Machinery & Energetics. Kyiv. Ukraine. 2018, Vol. 9, No. 3, 147-151
ISSN 2222-8594 (Print), ISSN 2415-7694 (Online), www.journals.nubip.edu.ua/index.php/Tekhnica

DOI: 10.1515/agriceng-2018-0023

UDC 504.5:621.434 - 629.113

ASSESSMENT OF RISK TO HUMAN HEALTH FROM HARMFUL EMISSIONS OF AGRO-INDUSTRIAL COMPLEX

Semenenko M. V.

National University of Life and Environmental Sciences of Ukraine, Ukraine.

Corresponding author: m.maryscorp@gmail.com.

Article history: Received: May 2018. Received in the revised form: June 2018. Accepted: September 2018.
Bibl. 12, fig. 0, tabl. 0.

Abstract. The article presents the results of the study of the element of the mathematical model to calculate the quantitative risk to health of the population who live in the technogenic-loaded territory. The author proposes a mathematical tool that will make rapid analysis of the influence of carcinogen, which is in the air on the number of cancer in the population. The results of the study had a practical confirmation with a high degree of adequacy. The study of the proposed methods and models will allow practitioners and scientists on the basis of the proposed mathematical apparatus of analysis (or further development) to minimize the risk and optimally manage it, especially in areas with high technogenic stress. Thus, this approach can be applied to the analysis, forecasting and development of measures to ensure the safety of the population.

Key words: risk assessment, mathematical model, technogenic-loaded area, stationary and mobile sources, carcinogen, air, Express analysis, forecasting, safety.

Introduction

The concept of risk in general is a system approach that includes the main elements: risk assessment, risk management and risk perception.

At present, the tasks of identifying hazards and risk assessment procedures at optimal and emergency functioning of stationary and mobile sources of pollutant emissions are more solvable tasks.

Formulation of problem

The methodology of risk assessment, namely the influence of chemical components on the state of health of the population, was first used in the United States since the 80s of the last century. Since then, a large number of methods have been developed to identify different types of risk, and many different reasons have been identified that led to the need for such an assessment.

Risk analysis is a part of a systemic approach for making a decision, procedures and practical measures to address the objectives of preventing or reducing the risk to human life and the environment.

In our country, this is commonly called "industrial safety", and abroad risk management.

In this case, Risk Analysis or Process Hazard Analysis is defined as the systematic use of available information for hazard identification and risk assessment for individuals or groups of people, property or the environment [1]. Risk analysis is to identify (identify) hazards and risk assessment.

Danger is the source of potential harm or damage, or the situation with the possibility of causing harm, and the risk or degree of risk (risk level) is the combination of the frequency or probability and the consequences of a particular hazard [2].

That concept of "risk" always includes two elements:

- the frequency with which a dangerous event occurs;
- consequences of a dangerous event.

The use of the notion of risk, thus, allows you to translate the danger into a category of measured categories.

Risk, in fact, is a measure of danger.

Analysis of recent research results

While the principles and methods for evaluating chemicals which are not carcinogens are relatively similar across countries, it is noteworthy that approaches to assessing the risk of carcinogenic chemicals vary considerably. There are not only significant differences between countries, but even in one country different regulatory agencies, committees and scientists use or advocate different approaches to risk assessment. The risk assessment of substances which are not carcinogenic is consistent enough and has a long tradition, in part because of a long history and a deeper understanding of the nature of the toxic effects compared to carcinogens, and a higher level of consensus and trust on both scientists and the general public regarding methods used and the results obtained. In the late 1960s and early 1970s, the regulatory authorities of various countries – beginning with the US – faced a problem whose importance increased every day, in which the approach based on the factor of safety was considered by many scientists as unsuitable and even dangerous.

Later, risk assessment, as a scientific methodology, was first used in the world since the 80s of the last century in America.

At that time, many methods had been developed to identify different types of risks and many reasons had been identified for the importance of such an assessment.

