Secure Systems Design and Technology Development. Veliko Tarnovo, Bulgaria
Proceedings of the International Scientific Conference, 2026. Volume I, 155-160

Use of Mobile Autonomous Systems to Control Pollution of Continental Water Bodies

Nikolay Dolchinkov
Vasil Levski National military University, Bulgaria bul.76,
Veliko Tarnovo, 5000, Bulgaria
E-mail: n_dolchinkov@abv.bg,
ORCID: 0000-0002-6171-6083

***Abstract* — Pollution of continental water resources has emerged as one of the most significant environmental problems in recent decades. This affects both the natural ecosystems inhabiting water areas and the quality of life of the population. The unregulated disposal of large amounts of plastic, construction and household waste into rivers, lakes and adjacent territories leads to significant consequences - degradation of biodiversity, disruption of natural hydrological processes, as well as crises such as floods, pollution of groundwater and drinking water. This study examines the possibilities of applying autonomous technical means - both aerial (drones) and floating (robotic platforms) - for monitoring and control of pollution. These technologies offer a number of advantages: effective monitoring of large areas with minimal resources, the possibility of early detection of unregulated landfills, as well as rapid response to risky situations**

Keywords* — *environment, pollution, aircraft, vessels, control, water surface.

I. Introduction

The article examines the opportunities and challenges of using mobile autonomous systems for monitoring, early detection and local remediation of pollution in rivers, lakes, water channels and adjacent territories [1, 2]. The main types of autonomous platforms, key sensor and communication solutions, application examples and operational concepts, as well as the legal and institutional context and recommendations for implementation within the framework of integrated water resources management are presented [3, 4, 5].

Inland water bodies are vital for ecosystems, drinking water supplies, agriculture and industry. Traditional methods of pollution control — stationary stations and periodic sampling — often do not provide the spatial and temporal coverage necessary for early detection of incidents and for monitoring dynamic processes such as pollutant dispersion and mass algal blooms. Mobile autonomous systems offer the possibility of flexible, frequent and targeted monitoring that complements and extends classical approaches [6, 7].

II. Materials and Methods

Modern platforms and technologies are used in the monitoring of water bodies and their adjacent territories, with some of the most commonly used being autonomous surface platforms.

Autonomous Surface Vessels (ASVs) are designed for long-duration sampling and measurement missions along defined trajectories, combining GNSS navigation, precision propulsion, and modular sensor architecture (DO, pH , conductivity, chlorophyll, turbidity, etc.). Commercial and research solutions are already demonstrating the great potential for autonomous transects, integration of battery systems, and connectivity to ground stations for real-time data transmission.

In recent years, autonomous underwater vehicles (AUVs) and remotely operated underwater robots (ROVs) have been increasingly used. They allow exploration of the water column and bottom, leak detection, sample collection, and visual inspection using cameras and sonar. These systems are particularly useful for sediment mapping and locating sunken waste or contaminants [8, 9, 10].

For a more complete picture of observations and research, various types of aerial and ground unmanned systems are also used.

Drones (UAVs) provide rapid survey of large areas, detecting oil slicks, floating debris and coastal pollution using multispectral and thermal cameras. Ground-based autonomous platforms and robotic shoreline systems support waste collection and inspection of adjacent areas.

Here we will look at airborne (UAV) and surface water (ASV/USV) pollution monitoring in continental water bodies: what sensors and platforms are used, how data is processed (algorithms and machine learning), operational

Online ISSN 3044-7771
https://doi.org/10.68302/std2026.vol1.190

workflows, and main limitations when applied in field conditions.

Various platforms and sensors are used for aerial surveillance (UAV), and we will provide a brief overview of the most commonly used ones.

Multispectral cameras (4–8 channels) and RGB cameras for rapid mapping of surface anomalies such as oil slicks, floating debris, and coastal pollution.

Hyperspectral sensors for detection and quantification of chlorophyll a and differentiation of algae species in blooms (HABs) through specific spectral signatures.

Thermal cameras and NIR channels for detecting temperature anomalies and differences in reflectivity between water and oil films [11].

Various algorithms and information processing are used when processing information and analyzing the received data.

Deep neural networks (e.g. U-Net, YOLO variants) are used for segmentation and detection of oil and waste spills on a water surface, and also create models trained on multispectral input data, increasing accuracy in complex conditions (waves, reflections, vegetation).

