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ENVIRONMENTAL PROTECTION

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Мутные воды в понимании экологии водных загрязнении

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Аннотация. В этой статье рассказывается о проблеме загрязнения воды в целом, так как наличие свежей и чистой воды является основным и критическим вопросом, который изучается. Многие люди страдают от нехватки пресной воды. В статье рассматривается эта проблема, показаны причины ее возникновения и проиллюстрированы некоторые методы в этой области. Многие предложенные методы, как и гибридные, также предлагаются и обсуждаются в качестве выводов данной работы. Искусственный интеллект и методы машинного обучения также освещены в этой статье и способ использования многих алгоритмов в области загрязнения воды и как устранить или избежать его, чтобы получить свежую и чистую воду.

Ключевые слова: загрязнение воды, пресная вода, машинное обучение, гибридные методы.

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Navigating the murky waters understanding the ecology of water pollution̆

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Abstract. This paper explains the problem of water pollution in general, since having a fresh and clean water is major and critical issue and according to studied. There are a lot of people are suffered from lack of fresh water. The paper discusses this problem showing reasons of this problems and illustrates some methods in this field. Many suggested methods as hybrid methods are also proposed and discussed as the findings of this paper. Artificial intelligence and machine learning methods also highlighted in this paper and the way of using many algorithms in the field of water pollution and how to eliminate or to avoid it to get fresh and clean water.

Keywords: water pollution, fresh water, machine learning, hybrid methods.

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Introduction

Humans can live for three weeks without food, according to science, yet most individuals cannot survive for three to four days without water! When dehydration sets in, a person will go into shock and become vegetative even if they are still breathing. Put otherwise, water is the most important requirement. A live thing just cannot thrive without it. Nonetheless, the idea that billions of people worldwide lack access to adequate drinking water is horrifying [1].

Getting clean water at home is as «natural» as breathing fresh air in industrialized nations—those with access to all modern conveniences. While most individuals in developed nations would not give it much thought, this is not the case for people in other parts of the world. Many countries still lack access to sources of clean water or water suitable for human use.

Unfortunately, many people still lack access to clean water, and this situation won't change until governments are prepared to take action. These are the top five reasons why everyone should have access to safely regulated sanitation and clean drinking water at home. Provides Nourishment, The Disease Prevention, Aids in Eliminating Toxins, Required for Food Production and Agriculture, and Better Sanitation Facilities [2].

Not only is clean water necessary for drinking, but it also serves sanitary needs. Diseases will also spread if clothing is laundered or if the body is cleaned in tainted water. The same holds true for household chores like cooking and cleaning that are essential to our daily existence. To be healthy, one needs access to clean water.

Water pollution is the discharge of pollutants into lakes, streams, rivers, estuaries, and seas that are so large as to impede the natural functioning of ecosystems or the beneficial use of the water. Water pollution may also involve the discharge of energy into bodies of water, such as heat or radioactivity, in addition to the release of materials like chemicals, debris, or germs [3].

Official regulatory data indicates that 35 to 60 percent of Russia's drinking water reserves do not exceed safety criteria. for spring and surface water. Impermeable percentages are, respectively, 40 and 17. Eleven million Russians lack access to clean drinking water. Dumping from the Soviet period is mostly to blame for the widespread water contamination. Russia's waterways were overflowing with sewage and chemicals, even radioactive wastes in certain areas. There is a significant influence on Russia's water supplies, both in Moscow and other places.

Scientists from Germany and the Netherlands utilized modeling techniques to assess the impact of nitrogen pollution on water quality across more than 10,000 river basins worldwide. Their findings reveal a significant increase in the number of river basins facing clean water scarcity when accounting for nitrogen pollution alongside traditional water quantity estimates. By 2010, the number of affected river basins rose from 984 to over 2,500 when nitrogen pollution was considered. Projections for 2050 under a worst-case pollution scenario suggest an even greater challenge, with over 3,000 river subbasins potentially facing clean water scarcity, impacting millions of square kilometers of basin area and potentially affecting billions more people.

Many researchers identify nitrogen pollution hotspots in several regions, including China, India, Europe, North America, and Africa. This divergence in estimates underscores the significance of incorporating water quality assessments alongside quantity assessments in evaluating water scarcity.