It was about chemicals that, under certain conditions, increased the risk of cancer in humans and animals. These substances have received the working title of carcinogens. There are still disputes over the definition of a carcinogen and there are various opinions on methods for the identification and classification of carcinogens, as well as the process of the occurrence of cancer under the influence of chemicals.

Complex reviews of discussions of various aspects of models of mathematical extrapolation are given in Kramer et al. (1995) and Park and Hawkins (1993). Krewski et al. (1990) revised the concept of "threshold regulation" for chemical carcinogens. To date, no mathematical model is considered to be the most suitable for low-dose extrapolation in carcinogenesis.

The works of Aksoy M. [3], Anderson B.A. Silver B.D. [4], Babich H., Devanas M.A., Stotzky G. [5], Csicsaky M.J., Roller M., Pott F. [6], Comstock M.L. [7] Demmerle G., Arndt A. [8], and others are devoted to the improvement and others are devoted to the improvement methodologies for risk assessment of carcinogenic substances that are emitted into the atmosphere from different anthropogenic sources.

Purpose of research

The purpose of the study is to offer a practical simple mathematical tool for the quantitative rapid assessment of the risk to health of the population who live in a technogenic area and breathe air with carcinogenic toxicants

Results of research

Risk assessment is the use of available information and scientifically based forecasts to assess the risk of adverse environmental factors and human health conditions.

Risk, in fact, is a measure of danger.

The use of the concept of risk does not translate safety into the category of quantitative measured values.

Risk profile is the last stage of risk assessment and the first stage of risk management.

It is known that the calculation of risks and their characteristics are separately for carcinogenic and non-carcinogenic effects.

Consider carcinogenic risk:

$$Rind = C \times Uri, \quad (1)$$

where *Rind* – is an annual individual (additional to background) risk cancer development (year-1);

C – average daily concentration of pollutant, which affects a person throughout his life (μg / m^3);

Uri – is a single risk for inhalation exposure, characterizing the risk value for one unit of concentration of a pollutant in air for one year [(μg / m^3) · year] $^{-1}$.

In the methodology of risk assessment, the combined effect of carcinogenic factors is considered to be additive, therefore the total carcinogenic risk is calculated by the formula:

$$R_{\Sigma} = R_1 + R_2 + ... R_n, \quad (2)$$

where R_{Σ} – total carcinogenic risk from exposure to several toxicants;

R_1, R_2, R_n – carcinogenic risks caused by the influence of the components of a mixture of chemicals.

For carcinogens, the process of risk characterization is to determine the number of expected additional cases of cancer, using the concentrations obtained at the points – receptors and potential factors. The following main types of risk are taken into account:

- an individual carcinogenic risk throughout life that is defined as an additional (above background) risk for an individual to contract a cancer during a lifetime under the influence of a particular substance at a specific concentration or dose;

- annual population oncological risk is defined as the number of additional cases of cancer expected during each year for a certain number of people in the region under study as a result of exposure to a specific dose of a carcinogenic contaminant.

- additional individual carcinogenic risk of exposure to atmospheric pollutants throughout life is a function of three main factors:

a) average daily inhalation dose calculated from concentration in the air, set in point-receptor using scattering models pollutants in the atmospheric air;

b) the probability that a specific pollutant will trigger tumor formation;

c) вuration of influence.

Based on the methods developed by the American Agency for the Protection of the Environment, the calculation of individual additional carcinogenic risk throughout life is carried out by multiplying the concentration at the point – on the factor factor receptor for the total part of the time of life, when there was a negative impact [9].

According to the author, in quantitative estimations of the ecological risk associated with contaminating carcinogens from operating stationary and mobile sources located in a certain territory, it is expedient to calculate the total (existing) risk and the so-called additional.

Mechanisms of formation of negative consequences (effects), caused by existing and additional risks and are taken into account with the help of the indicator q_e – the parity of harmful influences.

