MONOGRAPH

KUNYTSKYI S., IVANCHUK N., SHATNYI S.,
PINCHUK O., KUNYTSKYI M.

SAFETY-ORIENTED RATIONAL WATER USE IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

2023

Kunytskyi S., Ivanchuk N., Shatnyi S., Pinchuk O., Kunytskyi M.

SAFETY-ORIENTED RATIONAL WATER USE IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

Included in International scientometric databases

MONOGRAPH

ScientificWorld-NetAkhatAV
Karlsruhe 2023

Authors:
Kunytskyi S., Ivanchuk N., Shatnyi S., Pinchuk O., Kunytskyi M.

Reviewers:
Pichura Vitalii Ivanovych, Doctor of agricultural sciences, Professor, Head of the department of Ecology and Sustainable Development named after Professor Yu.V. Pylypenka of Kherson State agrarian and economic University, Kherson
Safonyk Andrii Petrovych, Doctor of technical sciences, Professor, Director of the Institute of Energy, Automatics and Water Management of National University of Water and Environmental Engineering, Rivne

Safety-oriented rational water use in the context of sustainable development [Text] : Monograph / S. Kunytskyi, N. Ivanchuk, S. Shatnyi, O. Pinchuk, M. Kunytskyi. Karlsruhe, 2023. 136 p.

The monograph highlights the problems of natural water preparation, its supply to consumers, and wastewater treatment of united territorial communities. The methods of water preparation, technological schemes and water supply systems, the main structures on them were considered; methods of improving the operation of treatment facilities by using rational technical solutions and equipment. The scientific and practical results of research on the preparation of natural water and wastewater treatment are presented, technological schemes of water supply of enterprises and features of operation of facilities in rural areas have been improved.
The monograph is useful for scientists, researchers, collectors, managers and workers of united territorial communities and everyone who is interested in environmental issues, in particular, issues of water treatment and wastewater treatment from the population and industrial enterprises.

ISBN 978-3-98924-011-7
DOI: 10.30890/978-3-98924-011-7.2024

Published by:
ScientificWorld-NetAkhatAV
Lußstr. 13
76227 Karlsruhe, Germany
e-mail: *editor@promonograph.org*
site: https://de.promonograph.org

ABOUT THE AUTHORS:

Kunytskyi Serhii, PhD, Senior Research Fellow, Leading Researcher of Science and Research Department of National University of Water and Environmental Engineering, ORCID: 0000-0003-0318-6149

Ivanchuk Natalia, PhD, Associate Professor, Associate Professor of the Department of computer science and applied mathematics of National University of Water and Environmental Engineering, ORCID: 0000-0002-6824-9406

Shatnyi Serhii, PhD, Associate Professor of the Department of computer science and applied mathematics of National University of Water and Environmental Engineering, ORCID: 0000-0003-4650-5090

Pinchuk Oleg, PhD, Associate Professor of the Department of Department of Hydrotechnical Construction and Hydraulics of National University of Water and Environmental Engineering, ORCID: 0000-0003-4650-5090

Kunytskyi Myhailo, Junior Research Fellow of Science and Research Department of National University of Water and Environmental Engineering, ORCID: 0000-0003-1700-8167

CONTENT

INTRODUCTION 6

1. STATE POLICY OF UKRAINE REGARDING THE INDUSTRY OF WATER SUPPLY AND WATER DISTRIBUTION 8

2. THE MOST COMMON WATER SUPPLY SYSTEMS AND SCHEMES USED IN UKRAINE 21
   - 2.1. Sources of water supply 21
   - 2.2. Schemes and systems of water supply from surface and underground sources 25
   - 2.3. Water intake facilities for water supply from underground sources 27
   - 2.4. Water intake structures for water supply from surface sources 31

3. FEATURES OF WATER PREPARATION FROM UNDERGROUND HORIZONS OF SMALL SETTLEMENTS 34
   - 3.1. Reconstruction of the station for iron removal and disinfection of drinking water in the village of Goshcha, Rivne region 35
   - 3.2. Empirical studies of the parameters of the water de-ironing process at the water treatment plant of the village of Goshcha 39
   - 3.3. Production recommendations for operation of expanded polystyrene filters with high size of industrial production granules with filtration flow 51

4. SYSTEM AND SCHEMES OF DRAINAGE 52
   - 4.1. Elements of the drainage system 52
   - 4.2. Types of wastewater 53
   - 4.3. Types of drainage systems 55
   - 4.4. Tracing external drainage networks 57
   - 4.5. Equipment and structures on drainage networks 59
   - 4.6. The order of designing a settlement drainage system 60
   - 4.7. Conditions for receiving sewage into the city's sewage network 62
   - 4.8. Terms of resetting purified wastewater into water bodies 63

5. FEATURES OF SEWAGE TREATMENT 65
   - 5.1. Methods and technological schemes of wastewater treatment 65
   - 5.2. The structures of mechanical sewage treatment 69
   - 5.3. The biochemical treatment of sewage 70
   - 5.4. Disinfection of biologically treated wastewater 71

6. FUNDAMENTALS OF THE PROCESS OF WATER PURIFICATION ON BIOPLATO 73
6.1. Modeling water purification in bioplato 74
6.1.1. The method of research of water purification in bioplato 75
6.1.2. Construction of a mathematical model of water purification in bioplato 76
6.1.3. The results of numerical experiments of the solution of the constructed mathematical model and their analysis..... 80
6.1.4. The basis is the results of modeling of water purification in the bioplateau, taking into account the sufisi-clogging phenomena 84
6.2. Modeling of water purification in a bioplateau based on a profile filtration scheme 85
6.2.1. The status of the issue and setting of the research problem 85
6.2.2. Construction of a mathematical model of water purification in a bioplateau filter and its numerical solution..... 86
6.2.3. The basis is the results of simulation of water purification in the bioplateau based on a profile filtration scheme 89