For HABs, spectral indices and machine learning are used to estimate chlorophyll-a concentrations and distinguish cyanobacteria from other phytoplankton groups [12, 13].

When conducting observations, it is necessary to carry out mission planning and operational practices, such as:

Altitude and overlap: low flights (10–120 m) with high overlap for detailed maps; choice depends on sensor resolution and wind conditions.

Surveillance frequency: regular flights (daily/weekly) in critical areas are recommended for early detection of incidents; in the event of an event, intensive mapping and tracking missions are recommended.

When making observations, it is necessary to take into account some limitations such as cloud cover, strong wind, reflections and shadows, which can reduce the quality, when planning them. When making observations and collecting information, ground validation (samples) is necessary for model calibration [14].

In parallel with aerial monitoring, it is necessary to carry out surface water monitoring (ASV / USV) to obtain more complete and reliable data. It is especially important to select the right platforms on which to deploy the equipment and to take into account the payload of the platform. One of the most widely used are autonomous surface vessels (ASV / USV) with a modular architecture for the integration of various equipment to measure pH, dissolved oxygen (DO), conductivity, turbidity, chlorophyll- fluorimeters, spectrometers and automatic samplers (against contamination).

III. Results and Discussion

have been built that combine mechanical modules for collecting floating debris or filtering oil slicks, as well as solar charging for extending missions.

According to the sampling and measurement methods used, they can be categorized according to the following indicators:

1. Discrete samples: automatic samplers (syringe - type or piston) allow storage of multiple samples along a trajectory for laboratory analysis; this is important when monitoring toxic substances and microbiological parameters.

2. Continuous sensors: embedded sensors provide time series and allow mapping of spatial variability of parameters in real time.

The autonomous air, ground and water vehicles used must be reliable and provide reliable information. It is of utmost importance that they have a good navigation system and are reliable and safe.

ASVs must integrate GNSS, inertial systems and obstacle avoidance systems (LIDAR/camera/radar) for safe operation in shipping areas, and in limited communication, they execute local plans and buffer data for later transmission.

The use of these means to control pollution of water bodies must be in synergy between air and surface [15].

Tandem and swarm operations are used to fully map the surveyed area.

UAV → ASV workflow, where the drone performs rapid mapping and localizes anomalies, and then the ASV heads to the areas for detailed measurements and sampling. This approach optimizes resources and speeds up incident response.

ASV swarms can cover large areas in parallel, distribute sampling, and maintain continuous monitoring, while UAVs provide an operational picture from above.

Multisensor fusion combines multispectral or hyperspectral imagery with in-situ measurements (pH , DO, chlorophyll) to provide more reliable estimates and calibration of remote sensing; this improves quantitative estimates (e.g. chlorophyll-a concentration) and reduces false alarms.

At the same time, automated workflows are also being applied, such as cloud platforms for ingest, pre-processing (reflection correction, georeferencing), model inference (detection/ classification), and visualization in GIS for rapid decision-making.

In recent years, a lot of practical experience has been accumulated and the following practical considerations and recommendations for more effective activity and more accurate results can be formulated [16].

1. Calibration and validation, which involves regular field calibration of sensors and comparison of remote assessments with laboratory samples, are essential for reliable and accurate results.

2. Communications and processing, creating an architecture with local storage and asynchronous transmission upon connection recovery. In critical incidents, there should be a channel for priority transmission of compressed maps and alarms.

3. Energy and autonomy, which applies the use of energy-efficient missions, solar charging, and trajectory optimization to extend the operating time of ASVs and UAVs.

4. Regulations and safety in compliance with aviation and water regulations, flight zones, permits for operation over populated areas and collision avoidance procedures.

The concept of coordinated teams of heterogeneous autonomous platforms (ASV, AUV, UAV) allows for task separation: rapid mapping from the air, followed by detailed measurement and local cleaning by surface and underwater robots. Swarm approaches improve the coverage and resilience of operations through distributed autonomy and adaptive planning [17].

The use of these monitoring systems has wide application for pollution control.

1. Enable continuous monitoring and early warning. Mobile autonomous systems can perform regular transects and provide real-time data on key water parameters, allowing early detection of deviations from the norm and rapid response to incidents [18]. Integration with cloud platforms and machine learning facilitates automatic classification of events (e.g. blooms, oil spills) and prediction of spread.

