ABSTRACT AND REFERENCES

ECOLOGY

ENSURING COMFORT MICROCLIMATE IN THE CLASSROOMS UNDER CONDITION OF THE REQUIRED AIR EXCHANGE (p. 6-14)

Peter Kapalo
Technical University of Kosice, Kosice, Slovakia
ORCID: http://orcid.org/0000-0001-9571-3887

Orest Voznyak
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-6431-088X

Yuriy Yurkevych
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-8869-7759

Khrystyna Myroniuk
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-6090-2298

Iryna Sukholova
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-3319-2278

We performed comparative analysis of regulatory documents, which relate to ventilation of school premises and operate in European countries at present. We showed the essential difference of the recommended air exchange values. We assessed sanitary and hygienic conditions formed in classrooms at different efficiency of a ventilation system both by analytical calculations and by subjective monitoring of microclimate of experimental measurements conducted in school classrooms, when every pupil-participant performed an assessment of the internal environment in the form of a questionnaire. We measured carbonic acid gas contents emitted in a room and determined the required ventilation intensity in the evaluated school premises. We compared the multiplication factor of air exchange of the ventilation system determined in this way with the values obtained by analytical calculations carried out in accordance with current legislation and standards, which are active in Europe. We made calculations based on known analytical dependencies. We determined performance of the ventilation system of the classroom based on CO_2 concentrations in internal and inflow air at various values of the multiplication factor of air exchange. It made possible to state that we can achieve the optimal microclimate parameters at air exchange of 30 m^3/h per person.

We presented the results of field studies and analytical calculations in the form of tables and visual graphic dependencies. The proposed research method makes it possible to increase accuracy and reliability of air quality control in classrooms by direct measurement of CO_2 concentration in a serviced area of a room. The study results provide an opportunity to improve ventilation systems of school buildings. This creates prerequisites for obtaining a social effect due to an increase in labor and learning efficiency.

Keywords: multiplication factor of ventilation, energy saving, carbon dioxide concentration, ventilation efficiency, monitoring of microclimate.

References

1. Steiger, S., Noske, F., Kersken, M., Hellwig, R. T. (2008). Untersuchungen zur Beluftung von Schulen. Tagungsband Deutsche Kalte-Klima-Tagung. Available at: http://www.bine.info/fileadmin/content/Publikationen/Projekt-Infos/2010/Projektinfo_15-2010/04_Steiger_Noeske_Kersken_Hellwig_2008_Untersuchungen_zur_Belueftung_von_Schulen_DKV.pdf

2. Hellwig, R. T., Antretter, F., Holm, A., Sedlbauer, K. (2009). Untersuchungen zum Raumklima und zur Fensterlüftung in Schulen. Bauphysik, 31 (2), 89–98. doi: https://doi.org/10.1002/bapi.200910013

3. PrEN 13779. Ventilation for-residential buildings – Performance requirements for ventilation and room-conditioning systems (2006). European Standard.

4. Székyová, M., Ferstl, K., Nový, R. (2004). Vetranie a klimatizácia. Vydavateľstvo Jaga group, 350.

5. Savchenko, O., Zhelykh, V., Voll, H. (2017). Analysis of the systems of ventilation of residential houses of Ukraine and Estonia. Selected Scientific Papers - Journal of Civil Engineering, 12 (2), 23–30. doi: https://doi.org/10.1515/sspjce-2017-0015

6. Persily, A. (2005). What we think we know about ventilation? Proceeding of the 10th International Conference on Indoor Air Quality and Climate "Indoor Air 2005". Beijing. Available at: https://www.nist.gov/publications/what-we-think-we-know-about-ventilation

7. Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast) (2010). Official Journal of the European Union, 153, 13–35. Available at: http://enref.org/wp-content/uploads/2015/01/2010-31-eu.pdf

8. Kapalo, P. (2014). Intenzita vetrania v budovách – teoretická a experimentálna analýza. Košice, 75.

9. Vyhláška Ministerstva zdravotníctva Slovenskej republiky (2007). Zbierka zákonov č. 527/2007. Available at: http://www.uvzsr.sk/docs/leg/527_2007_vyhlaska_zariadenia_pre_deti_a_mladez.pdf

10. DBN V.2.2-3-97. Vydannia. Budynky ta sporudy navchalnykh zakladiv (1997). Kyiv, 50.

11. Cao, G., Awbi, H., Yao, R., Fan, Y., Sirén, K., Kosonen, R., Zhang, J. (Jensen). (2014). A review of the performance of different ventilation and airflow distribution systems in buildings. Building and Environment, 73, 171–186. doi: https://doi.org/10.1016/j.buildenv.2013.12.009

12. Chenari, B., Dias Carrilho, J., Gameiro da Silva, M. (2016). Towards sustainable, energy-efficient and healthy ventilation strategies in buildings: A review. Renewable and Sustainable Energy Reviews, 59, 1426–1447. doi: https://doi.org/10.1016/j.rser.2016.01.074

13. Lei Z., Liu C., Wang L., Li N. (2017). Effect of natural ventilation on indoor air quality and thermal comfort in dormitory during winter. Building and Environment, 125, 240–247. doi: https://doi.org/10.1016/j.buildenv.2017.08.051

14. Cheng, Z., Li, L., Bahnfleth, W. P. (2016). Natural ventilation potential for gymnasia – Case study of ventilation and comfort in a multisport facility in northeastern United States. Building and Environment, 108, 85–98. doi: https://doi.org/10.1016/j.buildenv.2016.08.019

15. Panaras, G., Markogiannaki, M., Tolis, E. I., Sakellaris, Y., Bartzis, J. G. (2018). Experimental and theoretical investigation of air exchange rate of an indoor aquatic center. Sustainable Cities and Society, 39, 126–134. doi: https://doi.org/10.1016/j.scs.2018.02.012

16. Persily, A. (1997). Evaluating building IAQ and ventilation witn indoor carbon dioxide. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) annual meeting. Boston.

17. Karimipanah, T., Sandberg, M., Awbi, H. B. (2000). A comparative study of different air distribution systems in a classroom. Roomvent, 2, 1013–1018.

18. Federspiel, C. C. (1999). Air-Change Effectiveness: Theory and Calculation Methods. Indoor Air, 9(1), 47–56. doi: https://doi.org/10.1111/j.1600-0668.1999.t01-3-00008.x

19. Voigt, E., Pelikan, J. (2010). CO2-Measurement during Ventilation. Lübeck, 96.

20. Kapalo, P., Vilcekova, S., Voznyak, O. (2014). Using experimental measurements of the concentrations of carbon dioxide for determining the intensity of ventilation in the rooms. Chemical Engineering Transactions, 39, 1789–1794. doi: https://doi.org/10.3303/CET1439299

21. Kapalo, P., Voznyak, O. (2015). Experimental measurements of a carbon dioxide concentration for determining of a ventilation intensity in a room at pulsing mode. Journal of Civil Engineering, Environment and Architecture, XXXII (4/2015), 201–210. doi: https://doi.org/10.7862/rb.2015.189

22. Lee, K., Jiang, Z., Chen, Q. (2009). Air distribution effectiveness with stratified air distribution systems. ASHRAE Transactions, 115 (2). Available at: https://engineering.purdue.edu/~yanchen/paper/2009-9.pdf

23. Zhao, B., Li, X., Yan, Q. (2003). A simplified system for indoor airflow simulation. Building and Environment, 38 (4), 543–552. doi: https://doi.org/10.1016/s0360-1323(02)00182-8

24. El'terman, V. M. (1970). Ventilyaciya himicheskih proizvodstv. Moscow: Himiya, 240.

25. Korbut, V., Voznyak, O., Myroniuk, K., Sukholova, I., Kapalo, P. (2017). Examining a device for air distribution by the interaction of counter non-coaxial jets under alternating mode. Eastern-European Journal of Enterprise Technologies, 2 (8 (86)), 30–38. doi: https://doi.org/10.15587/1729-4061.2017.96774

26. Voznyak, O., Sukholova, I., Myroniuk, K. (2015). Research of device for air distribution with swirl and spread air jets at variable mode. Eastern-European Journal of Enterprise Technologies, 6 (7 (78)), 15–23. doi: https://doi.org/10.15587/1729-4061.2015.56235

27. Myroniuk, Kh. et. al. (2017). Air distribution by the interaction of counter non-coaxial jets. LAP LAMPART Academic Publishing, 43.

28. Zhukovsky, S., Klymenko, H. (2009). Experimental and analytical research of pressure effects inside the sectional source air distributor. Zeszyty naukowe Politechniki Rzeszowskiej. Budownictwo i inżynieria środowiska, 266, 151–157.