7.AUTOMATED SOFTWARE AND HARDWARE COMPLEX FOR MANAGEMENT OF WATER SUPPLY PROCESSES..... 90
7.1. General information about the automation of water supply systems..... 90
7.2. Analysis of the existing management system of the technological process of tent supply..... 91
7.2.1. Structure of the automated water supply management system..... 93
7.2.2. Calculation of consumption and load on the water supply 96
7.2.3. Calculation of the dependence of pressure and cross-sectional area of the flow valve..... 98
7.2.4. Calculation of the regulator of the automated regulation system 99
7.2.5. Modeling of the transition process..... 100
7.2.6. ARS pressure sensitivity analysis..... 101
7.3. Designing the structure of the automated measuring complex..... 103
7.4. Algorithm and control program of the automated measuring complex... 105
7.4.1. The process of preliminary training 105
7.4.2. Data pre-processing..... 107
7.4.3. Identification of signs..... 107
7.4.4. Design of neural network architecture 107
7.4.5. Computer simulation and analysis of results..... 110
7.5. Software implementation 113
7.6. Final provisions..... 118

GENERAL CONCLUSIONS 121

REFERENCES..... 123

GENERAL CONCLUSIONS

1. An important component of the functioning of water supply and sewage facilities should be the rational use of water resources by increasing the efficiency of their work based on technological and organizational principles.
2. According to the legislation of Ukraine, "state management in the field of water use and protection and reproduction of water resources should be carried out according to the basin principle on the basis of state, target, interstate and regional programs for the use and protection of water and reproduction of water resources, as well as river basin management plans.
3. The waters of natural sources are prepared for the economic and drinking needs of the population or the needs of industrial enterprises according to various technological schemes in order to bring their physical and chemical indicators in line with the requirements of consumers. In most cases, suspended substances, color, odors and tastes, iron cations, and organic impurities should be removed from water.
4. The problems of preparation of natural water, its supply to consumers and wastewater treatment of united territorial communities are highlighted. The methods of water preparation, technological schemes and water supply systems, the main structures on them were considered;
5. The scientific and practical results of studies on the preparation of natural water and wastewater treatment are presented, technological schemes of water supply of enterprises and features of operation of facilities in rural areas have been improved.
6. The improvement of technologies and technical means of preparing water for economic and drinking needs consists in the scientific justification of advanced water purification technologies, which will allow to increase the efficiency of the water use process.
7. To improve the operation of filtration facilities, it is advisable to use multi-stage filtration implemented in one facility; use high-efficiency fibrous filter materials for further purification of water after passing granular backfill; organize the operation of granular loading outside the protective action.
8. For different filtering modes (constant performance, constant pressure, and constant supply), numerical studies were carried out for the cases when a layer of sediment forms on the surface of the porous fibrous shell and when its pores are gradually blocked, which allowed to substantiate the improvement of the design of the drainage system, providing increasing the efficiency of the filtering facility.

9. The structural and functional scheme of the automated complex of control and management of the parameters of wastewater and process water treatment of production is proposed. The presented results can be used as independent measuring systems and integrated into existing measuring complexes in the water infrastructure.
10. The developed software based on a neural network with partial parallelization shows the improvement of the processing parameters of large volumes of data without loss of accuracy and with the possibility of working in real time mode.
11. The patterns of removal of nitrogen and phosphorus compounds from wastewater discharged into rivers during their purification in a modular block reactor were revealed.
12. Monitoring information technology is a procedure for analyzing the actual water consumption regime, which is based on the search for hidden patterns in its formation, taking into account the season and periods of the daily cycle, and is performed on the basis of the description of the irregularity and form of daily schedules of water supply from the water supply network.
13. Normative provision of centralized water supply, aimed at meeting high requirements for water quality, should cover not only technical and economic, but also environmental factors.

REFERENCES

1. Development of sectoral strategies and programs of water supply, drainage and sanitation in united territorial communities: methodical guide / V. I. Kozak, O. O. Kozlyuk. K.: DESPRO, 2019. 62 p.

2. R.B. Prymus, K.M. Hochachilov, V.V. Lutsyuk, E.I. Shmyrov, T.V. Sikorska, O.A. Andriychuk, A.V. Romakh, V.G. Haykovska, O.P. Galimova Tools for the development of united territorial communities in conditions of decentralization of power / *According to general ed. Doctor of Sciences in Public Administration, Professor*, Honored Lawyer of Ukraine V.M. Oluyko - K.: Waite, 2017. 432 p.

3. Internet resource: https://webcache.googleusercontent.com/search?q=cache:ht-28AoxwNsJ:https://mepr.gov.ua/files/KMU_Water%2520Strategy_new.pdf&cd=2&hl=ru&ct=clnk&gl= u.a. Date of application 11/21/2022

4. DSanPiN 2.2.4–171–10 "Hygienic requirements for drinking water intended for human consumption."

5. Korinko I.V. Innovative water treatment technologies: monograph / I.V. Korinko, Yu.O. Panasenko. Kharkiv: KhNAMG, 2012. 208 p.

6. Zapolsky, A.K. Water supply, drainage and water quality: *a textbook for students*. University / A.K. Zapolsky - K.: Higher School, 2005. 671p.

7. Nabyvanets B. Analytical chemistry of surface waters: a monograph / B. Nabyvanets, V. Osadchiy, N. Osadcha, Yu. Nabyvanets. - K.: Naukova dumka, 2007. 455 p.

8. Orlov V.O. De-ironing of groundwater by simplified aeration and filtration. Monograph / V.O. Orlov. Rivne: NUVHP, 2008. 158 p.

9. Tugai A.M., Orlov V.O. Water supply. Rivne: RDTU, 2001. 429 p.

10. Orlov V.O., Martynov S.Yu., Orlova A.M., Zoshchuk V.O., Kunytskyi S.O.. Preparation of water using polystyrene foam filters / Edited by V. O. Orlov. Monograph. Rivne: NUVHP, 2017. 170 p.