For the case of the same mechanisms of influence on human health:

$$q_e = q_t - q_c, \quad (3)$$

where q_t, q_c – particularly the appearance of such negative effects in the risk group and the control group.

If these mechanisms are different:

$$q_e = (q_t - q_c) / (1 - q_c), \quad (4)$$

To estimate the influence of a toxicant present in the atmosphere, the concept of "risk from the dose and toxicant j" is introduced, through $[P_e(D)]_{ij}$ [1].

In fact, the value $[P_e(D)]_{ij}$ is probable, it depends on the so-called risk factor of this toxicant F_r and its dose D. The dose is measured in mg, and the risk factor has a dimension (mg)$^{-1}$ and represents the risk that falls on unit dose.

The size of the risk factor should be established as a result of special studies. If the relationship between the dose and the risk is linear, and the effect of the toxicant has no threshold, then the value $[P_e(D)]_{ij}$ can be determined by the following formula:

$$[P_e(D)]_{ij} = (F_r \cdot D)_{ij} = (Fr \cdot c \cdot v \cdot t)_{ij}, \quad (5)$$

where c – toxicant concentration;

v – his daily intake in the body;

t – the time of exposure to the toxicant.

The number of serious consequences (for example, cancer) of toxicants per person is determined by the formula:

$$q_e = \sum^{n}_{i=1} \sum^{k}_{j=0} [P_e(D)]_{ij} \times N_{ij} , \quad (6)$$

where N_{ij} – the number of people exposed to toxicants;

k – number of toxicants;

n – number of dose levels of each toxicant.

The studies conducted by the author in the Agrokombinat "Pushcha-Voditsa" of Kyiv, in conjunction with the sanitary-epidemiological station for 36 months, showed that the above formula can also be used for express quantitative estimates of the population risk in a certain technogenic area.

In the selection of sources for the author used the following criteria to assess the risk to public health from environmental pollution:

- release of carcinogenic substances into the environment;

- hazard class of substances released into the environment and connections;

- multiplicity of exceeding the maximum permissible concentrations.

The object of research Agrokombinat "Pushcha-Voditsa" of Kiev (Polkovaya 57 str.) The research, production Agrokombinat "Pushcha-Voditsa" – the diversified enterprise, occupies about 2000 hectares where enter, including, more than 100 hectares of long-term plantings, a dairy farm, a champignon complex, plant on processing of agricultural production. The company produces and sells more than 100 products.

The author together with employees of the sanitary-epidemiological service, SES Darnytskyi district", which is located at the address: Kyiv, Pobedy Ave., 7.

Air samples were taken by specialists by high-performance liquid chromatography with fluorometric detection. Samples were taken in 6 batches of 10 days. Calendar time of sampling spring (beginning) and autumn (end) of large agricultural works). At this time, enterprises and vehicles are operating at maximum capacity.

Benzapyren is practically not found in the free state, and is always deposited on the particles contained in the air. When diesel engines of motor vehicles are working, they are carbon particles, which have a film of benzopyren on the surface. Together with the masses of air that move, the benzapyren spreads over a large area. And fall out together with solid particles from the air (for example, in precipitation) fall into the soil layers.

In the movement and accumulation of benzapyren plays an important role agricultural machinery and trucks. On the one hand, moving over long distances, cars contribute to a uniform spread of benzapyren. On the other hand, the settled benzapyren accumulates in large quantities along highways and gets to the earth where plants (so-called "secondary sources") grow.

Benzapyren (3, 4 – benzapyren) belongs to the class of polycyclic aromatic hydrocarbons, molar mass 252,32 g/mol.

The substance is a product of incomplete combustion (pyrolysis) of organic compounds present in the products of processing of coal, oil (heavy fractions).

Benzapyren has carcinogenic activity. In the atmosphere, it is mainly adsorbed on suspended particles.

Benzapyren refers to substances of hazard class 1. The average daily maximum permissible concentration of benzapyren in the air of populated areas is 0.001 μg / m^3.

