mode in Ukraine now. We suggest the way of new technical monitoring system development for the solution of environmental pollution problem in industrial regions of Ukraine.

IV. RESULTS. DEVELOPMENT OF ENVIRONMENTAL MONITORING SYSTEM AND ITS ANALYTICAL SUPPORT (BY THE EXAMPLE OF AMBIENT AIR)

In regions with highly developed coal industry there are a lot of objects – sources of pollution, including air pollution. On Figure 1 one can see the total number of coal industry pollutants sources before the military conflict at the east of Ukraine, ATO (antiterrorist operation); data are given according to "UkrNDIproekt" institute information [3].

Figure 2 demonstrates atmosphere pollutant emissions as amount of emitted pollutants during the year (firm and gaseous). There Kt signifies kilotons of pollutants near active sources of pollution: coal mines, enterprises etc. during few years of monitoring. From this diagram one can notice that amount of emissions increased during the period 2009–2013 due to the growing of intensity of coal mining activity. Further since 2013 emission reduction was registered. This fact may be explained by two factors - the use of new equipment for water treatment sys-

tems and the failure to provide data on coal enterprises emissions.

Monitoring of environment safety state and level of pollution in industrial regions using technical systems for pollutant monitoring is a widely spread practice in contemporary world.

That is why in order to track the ambient air condition parameters and to determine substances harmful for the life of population we tried to develop technical system for pollution monitoring. Actually, we suggested information-analytical indicators monitoring system (IAMS-1) for control of environmental characteristics for regions with coal industry in Ukraine (at Ukrainian state controlled territory). As basic characteristics we picked up coal industry pollutants emissions characteristics into the atmosphere.

The system IAMS-1 allows conducting constant supervision, to obtain quickly impartial information about the amount and composition of the most important pollutants in emissions to the environment and to respond effectively to any changes that are observed in coal regions during periods of coalmines operation and closure.

On Fig. 3 the system IAMS-1 structure is suggested. System IAMS-1 consists of some blocks (Fig. 3) that allow to process information and air parameters.

On Figure 4 is shown an example of possible data input/output document format. In this form may be input different characteristics of environment pollution in coalmining region. Filling system information is provided by entering and editing data unit; where there is the ability to import parameters from widespread file formats (for example, .xls. to speed up the process) (Fig. 4).
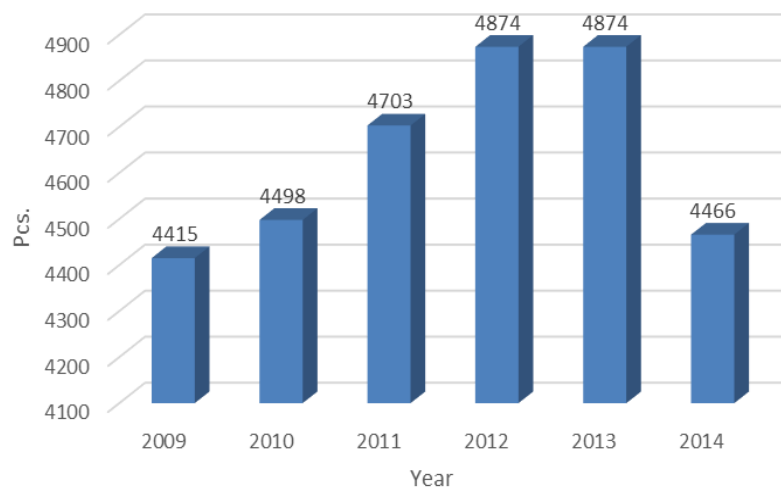