2. Localized cleaning and collection of litter, where robotic “cleaning” platforms designed for coastal areas and ports are already being used to collect floating plastic litter and prevent it from entering larger bodies of water. The combination of visual detection and mechanical collectors allows for the creation of “clean corridors” near the shore [19].

3. Coordinated strategies are being developed for oil spills, where swarms of autonomous platforms map the spill, localize the source, and implement local containment and collection measures (floating barriers, filtration modules). Research shows that heterogeneous teams can speed up the response and reduce environmental damage with proper coordination and trajectory modeling.

To implement the activity of controlling the pollution of water bodies, it is necessary to observe a legal framework and integration in water management [32].

The European Water Framework Directive sets targets for achieving “good status” for water bodies and requires monitoring programmes and pollution reduction measures. Autonomous systems can contribute to meeting these requirements through increased spatial and temporal coverage, but their implementation requires data standardisation, sensor certification and clear regulation of operational procedures. Political and institutional barriers are often linked to a lack of funding, insufficient coordination between agencies and the need to train staff to use the new technologies.

The technical and operational challenges to detecting plastic waste pollution in water bodies are:

1. High quality and calibration of sensors, because mobile platforms use a variety of sensors and maintaining accuracy and calibration in field conditions is critical for reliable data.

2. Energy autonomy, because battery limitations limit the duration of missions, and this can include solutions that include solar charging, hybrid systems, and trajectory optimization.

3. Excellent communications and data transmission, because in remote areas the connection can be unstable. An architecture for local data storage and asynchronous transmission upon connection recovery is required.

4. Good navigation, reliability and safety. Autonomous platforms must avoid collisions with vessels and operate in complex hydrodynamic conditions. This requires reliable localization systems and adaptive planning.

5. Ethics and liability, with clear rules for liability for damage, loss of platforms, or wrongdoing, are needed before widespread deployment.

Swarms of small autonomous platforms can perform parallel tasks (scanning, sampling, waste collection) and reallocate resources in real time based on detected anomalies, which increases the efficiency and resilience of operations [26], [31].

For sustainability, it is important that data and results are accessible to local authorities, water operators and civil society organizations. Training and joint pilot projects facilitate the adoption and proper use of technologies.

Recommendations for implementing these systems can be formulated as follows:

1. Pilot projects in priority basins with clearly defined objectives (monitoring, early warning, cleanup) and evaluation of effectiveness.

2. Data standardization and calibration through certified procedures and compatible exchange formats.

3. Integrated operations centers that coordinate UAV/ASV/AUV missions and provide liaison with rapid response institutions.

4. Financial and regulatory incentives for deployment, including public-private partnerships and innovation programs.

5. Development of swarm and coordination algorithms for optimal use of heterogeneous platforms in incidents such as oil spills [17], [27].

When flying in adverse weather conditions — fog, heavy rain, or snowfall — safety must be the top priority. Flights should be postponed whenever possible if conditions compromise safe operation. Fog greatly reduces visibility and complicates visual navigation; in such situations, drones equipped with thermal and infrared cameras can assist with orientation and object detection. Heavy rain poses a risk to many drone models because most are not waterproof and can be damaged by moisture ingress. For operations in rain, it is important to use platforms specifically designed to be water-resistant and to apply additional protective measures for the electronics. Snowfall combines reduced visibility with the risk of freezing mechanical and electrical components. Drones with cold-resistant materials and components, together with thermal sensors, can facilitate operations in these conditions, but strict preflight checks and safety procedures remain essential [24], [30], [36], [38].

Practical Measures and Recommendations for Safety

1. Preflight inspections: check seals, battery condition, sensor functionality, and protective coverings.

2. Platform selection: choose drones with appropriate ingress protection and low-temperature ratings for the expected conditions.

3. Sensor suite: combine visual cameras with thermal and infrared sensors for more reliable detection in low-visibility situations.

4. Mission limits: shorten flight durations and avoid risky maneuvers in bad weather; plan contingency options for safe landing.

5. Postflight maintenance: dry and inspect components after exposure to moisture or ice.

During the study it was found that in Bulgaria, besides the Yambol municipality, the Sofia municipality and the Burgas municipality are using marine drones and artificial intelligence to detect potential pollution risks to habitats in the Black Sea. This initiative is part of a project supporting the blue transformation of the Black Sea basin. These are still early tests of drone use in this area, which is typical for the adoption of new technologies — projects usually start with pilot trials and expand gradually [20], [25], 33], [39].