29. Voznyak, O. (2015). Air distribution in a room at pulsing mode and dynamic indoor climate creation. Cassotherm 2015, Non-Conference Proceedings of Scientific Papers – KEGA. Kosice, 31–36

METHOD OF AGRICULTURAL SEWAGE WATER PURIFICATION AT TROUGHS AND A BIOSORPTION BIOREACTOR (p. 15-24)

Anton Matsak
Ukrainian Scientific Research Institute of Ecological Problems, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-2856-9437

Kateryna Tsytlishvili
Ukrainian Scientific Research Institute of Ecological Problems, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-7468-0107

Olga Rybalova
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-8798-4780

Sergey Artemiev
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-9086-2856

Andrey Romin
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-3974-6702

Oleksandr Chynchyk
State Agrarian and Engineering University in Podilya, Kamianets-Podilskyi, Ukraine
ORCID: http://orcid.org/0000-0003-0566-2516

We proposed a method for sewage water purification of nitrogen and phosphorus compounds on a disk bioreactor of full displacement. The developed method of sewage water purification on a bioreactor of full displacement is very promising and we can use it for purification of sewage water, which contains a large amount of organic substances. The efficiency of purification of mineral nitrogen reaches 98.9 %, phosphates up to 40–50 %. The total nitrogen content decreases by 4–6 times and the total phosphorus content – by 2–2.5 times. We proposed combined purification of surface runoff from agricultural land and household or industrial sewage water on troughs with filtering nozzles and on a bioreactor of full displacement.

The conducted microbiological studies showed that the process of purification removes nitrogen compounds complexly: as a result of nitrite-denitrification and of the process of anoxide oxidation. We observed transformation of nitrogen mineral compounds under nitrification on the surface of biodisks in presence of oxygen and inside structural elements of biodisks, which is characteristic of anoxide oxidation during ANAMMOX process. Efficiency of purification of sewage water from the territories for agricultural purposes makes up: for suspended substances – 98 %; for mineral nitrogen – 99 %; for CCO – 99 %; for phosphates – 50 %. We can use the scheme of purification on troughs and a bioreactor of full displacement for sewage water of dairy industry, livestock farms, communal services, and surface runoff. Application of the proposed methods of sewage water purification will contribute to improvement of aquatic ecosystems.

Keywords: surface runoff, agricultural lands, purification, troughs, disk bioreactor of full displacement.

References

1. Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources.

2. Loboichenko, V. M., Tishakova, T. S., Vasyukov, A. E. (2016). Application of direct coulometry for rapid assessment of water quality in Krasno-Oskol Reservoir (Kharkiv Region, Ukraine). Der Pharma Chemica, 8 (19), 27–34.

3. Rybalova, O., Artemiev, S., Sarapina, M., Tsymbal, B., Bakhareva, A., Shestopalov, O., Filenko, O. (2018). Development of methods for estimating the environmental risk of degradation of the surface water state.

Eastern-European Journal of Enterprise Technologies, 2 (10 (92)), 4–17. doi: https://doi.org/10.15587/1729-4061.2018.127829

4. Vasenko, A., Rybalova, O., Kozlovskaya, O. (2016). A study of significant factors affecting the quality of water in the Oskil river (Ukraine). Eastern-European Journal of Enterprise Technologies, 3 (10 (81)), 48–55. doi: https://doi.org/10.15587/1729-4061.2016.72415

5. Zhang, H., Zhang, L., Li, J., An, R., Deng, Y. (2018). Climate and Hydrological Change Characteristics and Applicability of GLDAS Data in the Yarlung Zangbo River Basin, China. Water, 10 (3), 254. doi: https://doi.org/10.3390/w10030254

6. Lavrnić, S., Braschi, I., Anconelli, S., Blasioli, S., Solimando, D., Mannini, P., Toscano, A. (2018). Long-Term Monitoring of a Surface Flow Constructed Wetland Treating Agricultural Drainage Water in Northern Italy. Water, 10 (5), 644. doi: https://doi.org/10.3390/w10050644

7. Rozemeijer, J. C., Visser, A., Borren, W., Winegram, M., van der Velde, Y., Klein, J., Broers, H. P. (2016). High-frequency monitoring of water fluxes and nutrient loads to assess the effects of controlled drainage on water storage and nutrient transport. Hydrology and Earth System Sciences, 20 (1), 347–358. doi: https://doi.org/10.5194/hess-20-347-2016

8. Grewal, P. S., McCoy, E. L., Dick, W. A., Yang, H. (2009). Pat. No. US7967979B2. Bi-phasic bioretention system. No. 12/426,664; declareted: 20.04.2009; published: 28.06.2011.

9. Matsak, A., Tsytlishvili, K. (2018). Using different filter media of stormwater treatment performance. Norwegian Journal of development of the International Science, 1 (20), 19–22.

10. Stålnacke, P., Pengerud, A., Vassiljev, A., Smedberg, E., Mörth, C.-M., Hägg, H. E. et. al. (2015). Nitrogen surface water retention in the Baltic Sea drainage basin. Hydrology and Earth System Sciences, 19 (2), 981–996. doi: https://doi.org/10.5194/hess-19-981-2015

11. Dąbrowski, W., Horysz, M. (2016). Application of trickling filter for sewage treatment with high ammonia nitro gen concentration. Inżynieria Ekologiczna, 47, 89–94. doi: https://doi.org/10.12912/23920629/62852

12. Kłodowska, I., Rodziewicz, J., Janczukowicz, W. (2018). The Influence of Electrical Current Density and Type of the External Source of Carbon on Nitrogen and Phosphorus Efficiency Removal in the Sequencing Batch Biofilm Reactor. Journal of Ecological Engineering, 19 (5), 172–179. doi: https://doi.org/10.12911/22998993/89811

ANALYSIS OF CORRELATION DIMENSIONALITY OF THE STATE OF A GAS MEDIUM AT EARLY IGNITION OF MATERIALS (p. 25-30)

Boris Pospelov
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-0957-3839

Vladimir Andronov
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-7486-482X

Evgeniy Rybka
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-5396-5151

Ruslan Meleshchenko
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-5411-2030

Stella Gornostal
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-0789-7669

We have considered the application of the method of nonlinear dynamic systems in order to analyze and detect the structural patterns in the dynamics of increments in the state of a gas medium generated by early ignitions of materials in a non-sealed chamber. The research method is based on analysis of the correlation dimensionality of increments in the state of a gas medium during ignition of materials. We have theoretically justified the method for evaluating the dynamics of correlation dimensionality of increments in the state of a gas medium at ignition. The considered method for CD evaluation is based on the computation of the Grassberger-Procaccia correlation integral, applied to the gas medium state increments using a sliding window with a fixed width. That allowed us to derive a current estimate of CD increments in the state of the gas medium during ignition of flammable materials in a chamber synchronized with the observation data acquisition rate. We have analyzed the dynamics of correlation dimensionality of increments in the state of a gas medium at early ignition of alcohol, paper, wood, and textiles in a simulation chamber. It was established that for the investigated state of the gas medium during ignition of various examined materials, the dynamics of correlation dimensionality is within 0.1 to 0.6. It is noted that this fact testifies to the fractal structure of the considered increments in the state of a gas medium in a chamber and its chaotic dynamics at the emergence of ignition sites of tested materials. In this case, the fractal structure is not the same, suggesting a "transitional chaos" in the examined state of the gas medium. It was established that current estimates of the correlation dimensionality of increments in the state at the time of materials ignition tend to a sharp increase. A given fact can be used to reliably detect early fires indoors. The results obtained are important for the in-depth studying and understanding of patterns in the structure of dynamics of increments in the state of a gas medium at early ignition. It has been shown the increments in the states of a gas medium at premises characterize it as a chaotic dynamic system with a small fractal dimensionality as opposed to the traditional approach assuming a gas medium being either deterministic or random system.

Keywords: correlation dimensionality, increments in the state, gas medium, early ignition.

References

1. Vasiliev, M. I., Movchan, I. O., Koval, O. M. (2014). Diminishing of ecological risk via optimization of fire-extinguishing system projects in timber-yards. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 5, 106–113.

2. Kondratenko, O. M., Vambol, S. O., Strokov, O. P., Avramenko, A. M. (2015). Mathematical model of the efficiency of diesel particulate matter filter. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 6, 55–61.

3. Vasyukov, A., Loboichenko, V., Bushtec, S. (2016). Identification of bottled natural waters by using direct conductometry Ecology. Environment and Conservation, 22 (3), 1171–1176.

4. Semko, A. N., Beskrovnaya, M. V., Vinogradov, S. A., Hritsina, I. N., Yagudina, N. I. (2014). The usage of high speed impulse liquid jets for putting out gas blowouts. Journal of Theoretical and Applied Mechanics, 52 (3), 655–664.