Fig. 1. Total number of the coal industry pollutants sources before the ATO according to data of "UkrNDIproekt" institute (vertical dimension – number of active sources of air pollution: coal mines, enterprises etc.; horizontal dimension – year of registration)
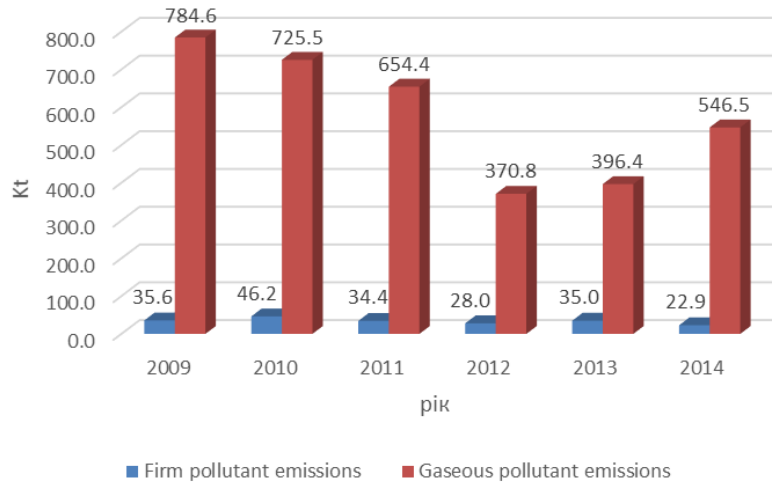
Fig. 2. Atmosphere pollutant emissions (vertical dimension – amount of emitted pollutants during the year (firm and gaseous) Kt – kilotons near active sources of pollution: coal mines, enterprises etc.; horizontal dimension – year of registration)
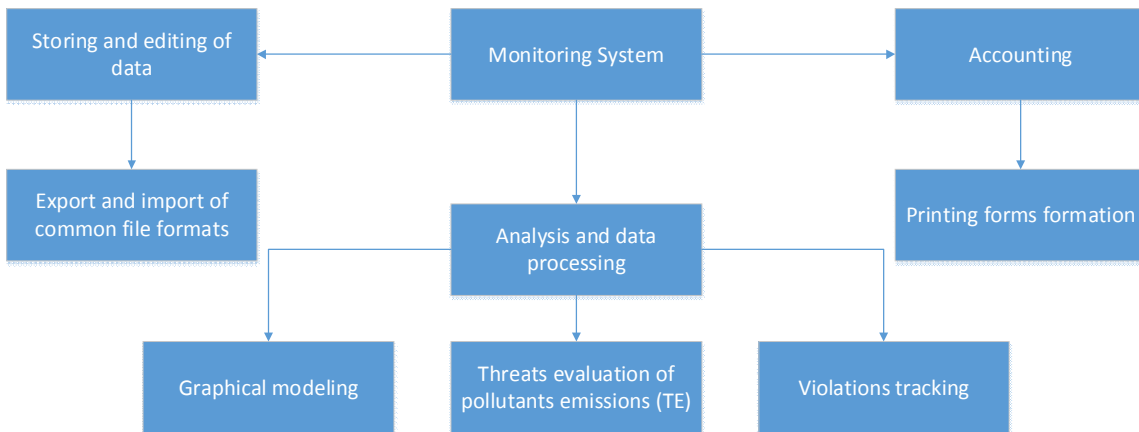


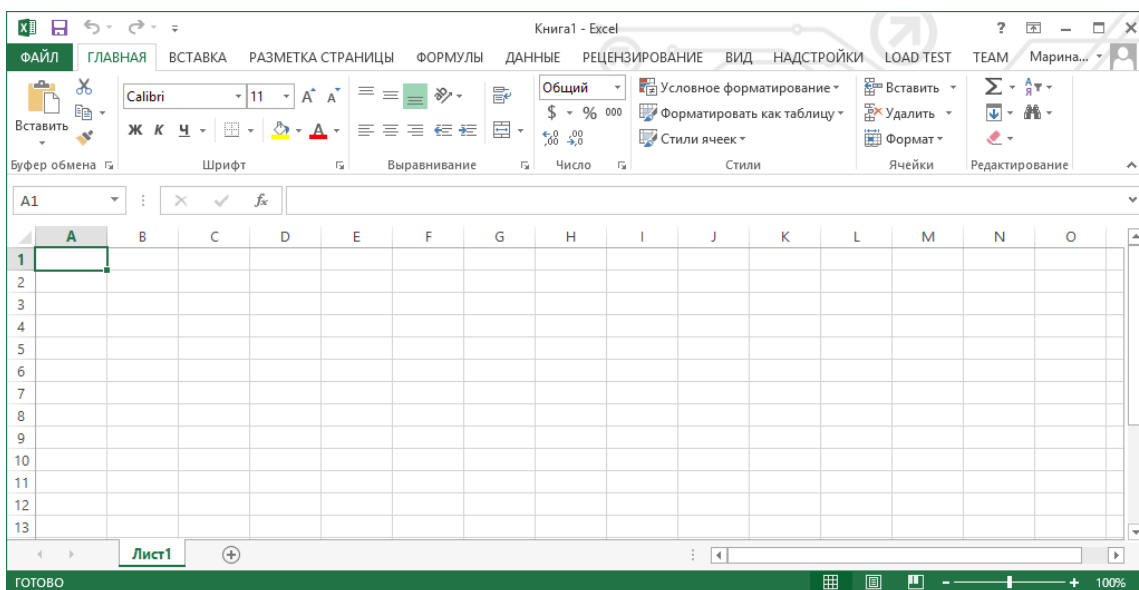Fig. 1. The general scheme of IAMS-1 system structure