Research methodology

Authors in [4] examined water quality and monitoring violations reported by the Environmental Protection Agency (EPA), revealing that over the past decade, an estimated 63 million Americans encountered potentially unsafe water on multiple occasions. These violations, highlighted by incidents in cities such as New York City and Flint, Michigan, have raised significant concerns among the public, with 63 percent of Americans expressing substantial worry about drinking water pollution. Despite increased media attention, the authors argue that many affected individuals remain overlooked. Moreover, they contend that systemic biases contribute to the unequal distribution of water quality issues across the population. In addition to the immediate concerns regarding drinking water, the authors emphasize the broader impact of water contamination on various aspects of daily life, including food consumption and recreational activities. They critique the existing regulatory framework for its complexity and inconsistency in addressing water pollution and resource management. The article focuses on the aftermath of the U.S. Supreme Court's decision in Rapanos v. United States, which disrupted the longstanding definition of «waters of the United States» (WOTUS). The authors explore the historical evolution of clean water regulations, analyzing the implications of the Rapanos decision on regulatory enforcement and state-level responses. They provide insights into the contrasting approaches of the Obama and Trump administrations toward clean water regulation. Ultimately, the authors advocate for reinstating the previous definition of WOTUS to restore regulatory clarity and uphold the original intent of clean water protections. They emphasize the importance of engaging with communities affected by water pollution in policymaking and advocate for judicial intervention to promote social justice in water resource management.

In [5], authors conducted an extensive investigation into the ecological dynamics of urban water bodies, focusing on the implications of anthropogenic activities on their biophysical and chemical characteristics. Their study involved regular monitoring of various parameters in Anchor and Dal lakes, spanning surface waters, sediments, and dominant macrophytes across multiple sampling sites. The authors found significant spatial and temporal heterogeneity in the studied variables, particularly influenced by human pressures. They observed pronounced fluctuations in temperature, pH, conductivity, and ion composition, with notable contributions from agricultural runoff and faunal organic pollution. Despite the eutrophic conditions indicated by elevated total phosphorus levels, nitrate concentrations remained relatively low, attributed to autotrophic assimilation and other natural processes.

The study also revealed the prevalence of anthropogenic trace elements in the water and sediment samples, with concentrations exceeding global averages. However, most priority pollutants remained below USEPA chronic levels, except for iron and zinc, which exceeded maximum permissible limits for irrigation.

Sediment analysis indicated the dominance of calcium and silicon, with notable gradients in pH, conductivity, organic carbon, and nitrogen content. The authors observed minimal outliers across the sampled sites, suggesting overall stability in sediment characteristics. Furthermore, the study highlighted the role of macrophytes in optimizing water quality and sediment conditions. Different species exhibited varying nutrient uptake capacities and bioaccumulation tendencies, with implications for overall ecosystem health. Based on findings, the authors proposed several management strategies for mitigating anthropogenic impacts and promoting eco-restoration in urban water bodies. These include periodic dredging, sediment trapping, and the establishment of vegetation buffer strips to maintain nutrient balance and enhance ecological resilience.

Results and discussion

To address the critical issue of water quality assessment, methodological framework leveraging supervised learning techniques is proposed. Water, a vital and scarce resource globally, is susceptible to contamination from various sources, necessitating efficient methods for assessing its suitability for consumption and other uses. It should be focused on developing predictive models using a labelled training dataset comprising physiochemical and microbiological parameters as input features. The problem is formulated as a binary classification task, where water samples are categorized as safe or non-safe based on their features. The performance of multiple machines learning algorithms, including Naive Bayes (NB), Logistic Regression (LR), k Nearest Neighbors (kNN), tree-based classifiers, and ensemble techniques should be evaluated. This proposed methodological framework offers a robust approach to water quality prediction using machine learning, providing valuable support to researchers in their efforts to safeguard this essential resource [6].

Another proposed method by CGI that leads and develops a pilot project in the United Kingdom, the aim is to leverage artificial intelligence (AI) in this project (thanks to its powerful features) to predict events related to water pollution by using collected data from sensors or satellites. This will enable the companies to have early warnings to various sectors such as soil, water (surface, underground), construction, and farming, enabling them to take preventative measures. The pilot project is covering a UNESCO-protected area that includes comprising natural habitats, cities, areas, and farmland. CGI collaborates with many different partners to monitor indicators of water health like acidity and ammonia levels. After collecting this data, AI system processes it by different algorithms to estimate pollution sources and then decide to take appropriate actions.

CGI's pilot project focuses on sustainability and climate, it is addressing challenges of pollution through technological innovation. By adopting technologies of machine learning, the AI works to identify pollution sources and provides valuable insights for stakeholders ranging from water companies to regulatory agencies. It collaborated with the United Nations so they aim to challenge conventional thinking around sustainability. The AI system uses diverse datasets that have been collected, including topographic and satellite data, to analyze trends and patterns related to pollution. Additionally, the AI aids in pinpointing pollution sources and tracking the movement of pollutants across water systems [7].