11. Water supply and drainage: Synopsis of lectures for students of the 1st year of full-time and part-time education in the field of study 6.060103 "Hydrotechnics (Water resources)" specialty "Water supply and drainage" / Author: K.B. Sorokina. Kharkiv: KhNAMG, 2009. 80 p.

12. Kulsky L.A. Theoretical foundations and technology of water conditioning. K: Science. dumka, 1983. 560 p.

13. Kulsky L.A., Strokach P.P. Technology of natural water purification. K: "Higher School", 1986. 352 p.

14. Water supply and drainage: Textbook. Approved by the Ministry of Education

and Culture / Orlov V.O., Tugai Y.A., Orlova A.M. K., 2011. 359 p.

15. Water supply: textbook / A. M. Tugai, V. O. Orlov. K.: Znannia, 2009. 735 p.

16. Shevelev F.A. Tables for hydraulic calculation of water pipes: Ref. Allowance – 6th ed., add. and processing / F.A. Shevelev, A.F. Shevelev. Stroyizdat, 1984. 116 p.

17. Patent 63282, C 02 F 1/64. Installation for deironing water / V.O. Orlov, V.O. Zoshchuk, S.O. Kunitskyi. 2011. Bull. No. 19.

18. Patent 43678, B 01 D 33/00, 24/00. Impulse washing of the water purification filter / V.O. Orlov, M.M. Trokhymchuk, S.O. Kunitskyi. 2010. Bull. No. 9.

19. Epoyan S.M. The use of drainage systems to increase the efficiency of rapid filters / S.M. Epoyan, A.S. Karagyaur, V.M. Volkov // Reclamation and water use - components of sustainable development of the country's water management complex. *Dedicated to the 85th anniversary of the "Melitopol College of TDATU" VSP: science-practice. conference*, September 30, 2016, Melitopol: theses for the subject. - Melitopol: "Zaporizhhydroproject" NSC, 2016. P. 27-29.

20. Epoyan, S. Increasing the efficiency of filtering structures when using drainage systems from porous polymer materials/ S. Epoyan, A. Karagyaur, V. Volkov, V. Yarkin // *MOTROL*. – Commission of motorization and energetics in agriculture. - Lublin-Rzeszow, 2016. Vol. 18, No. 6. P. 102-109.

21. Epoyan S.M. On the possibility of using drainage systems of fast filters for additional cleaning / S.M. Epoyan, A.S. Karagyaur, V.M. Volkov // *Problems of water supply, drainage and hydraulics: science and technology. coll*. K.: KNUBA. 2016. Issue 27. P. 121-129.

22. Volkov V.M. The use of polymer shells of drainage systems of fast filters for additional cleaning / V.M. Volkov, S.M. Epoyan, A.S. Karagyaur, S.P. Babenko // *Municipal management of cities: science and technology. coll. XNUMX named after O.M. Bektetov*. – Kharkiv: XNUMX named after O.M. Bekotova, 2017. Vol. 139. P. 135-142.

23. Oleynyk A.Ya. Modeling of clogging and suffocation processes in the pre-filter zone of wells / A.Ya. Oleynyk, A.M. Tugay // *Reports of the National Academy of Sciences of Ukraine*. 2001. No. 9. P. 190-194.

24. Epoyan S.M. Features of filtration of a low-concentration suspension through a porous fibrous partition / S.M. Epoyan, A.S. Karagyaur, V.N. Volkov // *Scientific Bulletin of Construction*. – Kharkiv: Khnuba, Hotv ABU, 2018. No. 1(91). P. 192-199.

25. Epoyan S.M. Study of the operation of a rapid filter with the removal of a part of the flow to the lower layers and after-cleaning on the drainage system / S.M. Epoyan,

A.S. Karagyaur, V.N. Volkov // *Problems of water supply, drainage and hydraulics: science and technology. coll.* K.: KNUBA, 2017. Issue 28. P. 140-148.

26. Epoyan S.M. Study of the operation of a fast filter with removal of part of the flow to the lower layers and further purification on the drainage system / S.M. Epoyan, A.S. Karagyaur, V.M. Volkov // *Water use: technologies, structures, management: IV international science and practice conference*, December 14–15, 2017, Kyiv: work program and theses of reports. K.: KNUBA, 2017. P. 14.

27. Karagyaur A.S. Some solutions for increasing the efficiency of the fast filter / A.S. Karagyaur, S.P. Babenko, V.M. Volkov // *73 science and technology conf. Khnuba, February 6–7, 2018*, Kharkiv: abstracts of reports. Kharkiv: KhNUBA, 2018. P. 79–80.

28. Karagyaur A.S. Mathematical modeling of the operation of a rapid filter with the removal of part of the flow into the lower layers / A.S. Karagyaur, V.N. Volkov // *Scientific Bulletin of Construction*. – Kharkiv: Khnuba, Hotv ABU, 2017. No. 4(90). P. 180-187.

29. Epoyan S. Research into the influence of vertical drainage elements on the operational efficiency of rapid filters / S. Epoyan, A. Karahiaur, V. Volkov, S. Babenko // *Eastern-European Journal of Enterprise Technology*. Kharkiv. 2018. 1/10 (91) P. 62-69.

30. Epoyan S.M. After-treatment of water on polymer drainage systems of fast filters / S.M. Epoyan, A.S. Karagyaur, V.N. Volkov // *Ecology, technology, economy, water supply, sewage (ETEVK - 2017): international. congress and technical exhibition, June 12-16, 2017*, Chornomorsk: coll. Reports. Chornomorsk, 2017. P. 104–106.

31. Volkov V.M. Water purification by filtering through layers of granular and fibrous materials / V.M. Volkov, S.M. Epoyan, A.S. Karagyaur, S.P. Babenko // *Current problems of energy and resource conservation and ecology: international science and technology conference*, October 10–11, 2017, Odessa: Mater. conf. Odesa: ODABA, 2017. P. 65–66.