5. Dubinin, D., Korytchenko, K., Lisnyak, A., Hrytsyna, I., Trigub, V. (2017). Numerical simulation of the creation of a fire fighting barrier using an explosion of a combustible charge. Eastern-European

Journal of Enterprise Technologies, 6 (10 (90)), 11–16. doi: https://doi.org/10.15587/1729-4061.2017.114504

6. Semko, A., Rusanova, O., Kazak, O., Beskrovnaya, M., Vinogradov, S., Gricina, I. (2015). The use of pulsed high-speed liquid jet for putting out gas blow-out. The International Journal of Multiphysics, 9 (1), 9–20. doi: https://doi.org/10.1260/1750-9548.9.1.9

7. Tiutiunyk, V. V., Ivanets, H. V., Tolkunov, I. A., Stetsyuk, E. I. (2018). System approach for readiness assessment units of civil defense to actions at emergency situations. Scientific Bulletin of National Mining University, 1, 99–105. doi: https://doi.org/10.29202/nvngu/2018-1/7

8. Pospelov, B., Andronov, V., Rybka, E., Meleshchenko, R., Borodych, P. (2018). Studying the recurrent diagrams of carbon monoxide concentration at early ignitions in premises. Eastern-European Journal of Enterprise Technologies, 3 (9 (93)), 34–40. doi: https://doi.org/10.15587/1729-4061.2018.133127

9. Turcotte, D. L. (1997). Fractals and chaos in geology and geophysics. Cambridge university press. doi: https://doi.org/10.1017/cbo9781139174695

10. Poulsen, A., Jomaas, G. (2011). Experimental Study on the Burning Behavior of Pool Fires in Rooms with Different Wall Linings. Fire Technology, 48 (2), 419–439. doi: https://doi.org/10.1007/s10694-011-0230-0

11. Zhang, D., Xue, W. (2010). Effect of heat radiation on combustion heat release rate of larch. Journal of West China Forestry Science, 39, 148.

12. Ji, J., Yang, L., Fan, W. (2003). Experimental study on effects of burning behaviours of materials caused by external heat radiation. JCST, 9, 139.

13. Peng, X., Liu, S., Lu, G. (2005). Experimental analysis on heat release rate of materials. Journal of Chongqing University, 28, 122.

14. Andronov, V., Pospelov, B., Rybka, E. (2017). Development of a method to improve the performance speed of maximal fire detectors. Eastern-European Journal of Enterprise Technologies, 2 (9 (86)), 32–37. doi: https://doi.org/10.15587/1729-4061.2017.96694

15. Pospelov, B., Andronov, V., Rybka, E., Skliarov, S. (2017). Design of fire detectors capable of self-adjusting by ignition. Eastern-European Journal of Enterprise Technologies, 4 (9 (88)), 53–59. doi: https://doi.org/10.15587/1729-4061.2017.108448

16. Pospelov, B., Andronov, V., Rybka, E., Skliarov, S. (2017). Research into dynamics of setting the threshold and a probability of ignition detection by selfadjusting fire detectors. Eastern-European Journal of Enterprise Technologies, 5 (9 (89)), 43–48. doi: https://doi.org/10.15587/1729-4061.2017.110092

17. Pospelov, B., Rybka, E., Meleshchenko, R., Gornostal, S., Shcherbak, S. (2017). Results of experimental research into correlations between hazardous factors of ignition of materials in premises. Eastern-European Journal of Enterprise Technologies, 6 (10 (90)), 50–56. doi: https://doi.org/10.15587/1729-4061.2017.117789

18. Bendat, J. S., Piersol, A. G. (2010). Random data: analysis and measurement procedures. John Wiley & Sons. doi: https://doi.org/10.1002/9781118032428

19. Shafi, I., Ahmad, J., Shah, S. I., Kashif, F. M. (2009). Techniques to Obtain Good Resolution and Concentrated Time-Frequency Distributions: A Review. EURASIP Journal on Advances in Signal Processing, 2009 (1). doi: https://doi.org/10.1155/2009/673539

20. Singh, P. (2016). Time-frequency analysis via the fourier representation. HAL. Available at: https://hal.archives-ouvertes.fr/hal-01303330

21. Pretrel, H., Querre, P., Forestier, M. (2005). Experimental Study Of Burning Rate Behaviour In Confined And Ventilated Fire Compartments. Fire Safety Science, 8, 1217–1228. doi: https://doi.org/10.3801/iafss.fss.8-1217

22. Pospelov, B., Andronov, V., Rybka, E., Popov, V., Romin, A. (2018). Experimental study of the fluctuations of gas medium parameters as early signs of fire. Eastern-European Journal of Enterprise Technologies, 1 (10 (91)), 50–55. doi: https://doi.org/10.15587/1729-4061.2018.122419

23. Stankovic, L., Dakovic, M., Thayaparan, T. (2014). Time-frequency signal analysis. Kindle edition, Amazon, 655.

24. Avargel, Y., Cohen, I. (2010). Modeling and Identification of Nonlinear Systems in the Short-Time Fourier Transform Domain. IEEE Transactions on Signal Processing, 58 (1), 291–304. doi: https://doi.org/10.1109/tsp.2009.2028978

25. Giv, H. H. (2013). Directional short-time Fourier transform. Journal of Mathematical Analysis and Applications, 399 (1), 100–107. doi: https://doi.org/10.1016/j.jmaa.2012.09.053

26. Pospelov, B., Andronov, V., Rybka, E., Popov, V., Semkiv, O. (2018). Development of the method of frequencytemporal representation of fluctuations of gaseous medium parameters at fire. Eastern-European Journal of Enterprise Technologies, 2 (10 (92)), 44–49. doi: https://doi.org/10.15587/1729-4061.2018.125926

27. Mandel'brot, B. (2002). Fraktal'naya geometriya prirody. Moscow: Institut komp'yuternyh issledovaniy, 656.

28. Andronov, V., Pospelov, B., Rybka, E., Skliarov, S. (2017). Examining the learning fire detectors under real conditions of application. Eastern-European Journal of Enterprise Technologies, 3 (9 (87)), 53–59. doi: https://doi.org/10.15587/1729-4061.2017.101985

DEVELOPMENT OF TECHNIQUES TO PREDICT AND PREVENT BOTH THE EFFECT OF XENOBIOTICS AND THEIR MIGRATION INTO PIG-DERIVED PRODUCTS (p. 31-39)

Oleksandr Nanka
Kharkiv Petro Vasylenko National Technical University of Agriculture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-4079-8822

Olga Chalaya
Kharkiv Petro Vasylenko National Technical University of Agriculture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-0189-6657

Sergiu Nagornij
Kharkiv Petro Vasylenko National Technical University of Agriculture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-7870-2342

Oleksandr Chalyi
Kharkiv State Zooveterinary Academy, Mala Danylivka, Dergachi district, Kharkiv region, Ukraine
ORCID: http://orcid.org/0000-0001-6159-9908

This paper reports research into the influence of heavy metals, specifically cadmium and plumbum, on the body of young pigs, and the effectiveness of the preparation to prevent intoxication with heavy metals. Heavy metals were fed separately and jointly, in doses that exceed the maximum permissible concentrations in fodder by 10 and 20 times. Thus, we have simulated the process of intoxication of a biological object (pigs) with heavy metals, which could happen as a result of environmental pollution. The study was carried out to determine the direction

and degree of influence of heavy metals on the live weight, the weight of internal organs of animals, the degree of accumulation in pig production, as well as determining the effectiveness of an anti–toxic additive that acts as a heavy metals detoxicant. Statistical processing of the acquired data made it possible to construct mathematical model and to establish the correlation relationship between the studied factors.

It was established that heavy metals exert a significant negative impact on the intensity of growth of animals with an elevated effect in proportion to the dose. This is confirmed by the high correlation connection between these attributes, the correlation coefficient (r) is equal to 0.854. Thus, the live weight of pigs at the end of the experiment both in series I and II under the action of chemotoxicants reduced by 5.5–14.8 % in comparison control. The strength of the impact depended on the toxin itself. Thus, the greatest negative effect was observed under the action of cadmium alone, as well as cadmium and plumbum together. The animals that received, against the background of intoxication with plumbum and cadmium, the antitoxic fodder additive, maintained the intensity of growth at the level of control, while, based on the results of series I, outperformed its indicators. Heavy metals mostly accumulated in the liver and kidneys, with the lowest level in the lungs, heart, and muscles. The constructed regression equations demonstrated that the main influence on the increase in the content of cadmium and plumbum in organs and meat is exerted by a rising dose of the respective element in the fodder. The content of plumbum in fodder affected the content of cadmium in meat, an increase in its concentration led to a decrease in the content of cadmium in meat.

The research data obtained allow better understanding of the direction and the extent of effect of heavy metals on biological objects. Mathematical models could be employed to predict the content of toxins in pig products.

Keywords: ecocidal impact, migration of xenobiotics, antitoxic additive, safe pig production.