Fig. 4. Data input/output: an example of document format .xls. In this form may be input different characteristics of environment pollution in coalmining region

The data stored in IAMS-1 system can be analyzed using the integrated functionality, such as graphical representation of data, threats evaluation (TE) and tracking pollutants emissions violations.

Graphical interface demonstrates comfortably the emissions amount changes at the mine or in a particular region during the period specified by user. Results can be viewed in a bar chart or graph.

Graphical interface also helps the user in environmental problems solution. Such functions as tracking pollutants emissions standards violations and TE for individual coal regions in the system are realized through using block "Analysis and data processing" (see Fig. 3).

At the end of analysis, it is necessary to determine which of the elements has the most significant influence on the general condition. Depending on the outcome of the overall situation, evaluation decisions about the impact on the most important elements may be taken.

*Expert systems*. The expert system is a computer system, which combines the possibilities of computer and human professional experience; such expert system by itself can suggest a standard way to solve some problems. An additional comfortable feature of expert system is its ability to explain the algorithm of its functioning in form understandable for user [4].

The main components of expert systems are *the knowledge base* and *the logical conclusions mechanism*. The presentation of factual knowledge often uses a separate mechanism - *database* and in the knowledge base only procedural knowledge is remained.

Danger and risk expert systems assessment are in need of development and improvement of new methods for emergency origin risk assessment, which would give an opportunity to solve comprehensively existing problems, and to provide a flexible models algorithms selection structure for correct system structure representation based on existing mathematics. An example is a system of integrated environmental TE (see Fig. 3).

On Figure 5 environment state violation actions hierarchy is shown. With aim to estimate the risk of technological processes of coal manufacturing influence on environment state (by example of ambient air pollution) and for determination of priority areas of pollutant emissions we have analyzed impact of different environmental pollutants. On the base of such analysis we have determined the complex hierarchy of such pollutants by their influence on environment state (Fig. 5).
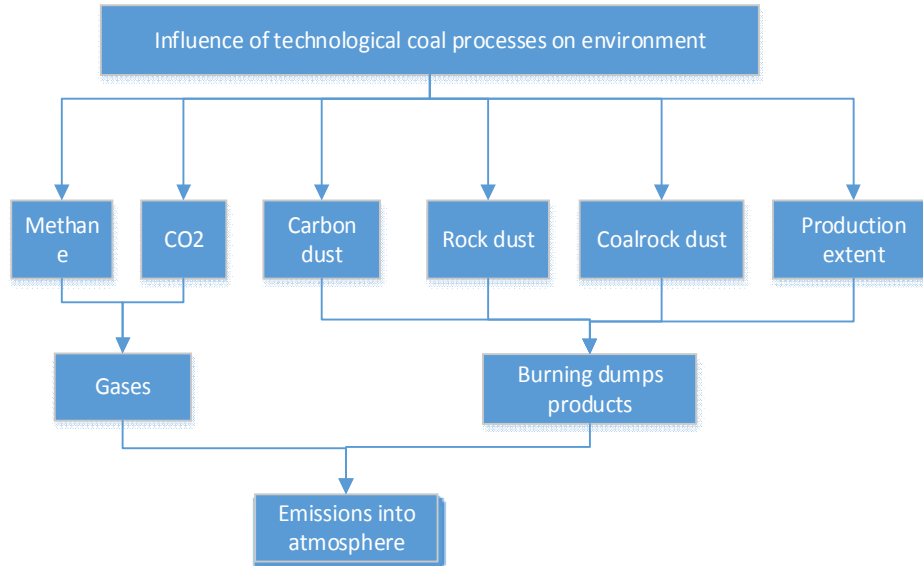