32. Volkov V.N. Intensification of the work of fast filters with the help of porous polymer drains / V.N. Volkov, S.M. Epoyan, A.S. Karagyaur, S.P. Babenko // *Resource and safety of operation of structures, buildings and structures: VIII international. of science conference*, October 18–19, 2017, Kharkiv: theses by subject. Kharkiv: Khnuba, 2017. P. 105–106.

33. Epoyan S.M. Application of drainage systems of quick filters for additional cleaning / S.M. Epoyan, A.S. Karagyaur, V.N. Volkov // *Methods of increasing the resource of urban engineering infrastructures: VII all-Ukrainian. of science seminar,*

October 11–12, 2016, Kharkiv: theses by subject. Kharkiv: KhNUBA, 2016. P. 95- 97.

34. Karagyaur A.S. The use of drainage systems of fast filters made of polymeric fibrous materials for further purification by microfiltration / A.S. Karagyaur, S.P. Babenko, V.M. Volkov // *72 Science and Technology conf. KhNUBA, March 14-17, 2017*, Kharkiv: abstracts of reports, Kharkiv: KhNUBA, 2017. P. 64-65.

35. Epoyan S.M. Increasing the duration of the filter cycle of fast filters due to drainage systems / S.M. Epoyan, A.S. Karagyaur, V.M. Volkov // *Reclamation and water use - sustainable development of the country's water management complex. On the occasion of World Water Day. Dedicated to the 19th anniversary of the University "Ukraine": science and practice. conference*, March 17, 2017, Melitopol: mater. conf. – Melitopol: Melitopol Institute of Ecology and Social Technologies of VMURoL "Ukraine", 2017. P. 7–10.

36. Epoyan S.M. On the possibility of using drainage systems of fast filters for additional cleaning / S.M. Epoyan, A.S. Karagyaur, V.M. Volkov // *Water use: technologies, structures, management: III international science and practice conference*, December 7–9, 2016, Kyiv: theses by subject. K.: KNUBA, 2016. No. 27. P. 13.

37. I.M. Hrushko Fundamentals of scientific studies / I. M. Hrushko, V. E. Sydenko. – [3rd ed.]. - Kharkiv: Vyssh. Shk., - *Kharkiv publishing house. University of Technology*, 1983. 224 p.

38. Basic numerical methods and their implementation / [I.M. Sulima, S.I. Havrylenko, I.A. Radchyk, Ya.A. Yuditsky]. K.: Higher. Shk., 1987. 309 p.

39. Volkov V.M. Recommendations for increasing the efficiency of the fast filter / V.M. Volkov, S.M. Epoyan, A.S. Karagyaur, A.A. Titov // *Methods of increasing the resource of urban engineering infrastructures: VIII all-Ukrainian. of science seminar, October 9–10*, 2018, Kharkiv: theses by subject. Kharkiv: KhNUBA, 2018. P. 73–75.

40. DBN V.2.5-74-2013. Water supply. External networks and structures. Basic provisions of design. K.: Ministry of Regions of Ukraine, 2013. 172 p.

41. The National Commission for State Regulation in Energy and Utilities [Electronic resource]: [Website]. – Electronic data. – Kyiv: NKRECP, 2018. – Access mode: http://www.nerc.gov.ua/?id=24902 (access date 11/15/2018) – Title from the screen.

42. Kovalchuk V.A. Wastewater treatment. - Rivne: JSC "Rivnenska Dokratranya", 2003. 622 p.

43. Shevchenko A. A., Kryven A. P., Melnyk D. V. Comparative characteristics of equipment for sludge dewatering at municipal and industrial sewage treatment facilities. *Scientific bulletin of construction: coll. of science works 2012*. Issue 70. P.

261–268.

44. Vaxelaire J., Ce´zac P. Moisture distribution in activated sludges: A review. Water Research. 2004. 38. P. 2214–2249

45. Yen P. S., Chen L. C., Chien C. Y., Wu R. M., Lee D. J. *Network strength and dewaterability of flocculated activated sludge. Water Research*. 2002. 36. P. 539–550.

46. Wastewater treatment of milk processing enterprises [Text]: monograph / A. O. Shevchenko, O. L. Pinchuk, S. O. Kunytskyi, T. O. Shevchenko. Lutsk: Vezha-Druk, 2019. 224 p.: illustrations.

47. Healy A., Cawleyb M. Nutrient Processing Capacity of a Constructed Wetland in Western Ireland. *J. Environ. Quality*. 2002. № 31. P. 1739–1747.

48. Gleichman-Verheyc E. G., Putten W. H., Vander L. Alvalwaterzuvering met helofytenfilters, een haalbaarheidsstudie. *Tijdschr. watervoorz. en. Afvalwater*. 1992. № 3. P. 56–60.

49. Zavatskyi S. V., Kotelchuk L. S., Kotelchuk A. L. Bioengineering facilities for low-productivity wastewater treatment. Construction, engineering systems and communications. 2012. No. 1(3). P. 57–63.

50. Filipchuk V. L., Kurylyuk M. S., Filipchuk L. V., Kurylyuk O. M., Krylyuk V. M., Pochtar O. V. Purification of turbid waters in filtration-regeneration bioplateaus. *Bulletin of the Engineering Academy of Ukraine*. 2016. Issue 3. P. 150–155.

51. Filipchuk V. L., Bondar O. I., Kurylyuk M. S., Ayaya A., Kryvoshey P. P., Kurylyuk O. M., Pochtar O. V. Water purification in filtration-regeneration bioplateaus. *Bulletin of the NUWEE*. 2016. Issue 2(74). P. 193–204.

52. Hosokova Y., Miyoshi E., Fukukawa K. Characteristics of the process of purification of coastal waters using reed beds. *Rept. Partand Harbour. Res*. 1991. Inat. 30, № 11. P. 206–257.