The following method was used in the research. The method is based on trapping of benzapyren in aerosol filter, extracting it with hexane, concentrating the extract, chromatographic separation, detection of the signals using a fluorescent detector, to identify the peak of benzapyren on the chromatogram at the retention time and the calculation of the mass concentration of benzapyren.

When sampling atmospheric air, the following conditions shall be met:

- no precipitation;

- the inlet openings of the sampling device shall be located away from the walls of buildings, fences, trees and other obstacles. Before sampling, measurements of direction, wind speed, temperature and atmospheric pressure are carried out. The sampling device is located at a height of 1.5-3.5 m.

Single samples are taken for 20-30 minutes, and the average daily discretely for 30 minutes at least 4 times a day. The exposed filters are Packed in paper marked bags and stored in a dry room or in a refrigerator for no more than 30 days.

The results were processed in the program "Multichrome for Windows".

The concentration of benzapyren in the sample is calculated by the formula:

$$X = C_k\, U_k\, Q_1\, Q_2 / U_o, \quad (7)$$

where U_o, X – concentration of benzapyren in air, μg / m^3;

C_k – concentration of benzapyren in the sample concentrate, μg / cm^3;

U_k – volume of the sample concentrate, cm^3;

Q_1 – is the dilution factor of hexane extract. If the entire volume of the extract is taken for analysis, then $Q_1 = 1$;

Q_2 – is the dilution ratio of the concentrate of the sample;

U_o – is the volume of air selected for analysis and brought to normal (investigation of atmospheric air: pressure 760 mm mercury column, temperature 0°C) or standard conditions (study of the air working area: pressure 760 mm mercury column, 20°C), m^3.

Evaluation of the effect of the concentration includes determining concentrations of chemical substances that affect the person during the period of exposure.

Taking samples of benzapyren in the air on the territory of the agro-industrial complex was carried out in the field on the border of sanitary zones of 3 industrial facilities. The objects were chosen so that the next working vehicles. All objects in their work use the technological process of burning different types of fuel. Then the samples were delivered to the laboratory and, according to the current method, the concentrations of benzapyren were determined.

Concentrations of benzapyren, which were determined empirically compared with concentrations that were calculated by mathematical modeling separately for stationary and mobile sources.

A good numerical value of the results of calculations and laboratory proves the correctness of the proposed method of calculating the characteristics of risk assessment and its acceptability for practical application.

As a result of the study of the action of the carcinogenic toxicant (benzapyren) in the air that is in the emission of harmful substances of mobile and stationary anthropogenic sources of the area, the concentration of which is 0.0087 mg / m^3 – the toxicant's risk factor is 10^{-6} mg^{-1}.

Population risk is an aggregated measure of the expected frequency of effects among all affected individuals [10].

Let, for example, on the territory of the agro-industrial complex "Pushcha-Voditsa" live a population of 10 thousand people for 3 years constantly (24 hours a day) exposed airborne toxicant carcinogen,

For example, in our case, the number of cases of cancer in a population that has been exposed to a toxicant on the research object is additionally 1 man of 10 thousand a man during 3 years [2].

Risk assessment can consider past, present and future impacts with different parameters for each phase [11].

If to speak differently, modeling the future, measurement of real analysis and summation of the biological effects of past impacts.

US federal agencies that are developing regulations that set health risk standards are based on the lower theoretical individual risk, which is equal to, according to EPA (Environmental Protection Agency) standards, 10-6, which corresponds to an increase in probability death for one chance per million - for 70 years of human life [2].

Benzapyren enters the environment from stationary and mobile sources of agriculture and accumulates in it. Benzopyren penetrates into plants, which then serve as feed for livestock or used in human nutrition. The concentration of benzapyren in plants is higher than its content in the soil, and in food (or feed) is higher than in the feedstock for their manufacture. It's a bioaccumulative effect [12].

