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ANALYSIS OF METHODS OF IDENTIFICATION OF ECOLOGICALLY DANGER SUBSTANCES IN ATMOSPHERIC AIR

The analysis of methods for identification of ecological dangerous substances in atmospheric air has been carried out. The analysis of literature data showed that the most widely used methods for assessing the state of atmospheric pollution are biological indication, chemical-analytical researches of air probe and remote methods. Modern remote methods are GIS technologies and lidars. The features of the presented methods are considered in detail. Significant advantages of laser monitoring such as mobility and high accuracy are noted. This allows not only to identify pollutants in conditions of emergency situations, but also to prevent the appearance of emergency situations at potentially danger objects such as solid domestic waste dumps, peat bogs, toxic waste disposal sites for industry, agricultural pesticides, waste heaps and the like. This study has shown the need to following study the possibility of unifying approaches to monitoring and developing techniques for its application to obtain qualitative and quantitative indicators.

Keywords: air, identification of contaminants, remote sensing, laser monitors.

Problem statement. Quality of environment and human population health level directly depends from atmospheric air quality factor. Development of infrastructure of cities and industry enterprises, increasing of amount of automotive transport on roads, using of wide specter of chemical substances and also trends of accumulation of industrial and domestic waste puts own negative impact on air space quality state by polluting it with ecological dangerous substances.

One of modern relevance problems is solving of tasks of environment quality saving namely atmospheric air. For it implementation we should aimed our activity into operative identification of ecological dangerous substances in atmospheric air and prevention of their distribution.

Achieving of results of in-time detection and identification of polluting substances in atmospheric air is start point for ensuring of ecological safety. Such results allows to propose measures and means for dangerous substances neutralization, ways of decreasing of their concentrations in atmospheric air up to acceptable values and prevention of their distribution.

Analysis of recent researches and publications.

The most common ways of studying of atmospheric air pollution level is bioindication, determination of chemical composition of air probes, which taking in researching district and remote scanning.

For adequate assessment of atmospheric air state widely used biological indicators as monitors. Bioindicators using for detection environmental pollutants on technogenic transformed territories [1], implementing of integral express-assessing of atmospheric space quality under conditions of industrial infrastructure changing [2], execution of impact monitoring of domestic solid waste (DSW) dumps on atmospheric space condition [3], assessment of ecological state of urbanic systems [4] and so on.

Regular probe taking of air in fixed space points which executing on stationary observation posts as a rule provides measuring of concentration in air dust, sulfur dioxide, carbon monoxide and nitrogen oxides and also substances concentrations of which exceeding the MCL. Authors of works [6–8] was investigated questions of modernization of Monitoring of Environment State System in part of technical maintains for increasing of efficiency of its functioning, optimization of atmospheric pollution monitoring net and adequateness of operating stationary observing posts net etc.

In recent years more and more widely used remote scanning methods because they expands opportunities of detection and identification of latent sources of danger, pollutants that contained in low concentrations and investigation of zones that inaccessible for application of other researching methods. Such diagnostic methods of air pollution is most prospective.

Problem of air pollution and models of distribution pollutants in atmosphere with using of geo informational systems (GIS-technologies) was investigated in works [9–15]. They includes analysis of opportunities and science grounding of ways of creation of regional monitoring system of atmospheric air pollution based on GIS-technologies. Using of spatial characteristics expans opportunities for implementation of researches, collection, storing, analysis and distributing of information. Combining of model image of territory and information of table type allows to realize the optimal managing decisions.

Remote scanning of atmospheric air also executes with using the laser method of researching. As instrument in this case used laser monitors (lidars).

Bases of laser monitoring of environment was analyzed in works [16–18] and features of its application for ecological tasks solving presented in works [19–23].

Statement of the problem and its solution.

In connection with above this works purpose is studying of methods of identification of ecologically

dangerous substances in atmospheric air, analyzing of possible areas of its application and determination of prospective methods of obtaining of operative and truthful results under conditions of emergency situations (EmS).

Object of the study is condition of atmospheric air pollution in area of emergency situations appearance.

Subject of the study is identification of ecological dangerous substances in atmospheric air in area of emergency situations appearance.

Bioindicators usually using for assessment of existing state of environment and observing of its changes dynamic.