53. Blankenberg A.-G. B., Braskerud B. C. «LIERDAMMEN» – a wetland testfield in Norway. *Retention of nutrients, pesticides and sediments from a agriculture runoff*: Diffuse Pollut. Conf.: Dublin, 2003. P. 128–130.

54. Dyrenko A. A., Kotsar E. M. The use of higher aquatic plants in the practice of wastewater treatment and surface runoff. *Plumbing, heating, air conditioning*. 2006. No. 4. P.12–15.

55. Medvid N. V., Martyniuk P. M. Mathematical modeling of the effect on excess pressure of the presence of a washout zone in an earthen dam with a water pipeline. *Mathematical and computer modeling. Series: Technical sciences*. 2014. Issue 10. P. 101–112.

56. Medvid N. V., Martyniuk P. M. Study of the influence of heat-salt transfer on the rate of filtration in an earthen dam (spatial problem). *Bulletin of TNTU*. 2015.

Volume 80, No. 4. Pages 172–181.

57. Medvid N. V. Study of the influence of the water pipeline and the leaching zone on the processes of filtration consolidation of the soil dam using the finite element method. *Bulletin of the National University of Water Management and Nature Management*. Series: Technical sciences. 2015. Issue 4(72). P. 132–142.

58. Dobronravov O. O., Kremez V. S. Modeling of groundwater filtration taking into account suffusion and occlusion. *Problem water supply, drainage and hydraulics*. 2006. Issue 7. P. 141–146.

59. Kapranov Yu. I., Tropin N. M. The structure of the collimated layer in the vicinity of the moving boundary. *Applied mechanics and technical physics*. 2011. Vol. 52, No. 6. P. 77–91.

60. Kapranov Yu. I. Peculiarities of clogging of the bottomhole zone of the formation. *Herald of KazNU. Ser. math., mech.*, inf. 2011. Vol. 68, No. 1. P. 117–122.

61. Seetha N., Mohan Kumar M. S., Hassanizadeh S. M. Modeling the co-transport of viruses and colloids in unsaturated porous media. *Journal of Contaminant Hydrology*. 2015. Vol. 181. P. 82–101.

62. Chetti A., Benamar A., Hazzab A. Modeling of Particle Migration in Porous Media: Application to Soil Suffusion. *Transport in Porous Media*. 2016. Vol. 113, № 3. P. 591–606.

63. Berres S., Bürger R., Wendland W. L. Mathematical Models for the Sedimentation of Suspensions. *Lecture Notes in Applied and Computational Mechanics*. 2006. Vol. 28. P. 7–44.

64. Zhang M., He F., Zhao D., Hao X. Transport of stabilized iron nanoparticles in porous media: Effects of surface and solution chemistry and role of adsorption. *Journal of Hazardous Materials*. 2017. Vol. 322, Part A. P. 284–291.

65. Chrysikopoulos C. V., Katzourakis V. E. Colloid particle size-dependent dispersivity. *AGU Water Resources Research*. 2015. Vol. 51, Issue 6. P. 4668–4683.

66. Francisca F. M., Glatstein D. A. Long term hydraulic conductivity of compacted soils permeated with landfill leachate. *Clay Science*. 2010. Vol. 49. P. 187–193.

67. Gerus V. A., Kutya T. V., Martyniuk P. M. Generalization of the equation of filtration and heat and mass transfer to the case of suffusion processes. *Mathematical and computer modeling. Series: Technical sciences*. 2016. Issue 14. P. 48–63.

68. Safonyk A. P. Modelling the filtration processes of liquids from multicomponent contamination in the conditions of authentication of mass transfer coefficient. *Int. J. Mathematical Models and Methods in Applied Sciences*. 2015. Vol. 9. P. 189–192.

69. I. V. Sergienko, V. V. Skopetsky, V. S. Deineka Mathematical modeling and research of processes in heterogeneous environments. Kyiv: Nauk. dumka, 1991. 432 p.

70. Vlasyuk A. P., Martynyuk P. M., Medvid N. V. Mathematical modeling of consolidation and filtration destruction of soils in the foundations of hydraulic and power engineering structures. Rivne: NUWEE, 2017. 423 p.

71. Vaganov I. I., Mayevska I. V., Popovych M. M. Engineering geology and environmental protection. *Educational manual of distance education*. Vinnytsia: VNTU, 2010. 262 p.

72. Bomba A., Safonik A. Mathematical Simulation of the Process of Aerobic Treatment of Wastewater under Conditions of Diffusion and Mass Transfer Perturbations. *Journal of Engineering Physics and Thermophysics*. 2018. № 91. P. 318–323.

73. Liu L., Fu Y., Wei Q., Liu Q., Wu L., Wu J., Huo W. Applying Bio-Slow Sand Filtrationfor Water Treatment. *Pol. J. Environ. Stud*. 2019. Vol. 28, No. 4. P. 2243–2251.

74. Liu J., Liu L., Huang Z., Fu Y., Huang Z. Contaminant Removal and Optimal Operationof Bio-Slow Sand Filtration Water Treatment Based on Nature-Based Solutions. *Pol. J. Environ. Stud*. 2020. Vol. 29, No. 2. P. 1703–1713.

75. Moshynskyi V., Filipchuk V., Ivanchuk N., Martyniuk P. Computer modeling of water cleaning in wetland taking into account of suffosion ang colmatation. *Eastern-European Journal of Enterprise Technologies*. 2018. № 1/10(91). P. 38–43.

76. Moshynsky V., Riabova O. Approaches to Aquatic Ecosystems Organic Energy Assessment and Modelling. *NAPSC*. 2013. P. 125–135.

77. Safonyk A., Bomba A., Tarhonii I. Modeling and Automation of the Electrocoagulation Process in Water Treatment. *Advances in Intelligent Systems and Computing*. 2018. Volume 871. P. 451–463.