CGI plans in future to expand the field of regions where program works. Continuous refinement and machine learning will be also developed according to the new algorithms in the field to keeps enhancing the effectiveness of the AI tool, contributing to its global ambitions in addressing water pollution challenges.

Some methods should be conducted and evaluated:

1. Natural Treatment Systems with Advanced Technologies: this means that some natural treatment methods such as biofiltration, phytoremediation, and constructed wetlands need be implemented, they also can be implemented with other modern and developed other techniques like nanotechnology or electrocoagulation. This hybrid approach can be used to investigate the natural ability of natural plants and microorganisms to be used to eliminate and remove contaminants, at the same time, they can improve the efficiency through advanced treatment processes and enhance quality of water and this cover many types of water existence such as surface and ground water [8].

2. Smart Monitoring and Control Systems: By Integration modern portable smart monitoring systems with real-time data analysis boards that have a lot of capabilities to detect pollution sources promptly, it is also possible by employing deep analysis to estimate while this source could be pollution in the future. There is a possibility to combine this approach with automation control systems to make some events every time a pollution is detected with a high percentage to do actions that can affect water treatment processes dynamically based on pollution levels that are detected and environmental conditions [9].

IoT sensors or technologies can be used as smart devices to incorporate with AI algorithms, and remote sensing technologies, this hybrid method ensures proactive pollution management.

3. Green Infrastructure and Grey Infrastructure Integration: By combination elements of green infrastructure (vegetated swales, rain gardens, and permeable pavements) with conventional grey infrastructure (sewage treatment plants and stormwater management systems). Using this hybrid method will:

1. Maximize the benefits of both systems
2. Enhancing water quality while improving urban resilience to pollution events and extreme weather.

4. Bioremediation with Chemical Treatment: Bioremediation techniques can be employed to use

enzymes or microbial cultures to degrade level of pollutants in water elements. Ozonation or activated carbon adsorption can be used with chemical treatment methods, this will process not all contaminants but specific contaminants depending on chemical properties. And in sequence, it will improve the overall treatment efficiency. This suggested method will offer multi-usage to addresses a wide range of pollutants while minimizing environmental impact [10].

5. Decentralized Water Treatment Systems with Centralized Monitoring: decentralized water treatment systems can be implemented by incorporating technologies such as:

1. Membrane filtration;
2. UV disinfection;
3. Biological reactors.

By using centralize monitoring and control functions, this will enable coordination of multiple decentralized treatment units in real-time. This will improve accessibility to get fresh and clean water.

6. Nature-Based Solutions with Floating Treatment Wetlands: this suggested solution aims to combine nature-based solutions such as floating treatment wetlands (FTWs) with traditional water treatment methods to achieve improvements in removing pollutants with high efficiency in water bodies. FTWs depend on floating vegetation mats that absorb nutrients and filter contaminants, complementing existing treatment infrastructure.

This solution does not require expensive materials and environmentally sustainable water purification solutions, particularly in surface resources of water.

7. Integrated Watershed Management Approaches: Adopt integrated watershed management approaches that combine land-use planning, pollution prevention measures, and water resource management strategies. Incorporate green infrastructure, soil conservation practices, and riparian buffer zones to mitigate nonpoint source pollution and protect water quality at its source. This holistic hybrid approach addresses pollution at the watershed scale, promoting sustainable water management practices and ecosystem health.

Conclusion

In summary, this paper addresses the pressing issue of water pollution, emphasizing its significance as a major global challenge impacting access to fresh and clean water. Through an exploration of the root causes and manifestations of this problem, various methods and strategies for mitigation are presented. Notably, hybrid approaches, combining traditional and innovative techniques, emerge as promising solutions. Furthermore, the paper underscores the role of artificial intelligence and machine learning in water pollution management, elucidating the application of diverse algorithms for the prevention and remediation of pollution to ensure the provision of safe drinking water.

Литература

[1] WHO/UNICEF Joint Water Supply, Sanitation Monitoring Programme. 2005. Water for life: making it happen. World health organization

[2] Dharminder, R. K. S., Kumar, V., Devedee, A. K., Mruthyunjaya, M., Bhardwaj, R., The clean water: The basic need of human and agriculture // IJCS. 2019. 7(2), C. 1994-1998

[3] Singh, J., Yadav, P., Pal, A. K., & Mishra, V., Water pollutants: Origin and status // Sensors in water pollutants monitoring: Role of material. 2020. C. 5-20

[4] Swanson, C. M., NAVIGATING MURKY WATERS: STATE-LEVEL STRATEGIES FOR WETLAND PRESERVATION AND TILE DRAINAGE REGULATION AFTER SACKETT V// EPA. 2024

[5] Qadri, H., Bhat, R. A., Mehmood, M. A., Dar, G. H., Fresh water pollution dynamics and remediation // Singapore: Springer. 2020. C. 15-26