Conclusions

1. The study of the proposed methods and models, according to the author, will allow practitioners and scientists, based on the use of the proposed mathematical apparatus for analysis (or further development), to minimize risks and optimally manage them, especially in areas with high technogenic loads.

2. The knowledge gained can be useful in practice activity at:

- development of recommendations on possible regional measures;
- level aimed at reducing the negative impact of environmentally hazardous industrial and agricultural production;
- forecasting of economic development of agro-industrial regions, taking into account the anthropogenic load on the environment;
- identification of critical territorial areas where reducing uncertainty leads to the most effective assessment of risk reliability and thus provides the best ways to reduce it; increase not only the life expectancy of the population, but also improve its quality.

References

1. *Semenenko, M. V.* (2013). Anthropogenic-loaded territory and the risk to public health. Urban planning and territorial planning: scientific and technical collection. Knuca. Kyiv, territorial planning: Scientific and technical. No. 47. 563-569.

2. *Semenenko, M. V.* (2016). Influence of air pollution anthropogenic sources on human health: monograph. Kiev. NULESU, 405.

3. *Aksoy, M.* (1989). Hematotoxicity and carcinogenicity of benzene. Environ. Health. Perspect. Vol. 82. 193-197.

4. *Anderson, B. A. Silver, B. D.* (1986). Infant mortality in Soviet Union: regional differences and measurement issues. Popul. and Develop. Rev. Vol. 12, №4. 705-738.

5. *Babich, H., Devanas, M.A., Stotzky, G.* (1985). The mediation of mutagenicity and clastogenicity of heavy metals by physiochemical factor. Environ. Res. Vol. 37, №2. 253-286.

6. *Csicsaky, M. J., Roller, M., Pott, F.* (1989). Risk modelling: which models to choose? Exp. Pathol. Vol. 37, №1-4. 198-204.

7. *Comstock, M. L.* (2008). Diesel exhaust in the occupational setting. Current understanding of pulmonary health effects. Clin. Lab. Med. Vol. 18. N24. 767-779.

8. *Demmerle, G., Arndt, A.* (1990). Le moteur diesel pour vehicules industriels et Penvironnement. Petrole et tehn. №535. 26-32.

9. *Epstein, S. S.* (1990). Losing the War Against Cancer: Who's to Blame and What to Do About it. Int. J. Hlth. Serv. Vol. 20, №1. 53-57.

10. *Semenenko, M. V.* (2012). Assessment of the level of technological risk traffic flows. Urban planning and territorial planning: scientific and technical collection. Knuca. Kiev. No 46. 498-501.

11. *Semenenko, M. V.* (2017). Automobile and the environment: a monograph. Kiev. NULESU. 805. ISBN 978-617-7595-28-9.

12. *Menshikov, V. V., Shviryaev, A. A.* (2003). Dangerous chemical objects and technogenic risk: tutorial. Moscow. 203.