78. Construction of bioponds and biobasins using German technology. Electronic resource. URL: https://master.kh.ua/uslugi/stroitelstvo-bioprudov-i-biobassejnov-po-nemeczkoj-texnologii.html.

79. Draginsky V.L. Increasing the efficiency of reagent water treatment at water treatment plants / V.L. Draginsky, L.P. Alekseeva // Water supply and sanitary equipment. 2000. No. 5. P. 45-47.

80. Resource-saving wastewater treatment technologies: monograph / S.S. Dushkin, A.N. Kovalenko, M.V. Degtyar, T.A. Shevchenko; Hark. national Acad. city farm Kh.: Khnakh, 2011. 146 p.

81. Shabalin A.F. Revolving water supply of industrial enterprises. M.:

Stroyizdat, 1972. 296 p.

82. Leibovich R.E., Yakovleva E.I., Filatov A.B. Technology of coke chemical production.: Metallurgy, 1982. 360 p.

83. Proskuryakov V.A., Schmidt L.I. Wastewater treatment in the chemical industry.: Chemistry, 1977. 463 p.

84. Ternovtsev V. E. Purification of industrial wastewater / V. E. Ternovtsev, V. M. Pukhachev. K.: Budivelnyk, 1986. 120 p.

85. S. V. Nesterenko Complex treatment of circulating water to prevent corrosion and scale formation / S. V. Nesterenko, S. P. Stasenko; Kharkov. national Acad. mountains hozva // *Kommunalnoe hozyazyto gorodov: scientific and technical*. Sat. Kyiv: Technika, 2003. No. 49. P. 87–93. – Series "Technical sciences and architecture".

86. V. D. Semenyuk Complex use of water in an industrial node / V. D. Semenyuk, V. E. Ternovtsev // Kyiv: Budivelnyk, 1974. 232 p.

87. Alfyorova L.A. Closed systems of water management of industrial enterprises, complexes and districts / L.A. Alfyorova, A.P. Nechaev, 1984. 272 p.

88. Aksyonov V. I. Closed systems of water management of metallurgical enterprises / V. I. Aksyonov, 1983. 112 p.

89. Creation of closed water supply systems for metallurgical enterprises. Ecology and resource saving / [V. I. Aksyonov and others] // Steel: mezhdunanar. scientific and technical and production Magazine. 2005. P. 83–85.

90. Water supply of metallurgical enterprises: textbook / [V. I. Aksenov and others] ; under ed. V. I. Aksyonova: UrFU, 2011. 262 p.

91. Water drainage and wastewater treatment / [S. V. Yakovlev, Ya. A. Karelin, Yu. M. Laskov, V. I. Kalytsyn]. : Stroyizdat, 1996. 591 p.

92. Yakovlev S.V. Closed systems of water supply of industrial enterprises / S.V. Yakovlev, A.P. Nechaev // *Water supply and sanitary technology*. 1985. No. 2. – P. 2–3.

93. Kucherenko D. I. Recirculating water supply (water cooling systems) / D. I. Kucherenko, V. A. Gladkov. Stroyizdat, 1980. 169 p.

94. Gogolev I. Ya. Water resources and their protection. Environmental protection and rational use of natural resources: *Analytical review* / I. Ya. Gogolev; Vseros scientific and technical inform. center, 1992. 65 p.

95. Lisohor O. S. Closed systems of circulating water supply of coke chemical plants: autoref. thesis ... candidate technical Sciences: spec. 05.23.04 - water supply, sewerage / Olena Serhiivna Lisohor; Kharkiv. state technical Univ. building and arch. - Kharkiv, 2001. 18 p.

96. Implementation of the technology of a pipeless closed circulating water supply of OJSC "Zaporozhkoks" / H.S. Pantelyat, G.V. Sleptsov, E.S. Lysogor, V.N. Rubchevskii // *Water supply and sanitary technology*. 2000. No. 12. P.13–14.

97. Choi D.-J. Development of an environmentally safe corrosion, scale and microorganism inhibitor for open recirculating cooling systems / D.-J. Choi, S.-J. You, J.-Gu Kim // *Materials Science and Engineering*: A. Vol. 335(1–2). 2002. P. 228–235.

98. Pantelet G. S. Prevention of salt deposits in systems of reversible water supply / G. S. Pantelet, V. A. Andronov, V. Ya. Kuznetsov // *Water supply and sanitary technology*. 1996. No. 3. P. 19–20.

99. Pantelet G. S. Improvement of systems of circulating water supply of metallurgical enterprises / G. S. Pantelet, V. D. Sakovsky // *Water supply and sanitary technology*. 1996. No. 8. P. 20–21.

100. Degremont. Technical reference book on water treatment [Text]: in 2 volumes: [trans. with French] / Ed. M. I. Alekseeva. St. Petersburg : Novy zhurnal, 2007. Vol. 1. 775 p.

101. Klyachko V. A. Preparation of water for industrial and urban water supply / V. A. Klyachko, I. E. Orange : Stroyizdat, 1962. 818 p.

102. Harrels R.M. Solvents, minerals, equilibria / Harrels R.M., Christ C.A.: Mir, 1968. 210 p.

103. Smylka E.P. Rational use of industrial waste water of coke chemical production // Territorial development prospects: theory and practice: Materials of international scientific practice. *Internet conferences of students, graduate students and young scientists*. / Khark. national University of Gor. hozva named after A.N. Beketov – Kharkiv: KhNAGH named after A.N. Beketova, 2013. P.135-136.

104. Kenny J.D. Calculation of the Langelier Index at High pH: Supplemental Material Technical Note: Calculation of the Langelier Index at High pH / J.D. Kenny, D.R. Hokanson, R.R. Trussell //*Journal-American Water Works Association*. - 2015. Vol. 107. No. 3. P. 82-83.