One of the monitoring systems in Europe is the Copernicus Marine Service, which integrates multiple observation sources. European countries use a combination of techniques to monitor plastic waste: numerical modeling, on-site monitoring, and satellite observation. These methods help track the movement of debris, estimate quantities, and plan targeted cleanups. The outlook is to expand monitoring to more water bodies and their surrounding areas, with a significant portion of surveillance carried out by drones [17], [21], [28], [37].

Around the world, different technologies are applied to detect and track plastic waste in the oceans. Ocean current modeling and satellite observation are key methods for following debris distribution and assessing impacts on marine ecosystems. Satellite imagery can reveal large accumulations of plastic in open waters. In coastal zones, especially in tropical regions such as parts of the Pacific with dense vegetation, coastal monitoring drones are particularly important for rapid mapping and pollution assessment [22], [29], [34], [40].

Selected Successful Projects and Examples

- HESOFF (LIFE): uses drones for remote forest imaging and health assessment; it demonstrates how unmanned platforms support biodiversity conservation and forest resource management.

- WWF projects: employ drones to monitor forests and wildlife in various regions; these initiatives show the effectiveness of drones as tools for environmental protection and climate action [17], [23], [34], [41].

IV. Conclusions

Mobile autonomous systems represent significant potential for improving pollution control in inland water bodies and adjacent territories. They complement traditional methods through greater spatial and temporal coverage, rapid response capabilities, and local cleanup. To realize this potential, coordination between technologies, regulations, and institutions, data standardization, and pilot implementation within existing legal mechanisms for water management are needed.

Combining multispectral/hyperspectral UAV missions with modular ASV platforms and integrated data processing provides a powerful toolkit for early detection, mapping and local response to pollution in inland water bodies. Effective implementation requires rigorous calibration, standardized workflows and coordination between operators, laboratories and regulatory authorities.

The future of drones in environmental protection looks promising, as they are expected to play an increasingly important role in various aspects of environmental monitoring and management. Based on the study conducted, the analysis of the results achieved so far in the use of drones for detecting plastic waste, and the assessment of the future use of these progressive technologies, some conclusions and recommendations can be drawn for the development of the use of these techniques and technologies. Here are some key trends and technologies that will shape the future of drones in this area based on this study:

1. With the development of artificial intelligence and machine learning, drones will become increasingly autonomous, which will allow them to perform complex tasks without the need for constant human control. It will be necessary for a person to set the parameters of the task and control its execution, and the activities themselves will be performed by autonomous drones

2. Drones will be connected and integrated with IoT (Internet of Things), with networks of sensors and other devices, which will allow for the collection and analysis of data in real time for better environmental management. This will allow for larger databases to be collected, which will make research more accurate and forecasts better.

3. The development of new and more sensitive sensors and cameras will allow for more precise detection and monitoring of pollution and other environmental problems. Less time and resources will be needed to assess the situation and make an adequate decision.

4. Drones will increasingly use renewable energy sources, such as stand-alone solar panels, to reduce their carbon footprint and be more environmentally friendly.

As prospects for the use of drones in the foreseeable future, the following can be mentioned:

1. Drones will continue to play a key role in the detection and monitoring of air, water and soil pollution. They will be an indispensable tool for detecting pollution of water bodies and their adjacent territory by plastic waste.

2. They will be used to track wildlife populations and detect illegal activities such as poaching. They will help to expand biodiversity and preserve the purity of the environment.

3. Drones will help to quickly assess damage after natural disasters and plan restoration activities. They will help to locate injured people and rescue them.

These trends and technologies show that drones will continue to be an important tool in efforts to protect the environment and sustainably manage natural resources.

In Bulgaria, work is underway to increase the use of drones in state, municipal and private structures, and they are also used in a number of projects, and emphasis will be placed on several of them:

A project for the blue transformation of the Black Sea basin has the Municipality of Burgas as the main beneficiary. Municipal administration employees are using marine drones and artificial intelligence to detect potential risks of pollution of habitats in the Black Sea. This project is part of a larger initiative to protect the marine environment and is about to be expanded.

The HESOFF project, which is funded under the LIFE program and monitors the environment, including water bodies. This project involves remote sensing of forests with unmanned aerial vehicles to assess the health of forests, the state of water bodies in them and the protection of biodiversity.