Fig. 5. Environment state violation actions hierarchy

*Algorithm for threats evaluation on environment*.

Because degrees of different factors influence on environment are different, it is rather important to estimate the risk for the nature for each factor. As algorithm for the risk estimation we picked up contemporarily widely used approach – T. L. Saaty algorithm of hierarchy analysis for decision making [5]. According to this method for the estimation of priorities of different factors influence on environ-

ment it is necessary to make a matrix for comparison of pairs of analyzed factors (criteria), formula that suggested for further analysis is [5]:

$$A_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}}.$$

where $A_i$ is the degree of *i*th factor (criterion) influence on environment in percents in comparison with

other factors (criteria); $\prod_{j}^{n}$ is the multiplication of elements in matrix of comparison; $a_{ij}$ is the element in matrix for comparison of pairs; $n$ is the number of factors (criteria).

The evaluation results or selected by the user air data parameters may be output for the formation of printing forms, which are proposed to print or to save in computer memory.

## V. CONCLUSION

1. The areas of information-analytical basis improvement of environment monitoring system during the removing of mines from service (by example of ambient air) were determined.

2. In order to track the ambient air condition parameters and to determine substances harmful for the life of population we developed technical system for pollution monitoring IAMS-1.

3. IAMS-1 system can be used for the registration of information-analytical indicators for control of environmental characteristics in regions with coal industry of Ukraine.

4. Suggested technical information-analytical system for monitoring of environment allows ones to collect and to store observations data, to analyze parameters of pollutants emissions into the ambient air.

5. As one of IAMS-1 blocks the expert system was developed; it helps to identify pollutants, to estimate exposure levels, and to determine respec-

tive measures for prevention negative changes of environment in compliance with environmental safety norms.

6. In present work were shown that the total number of coal industry pollutant sources has remained almost unchanged during 2009–2014 that coincided with results in [1], [3]. As explanation of this fact we suppose that main impact in Donbas environment pollution is occurred by coal dumps influence.

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**С. А. Плахотній, О. М. Ключко, М. В. Кротінова. Інформаційне забезпечення систем автоматичного керування моніторингом довкілля в промисловості**
Представлено результати з розробки інструментальних підходів для інформаційної підтримки системи моніторингу довкілля в промисловості. Розроблено інформаційно-аналітичні алгоритми для автоматичного управління в галузі промислового моніторингу навколишнього середовища. Розроблено аналітичну підтримку для безпере-

рвного прийому та обробки інформації на основі показників, що відображають зміни екологічного стану у регіоні видобутку вугілля і надано деякі практичні екологічні пропозиції.

**Ключові слова:** автоматизовані системи управління; аналітична система; моніторинг; джерела викидів; видобуток вугілля; вплив на навколишнє середовище.

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**С. А. Плахотний, Е. М. Ключко, М. В. Кротинова. Информационное обеспечение систем автоматического управления мониторингом окружающей среды в промышленности**

Представлены результаты по разработке инструментальных подходов для информационной поддержки системы мониторинга окружающей среды в промышленности. Разработаны информационно-аналитические алгоритмы для автоматического управления в области промышленного мониторинга окружающей среды. Разработана аналитическая система поддержки для непрерывного приема и обработки информации на основе показателей, отражающих изменения экологического состояния региона добычи угля и представлены некоторые практические экологические предложения.

**Ключевые слова:** автоматизированные системы управления; аналитическая система; мониторинг; источники выбросов; добыча угля; воздействие на окружающую среду.

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