References

1. Savchenko, Yu. I., Savchuk, I. M., Savchenko, M. H. (2016). Kontsentratsiya Pb i Cd u svynyni za vykorystannia v ratsionakh riznykh zernosumishei. Visnyk ahrarnoi nauky, 5, 21–24.
2. Ashok Kumar, G. (2015). Effects of Heavy Metals and Preventive Measures. RRJEES, 3 (1), 10–20.
3. Titov, A. F., Kaznina, N. M., Talanova, V. V. (2014). Tyazhelye metally i rasteniya. Petrozavodsk: Karel'skiy nauchniy centr RAN, 194.
4. Basiladze, G. V., Kalandiya, E. G. (2017). Vliyanie zagryaznennogo tyazhelymi metallami moloka na bezopasnost' molochnyh produktov. Innovacionnye tekhnologii v APK: teoriya i praktika: sbornik statey V Mezhdunarodnoy nauchno-prakticheskoy konferencii. Penza: RIO PGAU, 10–13.
5. Rybkin, V. S., Bogdanov, A. N., Chuykov, Yu. S., Teplaya, G. A. (2014). Tyazhelye metally kak faktor vozmozhnyh ekologicheski obuslovlennyh zabolevaniy v Astrahanskom regione. Gigiena i sanitariya, 2, 27–30.
6. Panagos, P., Van Liedekerke, M., Yigini, Y., Montanarella, L. (2013). Contaminated Sites in Europe: Review of the Current Situation Based on Data Collected through a European Network. Journal of Environmental and Public Health, 2013, 1–11. doi: https://doi.org/10.1155/2013/158764
7. Kroik, H. A. (2011). Toksykolohichni aspekty nakopychennia ta rozpodilu vazhkykh metaliv u gruntakh promyslovykh ahlomeratsiy. Bior-
8. iznomanittia ta rol tvaryn v ekosystemakh: Materialy VI Mizhnarodnoi naukovoi konferentsiyi. Dnipropetrovsk: Vyd-vo DNU, 15–18.
8. Kuranova, A. P., Ivanova, E. B. (2010). Tyazhelye metally kak ekotoksikanty. Prikladnaya toksikologiya, 1 (2), 14–17.
9. Burlaka, V. A., Hrabar, I. H., Mykytiuk, V. M. et. al.; Burlaka, V. A. (Ed.) (2012). Deterhenty suchasnosti. Zhytomyr: Vyd-vo «Zhytomyrskyi natsionalnyi ahroekolohichnyi universytet», 652.
10. Bokova, T. I. (2011). Ekologicheskie osnovy innovacionnogo sovershenstvovaniya pishchevyh produktov. Novosibirsk: Izd-vo NGAU, 284.
11. Yanovych, D. O., Yanovych, N. Ye. (2011). Biotransformatsiya ksenobiotykiv i mekhanizmy yikh rehuliatsiyi. Naukovyi visnyk Lvivskoho natsionalnoho universytetu veterynarnoi medytsyny ta biotekhnolohiyi im. S. Z. Hzhytskoho, 13 (2 (48)), 305–311.
12. Hassan, Z., Aarts, M. G. M. (2011). Opportunities and feasibilities for biotechnological improvement of Zn, Cd or Ni tolerance and accumulation in plants. Environmental and Experimental Botany, 72 (1), 53–63. doi: https://doi.org/10.1016/j.envexpbot.2010.04.003
13. Gonohova, M. (2008). Vliyanie na sviney tyazhelyh metallov v kormah. Zhivotnovodstvo Rossii, 12, 25–26.
14. Shatorna, V. F., Harets, V. I., Nefodova, O. O., Kryvoshei, V. V. (2016). Mekhanizmy vplyvu vazhkykh metaliv na morfofunktsionalnyi stan travnoi systemy. Visnyk problem biolohiyi i medytsyny, 1 (1 (126)), 57–61.
15. Boguslavskaya, N. V. (2010). Zagryaznenie okruzhayushchey sredy – vazhneyshiy faktor uhudsheniya produktivnogo zdorov'ya zhivotnyh. Ekologicheskaya bezopasnost' v APK. Referativniy zhurnal, 1, 224.
16. Romaniuk, A. M., Rudna, M. M., Rudna, V. M., Kuzenko, Ye. V. (2012). Vplyv nespryiatlyvykh faktoriv dovkillia (soli vazhkykh metaliv) na imunnu systemu (ohliad literatury). Visnyk Sumskoho derzhavnoho universytetu. Seriya: Medytsyna, 2, 36–41.
17. Chalaya, O. S. (2013). Rost i razvitie sviney na otkorme pri vysokih dozah kadmiya i svinca v racione. Izvestiya Orenburgskogo gosudarstvennogo agrarnogo universiteta, 2 (40), 158–160.
18. Chalaya, O. S. (2013). Deystvie kadmiya i svinca na organizm molodnyaka sviney na otkorme. Vestnik Kurskoy gosudarstvennoy sel'skohozyaystvennoy akademii, 8, 78–80.
19. Chalaia, O. S. (2012). Vidhodivelni ta zabiini yakosti svynei za vplyvu toksychnykh doz vazhkykh metaliv. Problemy zooinzhenerii ta veterynarnoi medytsyni, 24, 66–69.
20. Sharamok, T. S., Esipova, N. B., Fedonenko, O. V., Biletska, O. V. (2016). Ecological and hematological characteristics of common roach (rutilus rutilus linnaeus, 1758) in the zaporozhye reservoir. Biological Bulletin of Bogdan Chmelnitskiy Melitopol State Pedagogical University, 6 (2), 303–310.
21. Lane, E. A., Canty, M. J., More, S. J. (2015). Cadmium exposure and consequence for the health and productivity of farmed ruminants. Research in Veterinary Science, 101, 132–139. doi: https://doi.org/10.1016/j.rvsc.2015.06.004
22. MacLachlan, D. J., Budd, K., Connolly, J., Derrick, J., Penrose, L., Tobin, T. (2016). Arsenic, cadmium, cobalt, copper, lead, mercury, molybdenum, selenium and zinc concentrations in liver, kidney and muscle in Australian sheep. Journal of Food Composition and Analysis, 50, 97–107. doi: https://doi.org/10.1016/j.jfca.2016.05.015
23. Fiati Kenston, S. S., Su, H., Li, Z., Kong, L., Wang, Y., Song, X. et. al. (2018). The systemic toxicity of heavy metal mixtures in rats. Toxicology Research, 7 (3), 396–407. doi: https://doi.org/10.1039/c7tx00260b
24. López-Alonso, M., García-Vaquero, M., Benedito, J. L., Castillo, C., Miranda, M. (2012). Trace mineral status and toxic metal accumula-

tion in extensive and intensive pigs in NW Spain. Livestock Science, 146 (1), 47–53. doi: https://doi.org/10.1016/j.livsci.2012.02.019

25. Zhai, Q., Narbad, A., Chen, W. (2015). Dietary Strategies for the Treatment of Cadmium and Lead Toxicity. Nutrients, 7 (1), 552–571. doi: https://doi.org/10.3390/nu7010552

26. Dalia, M. (2010). El-Nahal Effect of using pectin on lead toxicity. The Journal of American Science, 6 (12), 541–554.

27. Butsiak, H. A., Cherevko, M. V., Sukhorska, O. P. (2010). Vykorystannia adsorbentiv ta antydotiv yak profilaktychnyi zasib poperedzhennia toksykoziv. Naukovyi visnyk LNUVMBT imeni S. Z. Gzhytskoho, 12 (3 (45)), 120–128.

28. Burlaka, V. A., Lavryniuk, O. O. (2016). Kumuliatyvnist vazhkykh metaliv u vnutrishni orhany svynei pry vkliuchenni sorbentiv, za umov dovhotryvalosti yikh nadkhodzhennia. Biodiversity after the Chernobyl accident, 34–40.

29. Lysenko, M. A. (2011). Snizhenie tyazhelyh metallov v organah i tkanyah pticy. Pticevodstvo, 2, 27–28.

30. Baranovskyi, D. I., Hetmanets, O. M., Khokhlov, A. M. (2017). Biometriya v prohramnomu seredovyshchi MS Excel. Kharkiv: SPD FO Brovin O. V., 90.

31. Lebed'ko, E. Ya., Hohlov, A. M., Baranovskiy, D. I., Getmanec, O. M. (2018). Biometriya v Excel. Sankt-Peterburg: EBS Lan', 172.

DEVELOPMENT AND STUDY OF HYDROMECHANICAL METHOD FOR CLEANING SEWAGE COLLECTORS FROM CONTAMINATION (p. 40–47)

Dmitriy Goncharenko
Kharkiv National University of
Construction and Architecture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-1278-0895

Sergey Zabelin
Operational area of the Industrial district
CE «Kharkovvodokanal», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-0318-0089

Alevtyna Aleinikova
Kharkiv National University of
Construction and Architecture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-2486-4263

Anna Anishchenko
Kharkiv National University of
Construction and Architecture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-3411-0385

Roman Hudilin
Kharkiv National University of
Construction and Architecture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-7218-2179

In connection with bad state of existing sewer headers, there is a great need for quick and high-quality cleaning for their further operation. To extend service life of distribution systems, new technologies for their repair and recovery are being developed which makes it possible to ensure their stable functioning and as a result, provision of continuous drinking water supply and sewer disposal to improve quality of life for population. From an economic point of view, extension of service life of distribution systems through development of alternative repair technologies is promising as it will ensure their sustainable operation in conditions of limited financing.

The proposed bucket design for cleaning the sewer headers has made it possible to identify the best option when using one design in different conditions.

A new design of the bucket was proposed which enables cleaning of the sewage headers either separately in a purely mechanical way or with additional use of the hydraulic method. Thanks to such combined method, it is possible to eliminate dirt which cannot be qualitatively done separately with each of the existing methods in various technical and economic conditions.