105. O. V. Suvorin, O. V. Suvorin, V. I. Mohonko, and S. A. Rysukhina, Evaluation and forecasting of corrosion-scale properties of industrial and natural waters / *Bulletin of the Kharkiv National Automobile and Road University*. 2010. no. 48.

106. Evaluation of corrosion and scaling potential of a water treatment plant / Hoseinzadeh E. et al. //*Archives of Hygiene Sciences*. 2013. Vol. 2. No. 2. P. 41-47.

107. Galkina O. P. Prediction of stability of the circulating water // *Journal of Urban and Environmental Engineering*, v.14, n.1, p.61-68.

108. Ashassi-Sorkhabi H. Effect of hydrodynamic conditions on the inhibition performance of l-methionine as a "green" inhibitor / H. Ashassi-Sorkhabi, E. Asghari //*Electrochimica Acta*. 2008. Vol. 54. No. 2. P. 162-167.

109. Marangou V. S. First desalination plant in Cyprus—product water aggresivity and corrosion control / V. S. Marangou, K. Savvides //*Desalination*. – 2001. Vol. 138. – No. 1-3. P. 251-258.

110. Belan F.I. Water treatment. Calculations, examples, tasks / F.I. Belan. : Energy, 1980. 256 p.

111. Vodnoe hozyazyto promyshlennykh predpriyatiya / [Aksenov V.I., Shcheklein S.E., Podberezny V.L. and others]; under the editorship YOU. Aksenov. [Kn. 4.]. : Teplotechnik, 2007. 239 p.

112. Evaluation of corrosion and precipitation potential in Ardebil drinking water distribution system by using Langelier & Ryznar indexes / Mokhtari S. A. et al. //*Journal of Health*. 2010. Vol. 1. Vo. 1. P.14-23.

113. Vodnoe hozyazyto promyshelnykh predpriyatiya / [Aksenov V.I., Shcheklein S.E., Podberezny V.L. and others]; under the editorship YOU. Aksenov. [Kn. 4.]. : Teplotechnik, 2007. 239 p.

114. Bargieł P., Zabochnicka-Świątek M. Technologies of Coke Wastewater Treatment in the Frame of Legislation in Force //*Ochrona Srodowiska i Zasobów Naturalnych*. 2018. Vol. 29. No. 1. P. 11-15.

115. Decyzja Wykonawcza Komisji z dnia 28 lutego 2012 roku ustanawiająca konkluzje dotyczące najlepszych dostępnych technik 'BAT' zgodnie z Dyrektywą Parłamentu Europejskiego i Rady 2010/75/ UE w sprawie emisji przemysłowych w odniesieniu do produkcji zelaza i stali, 2012/135/UE.

116. Nesterenko S.V. Reducing the Corrosion Losses of Metals when Using Phenolic Wastewater in Coke_Plant Cooling Systems / S.V. Nesterenko, V.A. Tkachev, E.P. Smilka // *Coke and Chemistry*, 2013, Vol. 56, No. 8, P. 286–291.

117. Galkina O.P. Technologies for the treatment of phenolic wastewater / O.P. Galkina, M.V. Degtyar // *Ecological sciences*. 2019. No. 5(24). Vol.2. P. 32-36.

118. Rozporządzenie Ministra Budownictwa z dnia 14 lipca 2006 r. w sprawie sposobu realizacji obowiązków dostawców ścieków przemystowych oraz warunków wprowadzania ścieków do urządzeń kanalizacyjnych, Dz.U. 2006 nr 136 poz. 964.

119. Bargieł P., Zabochnicka-Świątek M. Technologies of Coke Wastewater Treatment in the Frame of Legislation in Force //*Ochrona Srodowiska i Zasobów Naturalnyc*h. 2018. Vol. 29. No. 1. P. 11-15.

120. D.V. Baltser, "Usage of purified phenolic wastewater in the water supply of coke chemical production" / D.V. Baltser, L.B. Pavlovych // *Water supply and sanitary equipment*. 2012. No. 12. P. 52–58.

121. Pat. 109035 Ukraine C 23 F 11/18, C 02 F 1/50. A composition for preventing corrosion of metals in circulating systems and a method of disposal of wastewater from industrial enterprises containing ammonium nitrogen / S. V. Nesterenko, O. P. Smilka, V. I. Grigorov, L. D. Kantsedal, L. P. Bannikov , V. O. Tkachev (Ukraine); Kharkiv national city university farm named after O. M. Beketova. No. u2013 07467; statement 12.06.13; published 10.07.15, Bul. No. 13.

122. Avdeenko A.P., Polyakov A.E., Yusina A.L., Goncharova S.A. Corrosion and protection of metals: cprav. allowance Kramatorsk: DGMA, 2004. 112 p.

123. *Li X., Deng S., Fu H., Mu G.* Inhibition eff ect of 6-benzylaminopurine on the corrosion of cold rolled steel in H2SO4 solution // Corros. Sci. 2009. Vol. 51. P. 620–634.

124. Smilka *O.* The Complex Approach to Corrosion Protection of Steel in Coke-Plant Cooling Systems // *Chemistry Journal*. Vol. 1, No. 4. 2015. P. 124–132.

125. Otieno M., Beushausen H., Alexander *M.* Prediction of Corrosion Rate in RC Structures-A Critical Review // Modelling of Corroding Concrete Structures. Vol. 5. 2011. P. 15–37.

126. Siamphukdee K., Collins F., Zou R. Sensitivity Analysis of Corrosion Rate Prediction Models Utilized for Reinforced Concrete Aff ected by Chloride // *Journal of Materials Engineering and Performance*. 2013. Vol. 22, Issue 6. P. 1530–1540.

127. Tarantseva K. R. Models and methods of forecasting pitting corrosion // *Protection of Metals and Physical Chemistry of Surface*. 2010. Vol. 46, Issue 1. P. 139–147.