These projects show how Bulgaria strives for sustainable development and environmental protection through innovation and new technologies, including the use of unmanned aerial vehicles. Based on the research conducted, the analysis of the results obtained and the identified prospects for the use of drones in environmental monitoring, and in particular of water bodies and adjacent terrains, we can summarize that a wider use of drones in environmental protection is imminent.

REFERENCES

[1] Vassilev G., Radioecology, Tita Consult, Sofia, 2005

[2] Dolchinkov N., Karaivanova-Dolchinkova , BE, Impact of Types of Electromagnetic Radiation on Living Nature, 14th International Scientific and Practical conference Environment. Technology. Resources. Vide. Technology. Resources , 2023, ISSN 1691-5402, 1, pp. 55–59

[3] S. Madzharov, I. Ivanov, N. Yordanov, A Digitally Manipulated Gunshot Sound Identification. In Environment. Technologies. Resources. Proceedings of the International Scientific and Practical Conference, 2024, Vol. 3, pp. 170-174 , ISSN: 16915402, https://doi.org/10.17770/etr2024vol3.8150E.

[4] T. Trifonov, I. Simeonov, N. Yordanov, Advanced signal processing methods for analysis of high dynamic range acoustic phenomena, Communication, Electromagnetics and Medical Application, 2018, October, pp. 52–56.

[5] M. Musaev, A. Boboev, and E. Arziyev , Formalization of tasks to ensure the safety of emergency and explosive operations in the mining industry, ETR, vol. 1, pp. 257–260, Jun. 2024, https://doi.org/10.17770/etr2024vol1.8007

[6] Tsvetkov R. Electromagnetic fields created from mobile devices and methods for hygienic protection , Collection reports from International scientific conference " Radiation" safety in modern times world " , volume 2, National University " Vasil Levski" , Veliko Tarnovo, 2025, ISSN 2738-7607, pp. 150-155, https://doi.org/10.34660/INF.2025.23.39.048.

[7] Simeonov M., M. Marinov, Determine the location of nodes in wireless sensor network by using genetic algorithm, Environment. Technology. Resources. Proceedings of the 15th International Scientific and Practical Conference June 27-28, 2024, Vol. 2, https://doi.org/10.17770/etr2024vol2.8059 pp 247-252

[8] Koynakov K., Research of the energy status of military personnel during complex tactical exercises, Environment. Technology. Resources. Rezekne, Latvia Proceedings of the 16th International Scientific and Practical Conference. 2025. Volume V, 135-139

[9] Nichev N., Koynakov K., A model for using drones for medical reconnaissance in combat operations, Environment. Technology. Resources. Rezekne, LatviaProceedings of the 16th International Scientific and Practical Conference. 2025. Volume V, 209-212

[10] Nedev , N., Specificity on the international humanitarian right in the conditions on modern armed conflicts , Scientific Conference " Knowledge , Science , Innovations , Technologies ", December 13, 2024, Veliko Tarnovo, ISSN 2815-3480 (CD), pp . 1455-1468.

[11] Dolchinkov N., Optimizing energy efficiency in the conditions of a global energy crisis, Optimizing Energy Efficiency During a Global Energy Crisis, 2023, ISBN13: 9798369304006 EISBN13: 9798369304013, https://doi.org/10.4018/979-8-3693-0400-6 pp . 1–9

[12] Dolchinkov N., Ozerova NV, State of recycling of waste in Bulgaria, International scientific journal: Science. Business. Society 4/2019, ISSN 2367-8380 pp. 131-134;

[13] Tsvetkov. R. Risks of increasing the specific absorbed power (SAR) when using mobile devices. Proceedings of the International Scientific Conference "Radiation Safety in the Modern World", volume 3, National University "Vasil Levski", Veliko Tarnovo, 2025, ISSN 2738-7607, pp. 67-72, https://doi.org/10.34660/INF.2025.47.94.066.