Purposefulness of application of the proposed method for cleaning sewage headers using the bucket of new design providing a combined method of operation was presented and justified. Examples of application of the new method for cleaning the headers using the bucket of new design were given. The obtained indicators confirm quality of the sewage header cleaning when working in various conditions, both technical (diameter, length and type of the header material, degree, and nature of foulness) and economic (work duration, energy, and water costs).

Thanks to the use of this method, 75...85 % dirt elimination in the sewage headers and pipelines have been achieved which confirms its effectiveness and possibility of reducing work duration as well as resource and energy saving in carrying out these works.

Keywords: sewage header, sewage pipeline, sewage network, cleaning method, sediment.

References

1. Programma razvitiya KP «Har'kovvodokanal» do 2026 goda (2012). Kharkiv.

2. Aleinikova, A. I., Volkov, V. M., Honcharenko, D. F., Zubko, H. H., Starkova, O. V. (2017). Metodolohichni osnovy podovzhennia ekspluatatsiynoho resursu pidzemnykh inzhenernykh merezh. Kharkiv: Raritety Ukrainy, 320.

3. Bondarenko, D. O., Bulhakov, V. V., Harmash, O. O., Honcharenko, D. F., Pilihram, S. S. (2018). Kanalizatsiyni tuneli Kharkova: QUO VADIS? Kharkiv: Raritety Ukrainy, 232.

4. Goncharenko, D., Aleinikova, A., Volkov, V., Zabelin, S. (2016). Research into the factors which influence efficiency of the water supply networks reconstruction by the «Berstlining» technology. Eastern-European Journal of Enterprise Technologies, 6 (1 (84)), 21–28. doi: https://doi.org/10.15587/1729-4061.2016.85865

5. Aleinikova, A. (2016). Method for evaluating the economic efficiency of water supply lines restoration based on teleinspection results. Actual Problems of Economics, 8, 224–228.

6. Rehabilitation von Rohrleitungen: Sanierung und Erneuerung von Ver- und Entsorgungsnetzen (2015). Bauhaus-Universitätsverlag Weimar, 420.

7. Körkemeyer, K. (2015). State-of-the-art sewer construction using precast elements. Moderner Kanalbau mit Betonbauteilen – Qualitätssicherung und Fehlervermeidung. 59. BetonTage, Neu-Ulm 2015. Betonwerk- und Fertigteiltechnik (BFT), 180–183.

8. Praetorius, S., Schößer, B. (2015). Bentonithandbuch. Ringspaltschmierung für den Rohrvortrieb Bauingenieur-Praxis. Kartoniert Ernst & Sohn, 232.

9. Sterling, R., Alam, S., Allouche, E., Condit, W., Matthews, J., Downey, D. (2016). Studying the Life-cycle Performance of Gravity Sewer Rehabilitation Liners in North America. Procedia Engineering, 165, 251–258. doi: https://doi.org/10.1016/j.proeng.2016.11.797

10. Ellgass, R., Jeyapalan, J. K., Gipson, B., Biesalski, M., Miles, W., Leffler, S. et. al. (2015). An Evaluation of Trenchless Point Repair

Solutions for Pipes of Varying Inner Diameter and Offset Joints. Pipelines 2015. doi: https://doi.org/10.1061/9780784479360.124

11. Teimouri Sendesi, S. M., Ra, K., Conkling, E. N., Boor, B. E., Nuruddin, M., Howarter, J. A. et. al. (2017). Worksite Chemical Air Emissions and Worker Exposure during Sanitary Sewer and Stormwater Pipe Rehabilitation Using Cured-in-Place-Pipe (CIPP). Environmental Science & Technology Letters, 4 (8), 325–333. doi: https://doi.org/10.1021/acs.estlett.7b00237

12. Wilson, D., Filion, Y., Moore, I. (2015). State-of-the-art review of water pipe failure prediction models and applicability to large-diameter mains. Urban Water Journal, 14 (2), 173–184. doi: https://doi.org/10.1080/1573062x.2015.1080848

13. Bakry, I., Alzraiee, H., Kaddoura, K., El Masry, M., Zayed, T. (2016). Condition Prediction for Chemical Grouting Rehabilitation of Sewer Networks. Journal of Performance of Constructed Facilities, 30 (6), 04016042. doi: https://doi.org/10.1061/(asce)cf.1943-5509.0000893

14. Kaushal, V., Young, V. (2017). Microbiologically Induced Concrete Corrosion in Sanitary Sewer Systems. Trenchless Technology and Pipe Conference TX. The University of Texas, Arlington, TX. doi: https://doi.org/10.13140/RG.2.2.11061.47844/1

15. Almahakeri, M., Moore, I. D., Fam, A. (2017). Numerical Study of Longitudinal Bending in Buried GFRP Pipes Subjected to Lateral Earth Movements. Journal of Pipeline Systems Engineering and Practice, 8 (1), 04016012. doi: https://doi.org/10.1061/(asce)ps.1949-1204.0000237

16. ROTHENBERGER. Available at: https://rothenberger.com/de-de/

17. Tekhnologii gorizontal'no-napravlennogogo bureniia. Available at: http://intelpipe.by/technolgies/pipeline-flushing/method/

18. Böhm, A. (1993). Betrieb, Instandhaltung und Erneuerung des Wasserrohrnetzes. Essen: Vulkan-Veriag, 65.

19. Nezat, II, M. A. (Rusty) (2003). An Innovative Method for Cleaning Large Bore Sewer. New Pipeline Technologies, Security, and Safety. doi: https://doi.org/10.1061/40690(2003)105

20. Attaf, B. (2015). Eco-technique of sewer renovation using composite shells: structural analysis. Journal of Fundamental and Applied Sciences, 3 (2), 144. doi: https://doi.org/10.4314/jfas.v3i2.3

21. Bulgakov, Yu. V. (2015). Issledovanie processa razrusheniya konstrukciy kanalizacionnogo tonnel'nogo kollektora. Naukovyi visnyk budivnytstva, 5 (79), 79–84.

22. Goncharenko, D. F., Karzhinerova, T. I., Zabelin, S. A., Kurovskiy, I. I. (2010). Podgotovka k remontu kanalizacionnyh kollektorov. Naukovyi visnyk budivnytstva, 58, 284–290.

23. Zabelin, S. A., Aleinikova, A. I., Anishchenko, A. I. Zaiavka na otrymannia patentu Ukrainy na vynakhid No. a201805537 vid 18.05.2018 r. «Kivsh dlia ochyshchennia kanalizatsiynykh kolektoriv».

24. Zabelin, S. A., Storozhuk, Yu. V., Vlasenko, O. M., Bulhakov, V. V. (2010). Pat. No. 51598 UA. Sposib mekhanichnoi prochystky kanalizatsiynoho truboprovodu. MPK (2009) E03F 3/00. No. u201000158; declareted: 11.01.2010; published: 26.07.2010, Bul. No. 14.

25. Metody ekspertnyh ocenok. Available at: https://habr.com/post/189626/

26. Khovanskyi, S. O., Nenia, V. H. (2010). System analysis of the complex water supply and distribution of housing and communal services. Eastern-European Journal of Enterprise Technologies, 4 (4 (46)), 56–59. Available at: http://journals.uran.ua/eejet/article/view/2967/2770

DEVELOPMENT OF COMBINED METHOD FOR PREDICTING THE PROCESS OF THE OCCURRENCE OF EMERGENCIES OF NATURAL CHARACTER (p. 48-55)

Hryhorii Ivanets
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-4906-5265

Stanislav Horielyshev
National Academy of National Guard of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-1689-0901

Mykhailo Ivanets
Ivan Kozhedub Kharkiv University of Air Force, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-3106-7633

Dmitro Baulin
National Academy of National Guard of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-7082-6954

Ihor Tolkunov
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-5129-3120

Natalia Gleizer
Ukrainian State University of Railway Transport, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-9302-0681

Aleksandr Nakonechnyi
Ivan Kozhedub Kharkiv University of Air Force, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-9659-9681

We developed a combined method for forecasting of the process of occurrence of emergency situations of a natural character. In contrast with other methods, it makes it possible to perform a complex forecasting of emergency situations, both in general and by types, taking into consideration trends of periodic changes in the process. We considered a number of emergencies for a certain period of time as a generalized parameter of the process. Taking into consideration an influence impact of all destabilizing factors, we should present the process in the form of an additive mixture of systematic, periodic, and random components. The systematic component is a polynomial of some degree. We performed detection and assessment of the periodic component based on the statistical criterion, which subordinates to the chi-square distribution. We used the method of group consideration of arguments to forecast the random component. We should carry out forecasting of emergency situations by type by the probabilistic-statistical method of forecasting.

The need to develop a combined forecasting method appears is due to that the existing methods for forecasting of emergency situations focus mainly on forecasting of certain types of emergency situations. Existing methods do not solve the problem of complex forecasting of emergency situations. We should also note that the presence of periodic components of an arbitrary form is characteristic for the process of occurrence of natural emergencies. Consideration of such components in the forecasting of emergency situations makes analysis of the processes of occurrence and development of emergency situations deeper.

In the process of experimental studies, we found that the use of the combined method makes it possible to perform forecasting of emergency situations at least a year ahead with a relative forecast error of no more than three percent.