Список літератури

1. *Семененко М. В.* Антропогенно-нагруженная территория и риск для здоровья населения. Градостроительство и территориальное планирование: научно-технический сборник. КНУБА. Киев, territorial planning: Scientific and technical. 2013. № 47. P. 563–569.
2. *Семененко М. В.* Вплив забруднення атмосферного повітря антропогенними джерелами на здоров'я населення: монографія. Київ. НУБіП України, 2016. 405 с.
3. *Aksoy M.* Hematotoxicity and carcinogenicity of benzene. Environ. Health. Perspect. 1989. Vol. 82. P. 193–197.
4. *Anderson B. A. Silver B. D.* Infant mortality in Soviet Union: regional differences and measurement issues. Popul. and Develop.Rev. 1986. Vol. 12, №4. P. 705–738.
5. *Babich H., Devanas M.A., Stotzky G.* The mediation of mutagenicity and clastogenicity of heavy metals by physiochemical factor. Environ. Res. 1985. Vol. 37, №2. P. 253–286.
6. *Csicsaky M. J., Roller M., Pott F.* Risk modelling: which models to choose? Exp. Pathol. 1989. Vol. 37, №1-4. P. 198–204.
7. Comstock M. L. Diesel exhaust in the occupational setting. Current understanding of pulmonary health effects. Clin. Lab. Med. 2008. Vol. 18. N24. P. 767–779.
8. *Demmerle G., Arndt A.* Le moteur diesel pour vehicules industriels et Penvironnement. Petrole et tehn. 1990. №535. P. 26–32.
9. *Epstein S. S.* Losing the War Against Cancer: Who's to Blame and What to Do About it. Int. J. Hlth. Serv. 1990. Vol. 20, №1. P. 53–57.
10. *Семененко М. В.* К вопросу оценки уровня техногенной опасности транспортных потоков в городах. Містобудування та територіальне планування: науково-технічний збірник. КНУБА. Київ. 2012. №46. С. 498–501.
11. *Семененко М. В.* Автомобилізація та довкілля: монографія. Київ. НУБіП України, 2017. 805 с. ISBN 978-617-7595-28-9.
12. *Меньшиков В. В., Швыряев А. А.* Опасные химические объекты и техногенный риск: учебное пособие. Москва. 2003. 203 с.

ОЦІНКА РИЗИКУ ДЛЯ ЗДОРОВ'Я НАСЕЛЕННЯ ВІД ВИКИДІВ ШКІДЛИВИХ РЕЧОВИН АГРОПРОМИСЛОВИМ КОМПЛЕКСОМ

М. В. Семененко

Анотація. У статті представлені результати дослідження елемента математичної моделі для розрахунку кількісного ризику здоров'ю населення, яке проживає на техногенно-навантаженої території. Автор пропонує математичний інструмент, який дозволить зробити експрес-аналіз впливу канцерогену, що знаходиться в повітрі, на кількість онкологічних захворювань у популяції. Результати дослідження мають практичне підтвердження з високим ступенем адекватності. Вивчення запропонованих методів і моделей дозволить практикам і вченим на основі запропонованого математичного апарату аналізу (або подальшого розвитку) мінімізувати ризик і оптимально керувати ним, особливо в районах з високими техногенними навантаженнями.

Таким чином, даний підхід може бути застосований до аналізу, прогнозування та розробки заходів щодо забезпечення безпеки проживання населення на техногенно – напружених територіях.

Ключові слова: оцінка ризику, математична модель, техногенно-навантажена область, стаціонарні і мобільні джерела, канцероген, повітря, експрес-аналіз, прогнозування, безпека.

ОЦЕНКА РИСКА ДЛЯ ЗДОРОВЬЯ НАСЕЛЕНИЯ ОТ ВЫБРОСОВ ВРЕДНЫХ ВЕЩЕСТВ АГРОПРОМЫШЛЕННЫМ КОМПЛЕКСОМ

Семененко М., кандидат технических наук, доцент
Национальный университет биоресурсов и природопользования Украины
М. В. Семененко

Аннотация. В статье представлены результаты исследования элемента математической модели для расчета количественного риска здоровью населения, проживающего на техногенно-нагруженной территории. Автор предлагает математический инструмент, который позволит сделать экспресс-анализ влияния канцерогена, находящегося в воздухе, на количество онкологических заболеваний в популяции. Результаты исследования имеют практическое подтверждение с высокой степенью адекватности. Изучение предложенных методов и моделей позволит практикам и ученым на основе предложенного математического аппарата анализа (или дальнейшего развития) минимизировать риск и оптимально управлять им, особенно в районах с высокими техногенными нагрузками. Таким образом, данный подход может быть применен к анализу, прогнозированию и разработке мероприятий по обеспечению безопасности проживания населения на техногенно-нагруженных территориях.

Ключевые слова: оценка риска, математическая модель, техногенно-нагруженная область, стационарные и мобильные источники, канцероген, воздух, экспресс-анализ, прогнозирование, безопасность.