[14] Milen Simeonov, Penyo Penev, NASA's scientific research campaigns - benefits and prospects for development, Collection of reports from the scientific conference "Near Space - a common goal", May 10-11, 2022, Publishing Complex of the National University of Science and Technology "Vasil Levski", ISSN 2815-3510 Print , ISSN 2815-3529 CD

[15] Dimitar Dimitrov, Evgeni Andreev, Development of computer simulations of objects on the lunar surface under the international simulation program exploration experience , Collection of papers from the scientific conference "Near Space - a common goal", May 10-11, 2022, Publishing Complex of the National University "Vasil Levski", ISSN 2815-3510 Print , ISSN 2815-3529 CD

[16] Dolchinkov N., Sergey Vambol , Viola Vambol , Barbara Savitska , Measures to reduce plastic waste in water bodies, Scientific Conference "Radiation Safety in the Modern World", National University "V. Levski" - city of Veliko Tarnovo - March 18-20, 2025, ISSN 2738-7607 Print , ISSN 2603-4689 CD, https://doi.org/10.34660/INF.2025.97.57.056, volume 2 pp. 217-231

[17] Dolchinkov N., N. Nichev, Using Drones to Clean Continental Water Bodies, Environment. Technology. Resources. Rezekne, Latvia, Proceedings of the 16th International Scientific and Practical Conference. 2025 Volume V, Print ISSN 1691-5402, Online ISSN 2256-070X, https://doi.org/10.17770/etr2025vol5.8501 89-96

[18] Dolchinkov N., Building a System for Monitoring and Controlling Pollution of Water Bodies, Environment. Technology. Resources. Rezekne, Latvia, Proceedings of the 16th International Scientific and Practical Conference. 2025. Volume I, Print ISSN 1691-5402 , Online ISSN 2256-070X, https://dx.doi.org/10.17770/etr2025volX. 8693 , village 171-177

[19] Dolchinkov N., Management of Plastic Waste Processing and Recycling in Water Pollution Reduction, Economics Ecology Socium , Volume 9, Issue 3, 2025, e-ISSN 2786-8958, ISSN-L 2616-7107, https://doi.org/10.61954/2616-7107/2025.9.3-5, pp. 62-78

[20] Stefanova, D.P., Vasilev, V.P., Efremovski, I.P. (2023). Re-innovative organizational design: sustainable branding and effective communication - applied models in a world with new borders/without borders, Book Chapter: Handbook of Research on Achieving Sustainable Development Goals With Sustainable Marketing, pp. 112–127; https://doi.org/10.4018/978-1-6684-8681-8.ch006

[21] Dolchinkov N., . Construction Of A System For Monitoring The Pollution Of Water Bodies With Waste, Environment. Technology. Resources. Rezekne, Latvia, Proceedings of the 15th International Scientific and Practical Conference. Volume I, Print ISSN 1691-5402, Online ISSN 2256-070X, https://doi.org/10.17770/etr2024vol1.7989, pp 136-141

[22] Dolchinkov N., Karaivanova-Dolchinkova, B.E., Impact of Types of Electromagnetic Radiation on Living Nature, 14th International Scientific and Practical conference Environment. Technology. Resources. Vide. Technology. Resursi, 2023, ISSN 1691-5402, 1, pp. 55–59

[23] Haralampiev M., Global environmental problems and their relationship with the protection of the population and infrastructure, Collection of reports from the scientific conference "Actual problems of the protection of the population and infrastructure", Vasil Levski, Veliko Tarnovo, 2012, volume 4 , pp. 34-49, ISBN 978-954-753-104-8;

[24] Dolchinkov N., . Construction Of A System For Monitoring The Pollution Of Water Bodies With Waste, Environment. Technology. Resources. Rezekne, Latvia, Proceedings of the 15th International Scientific and Practical Conference. Volume I, Print ISSN 1691-5402, Online ISSN 2256-070X, https://doi.org/10.17770/etr2024vol1.7989, pp 136-141

[25] .Petrova, D., An Approach to Modeling Innovation Obsolescence, Vide Tehnologija Resursi Environment Technology ResourcesOpen source preview, 2023, 1, pp. 175–179.

[26] Vassilev G., Radio ecology, Tita consult, Sofia, 2005;

[27] Vasilev, V., Stefanova, D., Popescu, C. (2023). Human capital management and digitalization - From good practices and traditions to sustainable development; Book Chapter: Digitalization, Sustainable Development, and Industry 5.0: An Organizational Model for Twin Transitions, pp. 41–65; https://doi.org/10.1108/978-1-83753-190-520231004

[28] Dimitrov B., Problems in the special preparation for nuclear, chemical and biological protection, Collection of reports from a scientific conference, IV International Scientific Conference High Technologies. Business. Society 11-14.03.2019, Borovets, Bulgaria, Volume Iii "Society", pp. 263-265, ISSN 2535-0005