The combined method combines the regression analysis method, the method of verification of statistical hypotheses and the method of group consideration of argument. This proves usefulness and expedience of the method. That makes it possible to compensate disadvantages of some methods using other methods, which would lead to the improvement of forecast accuracy.

Keywords: emergency, generalized parameter, method of group consideration of arguments, method of verification of statistical hypotheses, regression analysis.

References

1. Zvit pro osnovni rezultaty diyalnosti Derzhavnoi sluzhby Ukrainy z nadzvychainykh sytuatsiy u 2017 rotsi. Available at: http://www.dsns.gov.ua/files/2018/1/26/Zvit%202017(КМУ).pdf

2. Guskova, N. D., Neretina, E. A. (2013). Threats of natural character, factors affecting sustainable development of territories and their prevention. Zbornik Radova Geografskog Instituta Jovan Cvijic, SANU, 63 (3), 227–237. doi: https://doi.org/10.2298/ijgi1303227g

3. Dubinin, D., Korytchenko, K., Lisnyak, A., Hrytsyna, I., Trigub, V. (2017). Numerical simulation of the creation of a fire fighting barrier using an explosion of a combustible charge. Eastern-European Journal of Enterprise Technologies, 6 (10 (90)), 11–16. doi: https://doi.org/10.15587/1729-4061.2017.114504

4. Ivanets, H. V. (2016). Analiz stanu tekhnohennoi, pryrodnoi ta sotsialnoi nebezpeky administratyvno-terytorialnykh odynyts Ukrainy na osnovi danykh monitorynhu. Zbirnyk naukovykh prats Kharkivskoho universytetu Povitrianykh Syl, 3, 142–145.

5. Tiutiunyk, V. V., Ivanets, H. V., Tolkunov, I. A., Stetsyuk, E. I. (2018). System approach for readiness assessment units of civil defense to actions at emergency situations. Scientific Bulletin of National Mining University, 1, 99–105. doi: https://doi.org/10.29202/nvngu/2018-1/7

6. Nivolianitou, Z., Synodinou, B. (2011). Towards emergency management of natural disasters and critical accidents: The Greek experience. Journal of Environmental Management, 92 (10), 2657–2665. doi: https://doi.org/10.1016/j.jenvman.2011.06.003

7. Golovan, Yu. V., Kozyr', T. V. (2015). Zashchita naseleniya v chrezvychaynyh situaciyah. Organizacionno-metodicheskiy kompleks. Moscow: Prospekt, 219.

8. Neisser, F., Runkel, S. (2017). The future is now! Extrapolated riskscapes, anticipatory action and the management of potential emergencies. Geoforum, 82, 170–179. doi: https://doi.org/10.1016/j.geoforum.2017.04.008

9. Novoselov, S. V., Panikhidnikov, S. A. (2017). Problems in prediction of number of emergencies by statistical methods. Mining Informational and Analytical Bulletin, 10, 60–71. doi: https://doi.org/10.25018/0236-1493-2017-10-0-60-71

10. Kryanev, A., Ivanov, V., Romanova, A., Sevastianov, L., Udumyan, D. (2018). Extrapolation of Functions of Many Variables by Means of Metric Analysis. EPJ Web of Conferences, 173, 03014. doi: https://doi.org/10.1051/epjconf/201817303014

11. McCarthy, J., Graniero, P., Rozic, S. (2008). An Integrated GIS-Expert System Framework for Live Hazard Monitoring and Detection. Sensors, 8 (2), 830–846. doi: https://doi.org/10.3390/s8020830

12. Vasiliev, M., Movchan, I., Koval, O. (2014). Diminishing of ecological risk via optimization of fire-extinguishing system projects in timber-yards. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 5, 106–113.

13. Migalenko, K., Nuianzin, V., Zemlianskyi, A., Dominik, A., Pozdieiev, S. (2018). Development of the technique for restricting the propagation of fire in natural peat ecosystems. Eastern-European Journal of Enterprise Technologies, 1 (10 (91)), 31–37. doi: https://doi.org/10.15587/1729-4061.2018.121727

14. Junk, C., Delle Monache, L., Alessandrini, S., Cervone, G., von Bremen, L. (2015). Predictor-weighting strategies for probabilistic wind power forecasting with an analog ensemble. Meteorologische Zeitschrift, 24 (4), 361–379. doi: https://doi.org/10.1127/metz/2015/0659

15. Cheyas, I. A., Smith, L. S. (2009). Neural Network Approach to Time Series Forecasting. Proceedings of the World Congress on Engineering. London, 2. Available at: http://www.iaeng.org/publication/WCE2009/WCE2009_pp1292-1296.pdf

16. Morariu, N., Iancu, E., Vlad, S. (2009). A neural network model for time series forecasting. Romanian Journal of Economic Forecasting, 4, 213–223.

17. Hinman, J., Hickey, E. (2009). Modeling and forecasting sort-term electricity load using regression analysis. Journal of Institute for Regulatory Policy Studies. Available at: https://irps.illinoisstate.edu/downloads/research/documents/LoadForecastingHinman-HickeyFall2009.pdf

18. Mazengia, D. H. (2008). Forecasting Spot Electricity Market Prices Using Time Series Models. Gothenburg, 89.

19. Pradhan, R. P., Kumar, R. (2010). Forecasting Exchange Rate in India: An Application of Artificial Neural Network Model. Journal of Mathematics Research, 2 (4), 111–117. doi: https://doi.org/10.5539/jmr.v2n4p111

20. Al-Jumeily, D., Ghazali, R., Hussain, A. (2014). Predicting Physical Time Series Using Dynamic Ridge Polynomial Neural Networks. PLoS ONE, 9 (8), e105766. doi: https://doi.org/10.1371/journal.pone.0105766

21. Szoplik, J. (2015). Forecasting of natural gas consumption with artificial neural networks. Energy, 85, 208–220. doi: https://doi.org/10.1016/j.energy.2015.03.084

22. Yohannes, Y., Webb, P. (1999). Classification and regression tress: A User Manual for Identifying Indicators of Vulnerability to Famine and Chronis Food Insecurity. International Food Policy Research Institute, 59. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1.1523&rep=rep1&type=pdf

23. Ivanets, H. V., Tolkunov, I. O., Stetsiuk, Ye. I. (2016). Model protsesu zminy uzahalnenykh parametriv nadzvychainykh sytuatsiy pryrodnoho kharakteru. Problemy nadzvychainykh sytuatsiy, 23, 46–52.

24. Ivahnenko, A. G., Lapa, V. G. (1971). Predskazanie sluchaynyh processov. Kyiv: Naukova dumka, 416.

25. Ivanec, G. V. (2017). Odin iz metodov ocenivaniya periodicheskoy sostavlyayushchey lyuboy formy sluchaynogo processa pri proizvol'noy dline realizacii izmeryaemogo parametra. Zbirnyk naukovykh prats Kharkivskoho universytetu Povitrianykh Syl, 1 (50), 38–41.

26. Stepashko, V. S. (2017). Dostizheniya i perspektivy induktivnogo modelirovaniya. Upravlyayushchie sistemy i mashiny, 2, 58–73.

27. Balasyanyan, S. Sh., Gevorgyan E. M. (2016). Sravnitel'niy analiz metodov regressii i metoda gruppovogo ucheta argumentov pri modelirovanii processov pererabotki poleznyh iskopaemyh. Izvestiya Tomskogo politekhnicheskogo universiteta. Inzhiring geo-resursov, 327 (4), 23–34.

28. Natsionalna dopovid pro stan tekhnohennoi ta pryrodnoi bezpeky v Ukraini u 2013 rotsi (2014). Kyiv, 542.

DEVELOPMENT OF PROCEDURE FOR ASSESSING THE DEGREE OF ENVIROMENTAL HAZARD FROM THE SOURCES OF AQUATIC ENVIRONMENT POLLUTION (p. 56-65)

Nataliya Magas
Admiral Makarov National University of Shipbuilding,
Mykolaiv, Ukraine
ORCID: http://orcid.org/0000-0002-2579-1465

Ganna Trokhymenko
Admiral Makarov National University of Shipbuilding,
Mykolaiv, Ukraine
ORCID: http://orcid.org/0000-0002-0835-3551

Volodymyr Blahodatnyi
Admiral Makarov National University of Shipbuilding,
Mykolaiv, Ukraine
ORCID: http://orcid.org/0000-0003-0462-2651

The new procedure for evaluation of the degree of environmental safety of water sites based on the comparison of the influence of separate point sources of sewage discharge was developed. The use of this procedure will make it possible to solve the problem of identifying ecologically dangerous sites and to determine priority directions of aquatic sites protection in the region. The essence of this procedure is to assess the environmental hazard of specific facilities of the national economy taking into account the safety level, the degree of influence on the water quality of an aquatic site, effectiveness of monitoring and the magnitude of anthropogenic load.