128. Alekseev Yu. V. The selection of statistical objects for physicochemical modeling of electrochemical and corrosion systems // *Journal of Physical Chemistry*. 2008. Vol. 82, Issue 10. P. 1699–1707.

129. Yosh H. Statistical model of stress corrosion cracking based on extended form of Dirichlet energy // Pramana. 2013. Vol. 81. Issue 6. P. 1009–1019.

130. Kuprienko N.V., Ponomareva O.A., Tikhonov D.V. Statistical methods of studying connections. Correlation-regression analysis. *Polytechnic publishing house*. University, 2008. 118 p.

131. Sastri V.S., Perumareddi J.R. (1997), Corrosion, Vol. 53, 617.

132. Chausov F.F., Raevskaya G.A. Complex water-chemical regime of thermal energy systems of low parameters / Ed. MA. Pletneva and S.M. Reshetnikova. - 2nd ed.: Regular and Chaotic Dynamics, 2003. 154 p.

133. Vinarsky N.S. The use of waste water of coke chemical production in systems of reversible water supply / N.S. Vynarskyi, G.I. Papkov // *Express-information*. Chermetinformizdat, 1978. Ser. 10, issue 1. P.7–10.

134. Freiman L.I. Potential static methods in corrosion studies and electrochemical protection / L.I. Freiman, V.A. Makarov, I.E. Bryskin. L.: Khimiya, 1982. 240 p.

135. Badr E. E., El-Shamy O. A. A., Ahmad E. M. and Hilalc N. M. (2014), Der Chemica Sinica, 5(1): P.161-168.

136. Keshe H. Corrosion of metals. Physico-chemical principles and actual problems / H. Keshe. Metallurgy, 1984. 400 p.

137. Ushakov G.V. The results of operational tests of the water circulation cycle of an industrial enterprise in the non-purging mode with the use of zinc-bichromate-phosphate corrosion inhibitor and deposited hardness salts / G.V. Ushakov, G.A. Solodov // Journal of the Polytechnic University. 2007. Vol. 310. No. 2. P. 144-148.

138. Galkina O. Corrosion Rates in Water-Circulation Systems at Coke Plants / O. Galkina // *Coke and Chemistry*, 2016. Vol. 59. No 7. P. 271–275.

139. DSTU 4500-4:2006. Cargo is dangerous. Test methods. Method of experimental determination of corrosion properties of substances. – Valid from 2006-08-01. - Kyiv: State Consumer Standard of Ukraine: UVB UkrNDIMF, 2006. 42 p.

140. Inhibition effect of 6-benzylaminopurine on the corrosion of cold rolled steel in H_2SO_4 solution / X. Li, S. Deng, H. Fu, G. Mu // Corros. Sci. 2009. Vol. 51. P. 620–634.

141. G. A. Carpenter, S. Grossberg, and D. B. Rosen,"Fuzzy ART: Fast Stable Learning and Categorization of Analog Patterns by an Adaptive Resonance System," Neural Networks, Vol. 4, No. 6, P. 759-771, Jun. 1991.

142. M. Martínez-Zarzuela, F. Pernas, J. Díez Higuera, and M. Antón-Rodríguez, "Fuzzy ART neural network parallel computing on the GPU," in Proc. *9th Int. Work-Conf. Art. Neural Networks*, LNCS 4507, 2007, P. 463-470.

143. M. Martnez-Zarzuela, F. Pernas, A. de Pablos, M. Rodrguez, J. Higuera, D. Giralda, and D. Ortega, "Adaptive Resonance Theory fuzzy networks parallel computation using CUDA," in Proc. *10th Int. Work-Conf. Art. Neural Networks*, LNCS 5517, 2009, P. 149-156.

144. T. Serrano-Gotarredona, B. Linares-Barranco, and A. G. Andreou, Adaptive Resonance Theory Microchips: Circuit Design Techniques. Norwell, MA: Kluwer, 1998.

145. Tymoshchuk P. Rank filtering based on an analog neural circuit for determining the maximum values from a set of signals // *Computer science and*

information technology. 2013. No. 771. P. 64-68. (Publication of Lviv Polytechnic National University).

146. P. Tymoshchuk and S. Shatnyi, "Hardware implementation design of analog neural rank-order filter," in Proc. XXth *Int. Conf. "Perspective technologies and methods in MEMS design"*, 2015, P. 88-91.

147. P. Tymoshchuk and M. Lobur, "Analogue globally stable WTA neural circuit", in Proc. II-nd *Int. Conf. "Perspective technologies and methods in MEMS design"*, 2006, P. 19-23.

148. S. Grossberg, "Adaptive Resonance Theory: How a brain learns to consciously attend, learn, and recognize a changing world," Neural Networks, Vol. 37, P. 1-47, Jan. 2013.

149. T. Y. Lo and P. C. Tang, "A fast bandpass filter for ECG processing," in Proc. *IEEE Eng. Med. Biol. Soc*. 4th Annu. Int. Conf., 1982, P. 321-325.

150. Davydenko L.V., Davydenko V.A., Davydenko N.V., Kunytskyi S.O. The application of neural networks of MGUA to detect changes in the operating conditions of the water supply pumping station caused by the influence of seasonal factors. *Bulletin of KrNU named after M. Ostrogradskyi*. 2021. Issue 4(129). P. 110-115.

SCIENTIFIC EDITION

MONOGRAPH

SAFETY-ORIENTED RATIONAL WATER USE IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

Authors:
Kunytskyi S., Ivanchuk N., Shatnyi S., Pinchuk O., Kunytskyi M.

Monograph published in the author's edition
The monograph is included in International scientometric databases

Authorized for printing 24.12.2023.
Publisher's sheet 7.6.
Order No. MGE07-2023. Contracted price.

Published:
ScientificWorld -NetAkhatAV
Lußstr 13,
Karlsruhe, Germany

e-mail: editor@promonograph.org
https://de.promonograph.org

ISBN 978-3-989240-11-7