Specifically in work [1] author was proposed and approved original bioindication scheme of technogenic transformed territories with using of D. melanogaster. Implementation of that scheme allows to detect of environmental pollutants which have direct impact on indicators of viability of cohorts D. melanogaster, pure rate of its reproduction and also phenotype distances between elementary populations of technogenic transformed and phonic territories. Achieving of reliable results is possible by the way of comparative analysis of conditions of cohorts D. melanogaster which formed technogenic transformed and phonic territories during certain time period.

Integral express-assessment of quality of atmospheric space was proposed in work [2]. In accordance with results of studying such assessment was implemented using fluctuating asymmetric of vascular plants in the upper tier in conditions changing of industrial infrastructure of region. Also it was determinate the most optimal plants-indicators of city atmosphere pollution respectively to bioindication sensitivity series of tree crops. The undoubted advantages of such assessment include simplicity and absence of need for special instrumental maintenance.

Further development received the scientific basis of application of bioindicators for assessment of impact of DSW dump on enviroment components [3]. Author adopted using of certain bioindicator kinds (leaf blade of Betula pendula and lihenoindication) for determination of environmental hazard states in the zone of the DSW dump.

But one and the same nature indicator can demonstrate of their reaction on certain pollutant differently that explained by process of adaptation to conditions of existence. Besides, that method is based on more longer observations of environment state and not allows detection of “latent” danger sources and clearly point on them. It is not possible to obtain operative information about degree of danger of short and salvo emissions which may be fatal to living organisms in a short time, for example in terms of emergency situation.

In addition, this system is low ineffective during cold season of year. So for implementing of qualitative and quantitative analysis of ecological dangerous substances in atmospheric air using chemical active methods of probe analyze.

For probe taking and its analysis organized posts of observation of atmospheric air pollution state (stationary, route, movable). For increasing of efficiency of work of observation posts, namely their operativeness of managing decision making, author of work [6] executes of optimization of subsystem structure of technical support of Environment Monitoring State System under standard conditions as well as in emergency situation. Hereinafter authors of research [8] proposed criterias for determination of degree of necessary of implementing of environment monitoring on enterprises which make negative impact on its state. But present atmospheric air pollution state observation posts nets not always are substantiated.

That’s why in work [7] scientists solved the task of selection of location places of observation posts on bases of which proposed update general scheme of observation posts net.

Wherein identification of pollutant substances that contains in atmospheric air are pretty difficult task for analytic chemistry because of presence of hundreds toxic compounds of different classes. This explained by that toxic substances concentrations which penetrate into atmosphere from different sources in outside contains in trace or microadmixtures amount levels [24].

Thus on each stage researcher should taking into account systematic errors which caused by imperfection of every link of multilink chain of probe taking method. In obtained results error of determination of substances concentration can reach 25 % wherein some measurements can last several days.

It is also important that in emergency situation appearance area determination of pollutant substance on basis of this method is difficult because of presence of danger for human (sometime taking of probe is simply impossible), besides is absent operativeness, veracity of results and consequently effectiveness of method in conditions of emergency situation in general.

Remote methods of observation of atmospheric air pollution state allows to detect of presence of ecological unsafe substances and identify their presence in conditions of emergency situation because not require of human presence in danger zone. Most wide spread of them is GIS-technologies and lidars.

Today vast majority of scientific works in which proposed certain approaches to modernization of existing system of monitoring of atmosphere of Ukraine are based on GIS-technologies. Namely, scientists proposes application of GIS-technologies for modernization of atmospheric air pollution observation posts net [9–12]. Also with using of GIS-technologies investigates of pollution of ground by atmospheric emissions, assess of state of environment components [13, 14] etc. Wherein if pictures has low spatial differentiation than it possible to implement of monitoring with rate up to 4 times per day, in case of middle spatial differentiation – up to 1 time per day or week and at high spatial differentiation – up to 1 time per month [15].

In the work [20] author proposes surely identify

source of harmful emissions with using of molecular gas lasers which has developed discrete spectrum of very narrow generation lines with enough intensity and radiation stability. It is undoubtedly their advantage over other types of laser for case of atmosphere remote monitoring.

Essentiality of laser identification method for harmful admixtures in air is that gas molecules of pollutants and aerosols absorbs and dissipates of laser radiation. Since polluted atmosphere contains not inherent gases (sulfur dioxide SO2, nitrogen oxides NO and NO2, hydrocarbons HC and etc.), their reactions products in form of acids or oxidants and also solid dust particles with dimensions of from 10-8 till 10-3 m (aerosols) than effect of accounting using laser ray of composition and concentrations of polluting substances on myriad of points on several routes ensure of execution of monitoring requirements about results authenticity and fullness of data [23].