[6] Zamri N., Pairan M. A., Azman W. N. A. W. [et al.]. River quality classification using different distances in k-nearest neighbors algorithm // Procedia Computer Science. 2022. C. 180-186. DOI 10.1016/j.procs.2022.08.022. EDN: YCTJIW

References

[1] WHO/UNICEF Joint Water Supply, Sanitation Monitoring Programme. 2005. Water for life: making it happen. World health organization

[2] Dharminder, R. K. S., Kumar, V., Devedee, A. K., Mruthyunjaya, M., Bhardwaj, R., The clean water: The basic need of human and agriculture // IJCS. 2019. 7(2), PP. 1994-1998

[3] Singh, J., Yadav, P., Pal, A. K., & Mishra, V., Water pollutants: Origin and status // Sensors in water pollutants monitoring: Role of material. 2020. PP. 5-20

[4] Swanson, PP. M., NAVIGATING MURKY WATERS: STATE-LEVEL STRATEGIES FOR WETLAND PRESERVATION AND TILE DRAINAGE REGULATION AFTER SACKETT V// EPA. 2024

[5] Qadri, H., Bhat, R. A., Mehmood, M. A., Dar, G. H., Fresh water pollution dynamics and remediation // Singapore: Springer. 2020. PP. 15-26

[6] Zamri N., Pairan M. A., Azman W. N. A. W. [et al.]. River quality classification using different distances in k-nearest neighbors algorithm // Procedia Computer Science. 2022. PP. 180-186. DOI 10.1016/j.procs.2022.08.022. EDN: YCTJIW

[7] Huntingford C., Yang H., Jeffers E. S. [et al.]. Machine learning and artificial intelligence to aid climate change research and preparedness // Environmental Research

[7] Huntingford C., Yang H., Jeffers E. S. [et al.]. Machine learning and artificial intelligence to aid climate change research and preparedness // Environmental Research Letters. 2019. № 12. C. 124007. DOI 10.1088/1748-9326/ab4e55. EDN: ACLXCP

[8] Mahmood Q., Pervez A., Zeb B. S. [et al.] Natural treatment systems as sustainable ecotechnologies for the developing countries // BioMed Research International. 2013. C. 796373. DOI 10.1155/2013/796373. EDN: RKTTVD

[9] Lakshmikantha, V., Hiriyannagowda, A., Manjunath, A., Patted, A., Basavaiah, J., Anthony, A. A. IoT based smart water quality monitoring system // Global Transitions Proceedings. 2021. 2(2), C. 181-186

[10] El-Sheekh M. M., Farghl A. A., Galal H. R., Bayoumi H. S. Bioremediation of different types of polluted water using microalgae // Atti Della Accademia Nazionale Dei Lincei Rendiconti Lincei Scienze Fisiche E Naturali. 2016. № 2. C. 401-410. DOI 10.1007/s12210-015-0495-1. EDN: FHFIKE

[11] Парреньо К., Саласар Флорес К., Слабоспицкая А. С., Адарченко И. А. Мутность как Основной показатель качества воды из поверхностных источников // Международный научно-исследовательский журнал. 2024. № 3(141). DOI 10.23670/IRJ.2024.141.44. EDN: TUHRIU

Letters. 2019. No. 12. PP. 124007. DOI 10.1088/1748-9326/ab4e55. EDN: ACLXCP

[8] Mahmood Q., Pervez A., Zeb B. S. [et al.] Natural treatment systems as sustainable ecotechnologies for the developing countries // BioMed Research International. 2013. PP. 796373. DOI 10.1155/2013/796373. EDN: RKTTVD

[9] Lakshmikantha, V., Hiriyannagowda, A., Manjunath, A., Patted, A., Basavaiah, J., Anthony, A. A. IoT based smart water quality monitoring system // Global Transitions Proceedings. 2021. 2(2), PP. 181-186

[10] El-Sheekh M. M., Farghl A. A., Galal H. R., Bayoumi H. S. Bioremediation of different types of polluted water using microalgae // Atti Della Accademia Nazionale Dei Lincei Rendiconti Lincei Scienze Fisiche E Naturali. 2016. No. 2. PP. 401-410. DOI 10.1007/s12210-015-0495-1. EDN: FHFIKE

[11] Parreno C., Salazar Flores C., Slabospitskaya A. A. S., Adarchenko I. A. Turbidity as the Main Indicator from Surface Sources // International Research Journal. S., Adarchenko I. A. Turbidity as the Main Indicator of Water Quality from Surface Sources. 2024. No. 3(141). doi 10.23670/irj.2024.141.44. EDN: TUHRIU

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