The logical-mathematical model of evaluating the impact of sources of water environment pollution, based on determining the coefficients of conditions of sewage discharge, sewage pollution and the load on an aquatic site, was proposed. The degree of environmental hazard of the sources of pollution of aquatic sites was determined by the value of coefficient of harmful influence of a pollution source on aquatic sites by the five-level scale from "safe" to "extremely hazardous". The designed scale corresponds to the environmental classification of the Water Framework Directive of the EU 2000/60/EU.

Testing of the developed procedure was performed on an example of the section of a river basin that is typical for territorial production complexes, where the facilities of nuclear power industry, industrial manufacturing and public utilities are located. Based on determining block and total coefficient of harmful influence of the sources of pollution of aquatic sites, we developed the map of ecological hazard of the sources of the river basin pollution. The sources of pollution of aquatic sites were classified by the designed scale. It was established that large enterprises of housing and communal services and the facilities of machine-building industry have the greatest degree of environmental hazard. These facilities belong to class II and are described as "hazardous'. Enterprises of atomic power and hydropower plants belong to class III of hazard − "moderately hazardous".

Results of the analysis can be used to develop water resources management strategies and measures to reduce the impact of pollution sources on aquatic sites.

Keywords: environmental safety, pollution source, harmful influence, load on aquatic site.

References

1. Magas, N., Gomelya, M. (2018). Assessment of the current state of water quality in the tributaries of the Southern Bug river. Scientific Letters of Academic Society of Michal Baludansky, 6 (2A), 122–129.

2. Mahas, N. I., Trokhymenko, H. H. (2013). Otsinka suchasnoho antropohennoho navantazhennia na basein richky Pivdennyi Buh. Ekolohichna bezpeka, 2, 48–52.

3. Klymenko, M. O., Hrokhovska, Yu. R. (2005). Otsinka ekolohichnoho stanu vodnykh ekosystem richok baseinu Prypiati za vyshchymy vodnymy roslynamy. Rivne, 194.

4. Udod, V. M., Trofimovych, V. V., Yatsiv, M. Yu. (2010). Ekolohichni kryteriyi otsinky yakosti vody hidroekosystem na prykladi vodozbirnoho baseinu r. Prut. Ekolohichna bezpeka ta pryrodokorystuvannia, 1, 84–93.

5. Klimenko, N. A., Liho, E. A. (2003). Ekologicheskoe sostoyanie rek Poles'ya Ukrainy. Aktual'nye ekologicheskie problemy Respubliki Tatarstan, 153–154.

6. Likho, O. A., Bondarchuk, I. A. (2010). Udoskonalennia metodyky otsinky ekolohichnoho stanu baseiniv malykh richok. Zbirnyk materialiv II Vseukrainskoho zizdu ekolohiv z mizhnarodnoiu uchastiu. Vinnytsia. Available at: http://eco.com.ua/sites/eco.com.ua/files/lib1/konf/2vze/zb_m/0035_zb_m_2VZE.pdf

7. Rybalova, O., Artemiev, S. (2017). Development of a procedure for assessing the environmental risk of the surface water status deterioration. Eastern-European Journal of Enterprise Technologies, 5 (10 (89)), 67–76. doi: https://doi.org/10.15587/1729-4061.2017.112211

8. Rybalova, O., Artemiev, S., Sarapina, M., Tsymbal, B., Bakhareva, A., Shestopalov, O., Filenko, O. (2018). Development of methods for estimating the environmental risk of degradation of the surface water state. Eastern-European Journal of Enterprise Technologies, 2 (10 (92)), 4–17. doi: https://doi.org/10.15587/1729-4061.2018.127829

9. Vasenko, A., Rybalova, O., Kozlovskaya, O. (2016). A study of significant factors affecting the quality of water in the Oskil river (Ukraine). Eastern-European Journal of Enterprise Technologies, 3 (10 (81)), 48–55. doi: https://doi.org/10.15587/1729-4061.2016.72415

10. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (2000). Official Journal of the European Communities. L. 327, 72.

11. Water Resource Management in Germany. Part 1. Fundamentals (2014). Berlin, 150. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/wawi_teil_01_englisch_barrierefrei.pdf

12. Water Resource Management in Germany. Part 2. Water Quality (2014). Berlin, 114. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/wawi_teil_02_englisch_barrierefrei.pdf

13. Arle, J., Mohaupt, V., Kirst, I. (2016). Monitoring of Surface Waters in Germany under the Water Framework Directive – A Review of Approaches, Methods and Results. Water, 8 (6), 217. doi: https://doi.org/10.3390/w8060217

14. Wang, X., Wen, J., Chen, P., Liu, N. (2018). Monitoring and Assessment of Youshui River Water Quality in Youyang. IOP Conference Series: Earth and Environmental Science, 113, 012069. doi: https://doi.org/10.1088/1755-1315/113/1/012069

15. Wu, Z., Zhang, D., Cai, Y., Wang, X., Zhang, L., Chen, Y. (2017). Water quality assessment based on the water quality index method in Lake Poyang: The largest freshwater lake in China. Scientific Reports, 7 (1). doi: https://doi.org/10.1038/s41598-017-18285-y

16. Szczerbiñska, N., Gałczyñska, M. (2015). Biological methods used to assess surface water quality. Archives of Polish Fisheries, 23 (4), 185–196. doi: https://doi.org/10.1515/aopf-2015-0021

17. Petry, C. T., Costa, G. M. da, Benvenuti, T., Rodrigues, M. A. S., Droste, A. (2016). Integrated assessment of chemical quality and genotoxicity of the water of the Luiz Rau Stream in the lower stretch of the Sinos River Basin, in South Brazil. Ambiente e Agua – An Interdisciplinary Journal of Applied Science, 11 (4), 878–890. doi: https://doi.org/10.4136/ambi-agua.1779

18. Florencio Ballesteros, M. A. P. (2015). A New Approach to Evaluate the Ecological Status of a River by Visual Assessment. Journal of Waste Water Treatment & Analysis, 06 (01). doi: https://doi.org/10.4172/2157-7587.1000185

19. Von der Ohe, P. C., Dulio, V., Slobodnik, J., De Deckere, E., Kühne, R., Ebert, R.-U. et. al. (2011). A new risk assessment approach for the prioritization of 500 classical and emerging organic microcontaminants as potential river basin specific pollutants under the European Water Framework Directive. Science of The Total Environment, 409 (11), 2064–2077. doi: https://doi.org/10.1016/j.scitotenv.2011.01.054

20. Slobodnik, J., Mrafkova, L., Carere, M., Ferrara, F., Pennelli, B., Schüürmann, G., von der Ohe, P. C. (2012). Identification of river basin specific pollutants and derivation of environmental quality standards: A case study in the Slovak Republic. TrAC Trends in Analytical Chemistry, 41, 133–145. doi: https://doi.org/10.1016/j.trac.2012.08.008

21. Daginnus, K., Gottardo, S., Payá-Pérez, A., Whitehouse, P., Wilkinson, H., Zaldívar, J.-M. (2011). A Model-Based Prioritisation Exercise for the European Water Framework Directive. International Journal of Environmental Research and Public Health, 8 (2), 435–455. doi: https://doi.org/10.3390/ijerph8020435

22. Snizhko, S. I. (2001). Otsinka ta prohnozuvannia yakosti pryrodnykh vod. Kyiv: Nika-Tsentr, 264.

23. Ekolohichna otsinka yakosti poverkhnevykh vod sushi ta estuariyv Ukrainy (1994). KND 211.1.4.010-94. Kyiv, 37.

24. Metodyka ekolohichnoi otsinky yakosti poverkhnevykh vod za vidpovidnymy katehoriyamy (2012). Kharkiv, 37.

25. Metodyka rozrakhunku antropohennoho navantazhennia i klasyfikatsiyi ekolohichnoho stanu baseiniv malykh richok Ukrainy (2007). Kyiv: Polimed, 71.

CURRENT DISTRIBUTION OF ^{137}Cs IN SOD-PODZOLIC SOILS OF DIFFERENT TYPES OF FOREST CONDITIONS (p. 65-71)

Viktoriia Melnyk
Zhytomyr State Technological University, Zhytomyr, Ukraine
ORCID: http://orcid.org/0000-0002-3551-5085

Tatiana Kurbet
Zhytomyr State Technological University, Zhytomyr, Ukraine
ORCID: http://orcid.org/0000-0001-7820-4263

We have examined the current distribution of ^{137}Cs in the turf-podzolic forest soils for different types of forest conditions. The analysis of the redistribution of ^{137}Cs in soil in 30 years after the Chernobyl nuclear plant accident is necessary in order to assess the intake of the radionuclide by the various components of forest ecosystems and to substantiate the rehabilitation of forest areas. We have discovered a significant displacement of significant amount of ^{137}Cs to mineral part of the soil in all types of forest conditions under consideration. The maximum magnitudes of the ^{137}Cs specific activity in the forest litter were established, as well as a reduction in this indicator from its upper part (current litter) to the bottom (decomposed). In fresh forests, it reduced by 3.1 times; in fresh subors, by 1.2 times; in wet subors, by 1.5 times. Based on the magnitude of specific activity of ^{137}Cs, the layers of the forest litter for the examined types of forest conditions can be placed in a descending order: decomposed layer > semi-decomposed layer > current litter. The humus-eluvial horizon of the soil with a capacity of 12 cm has concentrated: in fresh forests, 54.0 %; in fresh subors, 40.0 %; in wet subors, 52.8 %, of the total radionuclide activity in the soil, and, together with the content of ^{137}Cs in the forest litter, 75.0 %; 65.8 %, and 71.5 % (according to the type of forest conditions). We have noted a gradual decrease in the ^{137}Cs specific activity along the profile to the parent rock. Thus, 26.4 %, 35.7 %, and 28.5 %, respectively, of the total stock of the radionuclide in the soil, have migrated to the lower layers of the soil profile (12–88 cm). The obtained materials have been confirmed by a one-factor dispersion analysis at a 95-% confidence level. Based on the results obtained, one can predict the future levels of radioactive contamination in forestry products.