In practice scanning of atmosphere with using of method of differential laser ray absorbing characterized by two ways: lidar and trass [23]. For the first way as distributed reflector used atmospheric aerosol. On that regime is possible to remote measuring of profiles of gas admixtures with spatial resolution power which determines by duration of laser impulse τ:

$$\Delta R = \frac{1}{2} cR \,. \qquad (1)$$

For the second way is registered signal that reflects or diffusion reflects from topographic objects. Wherein is possible determination with high sensitivity of averaged concentrations of gas admixtures along the length of route of scanning in separate directions.

Certain results of application of lidar for identification of gas admixtures and aerosols in atmosphere obtained in works [20–22]. Wherein research in work [21] is aimed directly into studying of theoretical basis of laser monitoring of atmosphere in zone of appearance of emergency situation for identification of gas composition and aerosols.

For describing of aerosol diffusion of laser ray authors relied of empirical equation [19]:

$$\alpha_a = \frac{3.912}{R_m}\left(\frac{\lambda}{0.55}\right)^{-q}, \qquad (2)$$

where α_a – measured in km^{-1}, λ – measured in Mm, R_m – meteorological visibility range measured in km at λ = 0,55 Mm, q – exponent which depends on R_m.

Results of calculation of values q, α_a and $\Gamma_a(R_m)$ for different R_m (see table. 1) shows that value α_a decrease significantly at visibility improving at the same time value $\Gamma_a(R_m)$ at increasing values of R_m remains unchanged and equal $3{,}9\cdot10^{-3}$ [21]. This indicates that at R = R_m adsorbed around 0.78 % of visible radiation power.

Table 1 – Calculated values q, α_a and $\Gamma_a(R_m)$ at different values of R_m and λ = 0,55 Mm

Visibility in zone of emergency situation	R_m, m	q	α_a, m^{-1}	$\Gamma_a(R_m)$
very bad	1	0,059	$3{,}9\cdot10^{-3}$	$3{,}9\cdot10^{-3}$
badly	5	0,100	$0{,}8\cdot10^{-3}$	$3{,}9\cdot10^{-3}$
middle	10	0,126	$3{,}9\cdot10^{-4}$	$3{,}9\cdot10^{-3}$
satisfactorily	30	0,182	$1{,}3\cdot10^{-4}$	$3{,}9\cdot10^{-3}$
well	50	0,216	$0{,}8\cdot10^{-4}$	$3{,}9\cdot10^{-3}$
excellent	1000	0,585	$3{,}9\cdot10^{-6}$	$3{,}9\cdot10^{-3}$

In conditions of badly and very bad visibility laser method allows to diagnose of zone of emergency situation for length of 1…2 km. In case of more conductive visibility more important during scanning process is laser power than ray attenuation caused by aerosols.

It should be noted that monitoring method has another significant advantages like mobility and high accuracy. Taking into account that advantages it allows not only pollution substances identification in conditions of emergency situation but also prevention of appearance of emergency situation on potential dangerous objects such as DSW dumps, peatlands, place of disposal of toxic industrial waste, pesticides for agricultural purposes, heaps and so on.

Separately it should also allocate the problem of illegal emissions into atmosphere by industrial enterprises. In recent time there is increasing of illegal nightly emissions from industrial enterprises that requires intervention by supervisory authorities for bringing the perpetrators to justice. In case of using of remote contactless method intervention in the production process is absent, concentration is averaged along the scanning track, and after selection of several directions significance of "probe" repeatedly increases.

Executed preliminary analysis shows that it necessary of allocation of several tasks solving of which in further gives opportunity of ensuring of atmospheric air and preventing of emergency situations.

Firstly, it should to classify potential unsafe objects by attributes of potential influence on atmospheric air (physical, chemical, biological, radioactive) for unification of approaches to monitoring implementation and developing of methodics of its application for obtaining of quantitative and qualitative indicators.

Secondly, it should to analyze existing mathematical models of laser scanning for identification of gas composition and aerosols and to improve them with taking into account characteristics of classification groups of potential unsafe objects, such as its geometric dimensions and accessibility to place of data taking.

Thirdly, it should to determine influence of natural conditions on implementation of diagnostic and take into account that during methodics development. To

number of this conditions it can be include meteorological indicators at the moment of monitoring executing, season of year, time of day, landscape characteristics and topographic features of terrain.

Discussion of result of the analysis of methods of identification of ecologicaly dangerous substancess in atmospheric air.