[29] Loktionov, O.A., Fedotova, E.V., Kondrateva, O.E., Dolchinkov, N.T., Kuznetsov, N.S. Actual and design wind loads for overhead transmission lines in the Central European part of Russia, IOP Conference Series: Earth and Environmental Science This link is disabled., 2023, 1281(1), 012050

[30] L. Poiša, L. Antypova, Evaluation of the Effects of Herbicides on the Weeds and the Productivity of Hybrids Maize. Environment. Technology. Resources. Rezekne, Latvia. Proceedings of the 14 th International Scientific and Practical Conference, vol. 1, pp. 195–199, Jun. 2023, https://doi.org/10.17770/etr2023vol1.7204.

[31] Stanchev G., Technical obstacles to speech intelligibility, Environment. Technology. Resources. Proceedings of the 15th International Scientific and Practical Conference June 27-28, 2024, Vol. 3, pp 300-305

[32] Simeonov M., M. Marinov, Determine the location of nodes in wireless sensor network by using genetic algorithm, Environment. Technology. Resources. Proceedings of the 15th International Scientific and Practical Conference June 27-28, 2024, Vol. 2, https://doi.org/10.17770/etr2024vol2.8059 pp 247-252

[33] V. Vasilev, D. Stefanova, and M. Icheva (2024). Green human resource management as a component of sustainable organizational development in environmental and natural economics, ETR, vol. 1, pp. 402–407, Jun. 2024, https://doi.org/10.17770/etr2024vol1.7966

[34] Petrova, D., Vlahova, B., Lengerov, A., Zlateva-Petkova, T., Improvement of Constructive-Technological Approaches Reducing Innovative Obsolescence of Industrial Technologies in the Context of Industry 4.0, Vide Tehnologija Resursi Environment Technology ResourcesOpen source preview, 2023, 1, pp. 180–186.

[35] Petrova, D., Vlahova, B., Lengerov, A., Zlateva-Petkova, T., Study of the State of Innovation Development and Obsolescence in the Republic of Bulgaria of Companies from the Mechanical Engineering Sector, Vide Tehnologija Resursi Environment Technology ResourcesOpen source preview, 2023, 1, pp. 187–194.

[36] Petrova, D., Innovative Obsolescence in Mechanical Engineering and Singleness of Indicators, Vide Tehnologija Resursi Environment Technology ResourcesOpen source preview, 2024, 3, pp. 221–224.

[37] Toneva, D., Dimitrova, D., Some aspects of the water crisis in Bulgaria, 5th International Scientific Practical Conference „Environment. Technology. Resources ", Published by Rezekne Academy of Technologies, Latvia. Volume I, pp. 373-377, ISSN 1691-5402, ISBN 978–171389957–0.

[38] Rachovski, T., Petrova, D., Ivanov, I., Automated Creation of Educational Questions: Analysis of Artificial Intelligence Technologies and Their Role in Education, Vide Tehnologija Resursi Environment Technology ResourcesOpen source preview, 2024, 2, pp. 465–467.

[39] Ariphadzhaeva M.B., Mirsharipova Z.M. Algorithm and mathematical apparatus for determining the critical state of rescuers in extreme situations using innovative technologies // INNOVATION TECHNOSYSTEMS. — 2025. — No. 1/17. — P. 231-236 . URL: — mvahi.uz

[40] Suleymanov A.A. , Hasanov O.L. Mechanism of security of security // Actual problems of security of security in Russian Federation.

[41] Suleymanov A.A. , Hasanov O. About the science that studies development methodologies of the security of security // Actual problems of security of the security in Russian FederationA. Rezi and M. Allam, "Techniques in array processing by means of transformations, " in Control and Dynamic Systems, Vol. 69, Multidimensional Systems, C. T. Leondes, Ed. San Diego: Academic Press, 1995, pp. 133-180.

[42] Georgiev G., People as a resource in the organization, Plovdiv: Academic Publishing House Talent of the Higher School of Agribusiness and Regional Development, 2022. 232 p. ISBN 978-619-203-326-2 (CD)

[43] Ilcheva M., G. Georgiev, Information and social security – contemporary risks and challenges, KNOWLEDGE, science, innovations, technologies: collection of reports from a scientific conference, Publishing House "Institute for Knowledge, Science and Innovations", Veliko Tarnovo, 1/2024, pp. 1116-1128, ISSN 2815-3480 (CD) [NRS]