Keywords: ^{137}Cs, radioactive contamination, specific activity, forest plantations, sod-podzolic soils.

References

1. Karachov, I. I. (2006). Problemy radioaktyvnoho zabrudnennia kharchovykh produktiv lisu i vnutrishnie oprominennia naselennia. Problemy kharchuvannia, 1, 8–13.

2. Pozniak, S. P. (2010). Gruntoznavstvo i heohrafiya gruntiv. Lviv: LNU imeni Ivana Franka, 555.

3. Krasnov, V. P., Orlov, O. O., Vedmid, M. M. (2009). Atlas roslyn-indykatoriv i typiv lisoroslynnykh umov Ukrainskoho Polissia. Novohrad-Volynskyi, 488.

4. Arkhypov, A. M., Meleshyn, A. Yu., Mieshalkin, H. S., Paskevych, V. A., Arkhypov, M. P. (1997). Kilkisna otsinka vertykalnoi mihratsiyi ^{137}Cs ta ^{90}Sr v gruntakh zony vidchuzhennia. Nauka. Chornobyl-96: Zbirka tez. naukovo-prakt. konf. Kyiv, 69.

5. Didenko, L. G. (2000). K voprosu o formakh nahozhdeniya ^{137}Cs v lesnykh pochvakh. Problemy lesovedeniya i lesovodstva, 51, 223–228.

6. Irklienko, S. P., Krasnov, V. P., Orlov, A. A., Pristupa, G. K. (1995). Raspredelenie radioceziya v pochve i v sosne obyknovennoy v zavisimosti ot tipov usloviy proizrastaniya. Ekologicheskiy status zagryaznennykh radionuklidami territoriy: Sb. tez. dokl. Mezhdunar. sov. po Chernobyl'skoy ekologicheskoy issledovatel'skoy seti. Minsk, 60.

7. Shcheglov, A. I., Tihomirov, F. A., Cvetnova, O. B., Klyashtorin, A. L., Mamihin S. V. (1996). Biogeohimiya radionuklidov chernobyl'skogo vybrosa v lesnykh ekosistemah evropeyskoy chasti SNG. Radiacionnaya biologiya. Radioekologiya, 36 (4), 437–446.

8. Rühm, W., Steiner, M., Wirth, E., Dvornik, A., Zhuchenko, T., Kliashtorin, A. et. al. (1996). Dynamic of radionuclides behaviour in forest soils. The radiological consequences of the Chornobyl accident: Proc. of the first internat. conf. Luxembourg, 225–228.

9. Bulko, N. I., Mashkov, I. A., Tolkacheva, N. V., Moskalenko, N. V., Kozlov, A. K. (2016). O sostoyanii lesov i lesnykh zemel' zon otseleniya v kontekste vozmozhnostey ih reabilitacii. Problemy lesovedeniya i lesovodstva, 76, 363–370.

10. Bulko, N. I., Shabaleva, M. A., Mitin, N. V., Tolkacheva, N. V., Kozlov, A. K. (2016). Dinamika dlitel'nyh processov postupleniya ^{137}Cs v komponenty fitomassy sosny obyknovennoy iz avtomorfnyh

pochv v dal'ney zone avarii na ChAES. Problemy lesovedeniya i lesovodstva, 76, 371–379.

11. Bulko, N. I., Shabaleva, M. A., Mitin, N. V., Tolkacheva, N. V., Kozlov, A. K. (2015). Osobennosti dlitel'nyh processov migracii 137Cs na avtomorfnyh i gidromorfnyh pochvah sosnovyh fitocenozov v dal'ney zone avarii na ChAES. Problemy lesovedeniya i lesovodstva, 75, 391–404.

12. Perevolockiy, A. N., Bulavik, I. M., Perevolockaya, T. V. et. al. (2007). Osobennosti raspredeleniya 137Cs i 90Sr v pochve i nakopleniya drevesinoy i koroy sosny (Pinus sylvestrisL.) v razlichnyh usloviyah mestoproizrastaniya. Radiacionnaya biologiya. Radioekologiya, 47 (4), 463–470.

13. Garbaruk, D. K. (2015). Raspredelenie zapasa 137Cs v lesnoy podstilke i pochve dominiruyushchih tipov lesa sosnovoy formacii blizhney zony avarii na Chernobyl'skoy AES. Problemy lesovedeniya i lesovodstva, 75, 412–419.

14. Bulko, N. I. (2014). Transformaciya form nahozhdeniya 137Cs v pochvah nasazhdeniy razlichnogo sostava v dal'ney zone Chernobyl'skoy katastrofy spustya chetvert' veka. Problemy lesovedeniya i lesovodstva, 74, 380–391.

15. Krasnov, V. P., Kurbet, T. V., Shelest, Z. M., Boyko, A. L. (2015). ^{137}Cs distribution in sod-podzol forest soil of Ukrainian Polissia. Nuclear Physics and Atomic Energy, 16 (3), 247–253. doi: https://doi.org/10.15407/jnpae2015.03.247

16. Varfolomeeva, K. V. (2008). Peculiarities of radioactive contamination of the forest ecosystem after the Chernobyl accident. Radiation Hygiene, 1 (3), 49–54.

17. Pronevych, V. A. (2014). Mihratsiya 137Cs u lisovykh biotsenozakh Polissia. Naukovyi visnyk NLTU Ukrainy, 24.7, 145–150.

18. Boiko, O. L. (2012). Rozpodil sumarnoi aktyvnosti ^{137}Cs u lisovykh fitotsenozakh. Lisivnytstvo i ahrolisomelioratsiya, 120, 87–94.

19. Krasnov, V. P., Kurbet, T. V., Shelest, Z. M., Boiko, O. L. (2016). ^{137}Cs redistribution in time in wet bory and sugrudy soils in forests of Ukrainian Polissia. Nuclear Physics and Atomic Energy, 17 (1), 63–68. doi: https://doi.org/10.15407/jnpae2016.01.063

20. Krasnov, V. P., Kurbet, T. V., Orlov, A. A. (2008). Radioekologicheskie problemy, svyazannye so sploshnymi rubkami v sosnovyh lesah Ukrainskogo Poles'ya. Lisivnytstvo i ahrolisomelioratsiya, 112, 195–202.

21. Landin, V. P., Krasnov, V. P., Kurbet, T. V., Orlov, O. O., Savushchik, M. P., Davydov, M. M. (2011). Rezultaty radioekolohichnykh doslidzhen u lisovykh ekosystemakh Ukrainy, zabrudnenykh avariynymy vykydamy Chornobylskoi AES. Ahroekolohichnyi zhurnal, 1, 53–57.

22. Krasnov, V. P., Kurbet, T. V., Shelest, Z. M., Boiko, O. L., Zborovska, O. V. (2016). 137Cs distribution in the wood of scots pine radial growth in the forests of Ukrainian Polissia. Nuclear Physics and Atomic Energy, 17 (4), 394–399. doi: https://doi.org/10.15407/jnpae2016.04.394

23. Yoschenko, V., Nanba, K., Konoplev, A., Takase, T., Zheleznyak, M. (2015). Radiocesium distributions and fluxes in the forest ecosystems of Chernobyl and Fukushima. Geophysical Research Abstracts, 17, 235–241.

24. Jayasanka, D., Komatsuzaki, M., Hoshino, Y., Seki, H., Moqbal, M. (2016). Nutrient Status in Composts and Changes in Radioactive Cesium Following the Fukushima Daiichi Nuclear Power Plant Accident. Sustainability, 8 (12), 1332. doi: https://doi.org/10.3390/su8121332

25. Vinichuk, M. (2012). Selected Metals in Various Fractions of Soil and Fungi in a Swedish Forest. ISRN Ecology, 2012, 1–7. doi: https://doi.org/10.5402/2012/521582

26. Rosén, K., Lenoir, L., Stark, K., Vinichuk, M., Sundell-Bergman, S. (2018). Transfer of radionuclides and dose assessment to ants and anthills in a Swedish forest ecosystem. Journal of Environmental Radioactivity, 190-191, 97–104. doi: https://doi.org/10.1016/j.jenvrad.2018.05.003

27. Vedmid, M. M., Raspopina, S. P. (2010). Otsinka lisoroslynnoho potentsialu zemel. Kyiv: EKO-inform, 84.