Most of traditional methods of monitoring of environment used for assessment of general ecological state of technogenic loaded territories. Identification of ecological dangerous substancess in atmospheric air is possible only in accordance with limited amount of biological indicators types, by chemical active methods and laser diagnostic. Wherein using of bioindication and implementing of chemical analysis of probes are pretty problematical in conditions of appearance of emergency situation because of presence in atmospheric air unusual for it pollutant substances and aerosols. Besides emergency situations as a rule accompanied by significant increasing of air temperature, emission of toxic substances and other latent danger factors for human that makes impossible of probe taking.

The most prospective method of identification of ecological dangerous substances in atmospheric air is lidar. This is evidenced by large number of science researches dedicated to:

– determination of parameters for best selection of lasers for lidar systems [20];

– design and developing of methdics of measurement and processing of optical radiation which aims on assessment of concentrations of pollutant gaseous admixtures and aerosols in atmosphere in zones of emergency situations [21];

– features of ecological monitoring of atmospheric air in zones of emergency situations of technogenic character [23].

However it necessary to implement of following researches such as unification of approaches of executing of monitoring and development of methodics of its application for obtaining of qualitative and quantitative indicators. Because this promotes of prevention or reducing of distribution zone of emergency situation.

Conclusions. This can summarized as follows:

1. Implemented of analysis of bioindication, chemical analytical, GIS-technology and lidar methods of identification of ecological dangerous substances in atmospheric air, namely possible areas of its application, advantages and lacks during achieving of operative and truthful results in conditions of emergency situation.

2. Using of results of the study it can be recognized the lidar as the most prospective method of identification of ecological dangerous substances in atmospheric air.

3. Determined of general directions and tasks of following studies solving of that in the future allows to ensure of protection of atmospheric air and to prevent of emergency situations.

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АНАЛІЗ МЕТОДІВ ІДЕНТИФІКАЦІЇ ЕКОЛОГІЧНО-НЕБЕЗПЕЧНИХ РЕЧОВИН В АТМОСФЕРНОМУ ПОВІТРІ

Проведено аналіз методів ідентифікації екологічно-небезпечних речовин в атмосферному повітрі. Аналіз літературних даних показав, що найбільш широко поширеними методами оцінки стану забруднення атмосфери є біологічна індикація, хіміко-аналітичне дослідження відбору проб повітря й дистанційні методи. Сучасні дистанційні методи – це ГІС-технології і лідари. Детально розглянуті особливості представлених методів. Відзначено істотні переваги лазерного моніторингу такі, як мобільність і висока точність. Це дозволяє не тільки ідентифікувати забруднюючі речовини в умовах НС, але і попереджати виникнення НС на потенційно небезпечних об'єктах таких, як звалища сміття ТПВ, торфовища, місця поховання токсичних відходів промисловості, отрутохімікатів сільськогосподарського призначення, териконів тощо. Це дослідження показало необхідність надалі дослідити можливість уніфікації підходів до проведення моніторингу й розробки методик його застосування для одержання якісних й кількісних показників.

Ключові слова: атмосферне повітря, ідентифікація забруднювальних речовин, дистанційне зондування, лазерні монітори.

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АНАЛИЗ МЕТОДОВ ИДЕНТИФИКАЦИИ ЭКОЛОГИЧЕСКИ-ОПАСНЫХ ВЕЩЕСТВ В АТМОСФЕРНОМ ВОЗДУХЕ

Проведен анализ методов идентификации экологически-опасных веществ в атмосферном воздухе. Анализ литературных данных показал, что наиболее широко распространенными методами оценки состояния загрязнения атмосферы являются биологическая индикация, химико-аналитическое исследование отбора проб воздуха и дистанционные методы. Современные дистанционные методы – это ГИС-технологии и лидары. Детально рассмотрены особенности представленных методов. Отмечены существенные преимущества лазерного мониторинга такие, как мобильность и высокая точность. Это позволяет не только идентифицировать загрязняющие вещества в условиях ЧС, но и предупреждать возникновение ЧС на потенциально опасных объектах таких, как свалки мусора ТБО, торфяники, места захоронения токсичных отходов промышленности, ядохимикатов сельскохозяйственного назначения, терриконов и тому подобное. Данное исследование показало необходимость в дальнейшем исследовать возможность унификации подходов к проведению мониторинга и разработки методик его применения для получения качественных и количественных показателей.

Ключевые слова: атмосферный воздух, идентификация загрязняющих веществ, дистанционное зондирование, лазерные мониторы.