ARTIFICIAL INTELLIGENCE: IMPERATIVE FOR ENVIRONMENTAL PROTECTION AND MONITORING

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ABSTRACT

In the face of escalating global environmental issues, the role of artificial intelligence (AI) in environmental protection and monitoring has become increasingly significant. One of the key areas of focus is water quality monitoring in sewage treatment. AI has been instrumental in predicting and identifying potential contaminants, thus ensuring the safety and cleanliness of water resources. This not only aids in maintaining public health but also contributes to the preservation of aquatic ecosystems. The paper discussed the application of AI in sewage treatment, air cleansing and soil conservation and discussing in each case how these applications is used. Potential impacts of AI environmental modeling and its challenges and ethical considerations and also how AI can be leveraged to create a more sustainable and environmentally-friendly future were highlighted. Benefits of AI based environmental monitoring was reviewed. The paper underscores the importance of continued research, and development in AI to fully harness its potential in environmental protection and modelling.

Keywords: Artificial intelligence, environment; modeling, Monitoring, protection

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Introduction

We can't manage what we don't measure, goes the old business adage. This rings true more than ever today as the world faces a triple planetary crisis of climate change, nature and biodiversity loss, pollution, and waste. More environmental data is available than ever before, but how that data is accessed, interpreted and acted on is crucial to managing these crises. One technology that is central to this is Artificial Intelligence (AI).

So, what exactly does AI mean?

"AI refers to systems or machines that perform tasks that typically require human intelligence, and can iteratively improve themselves over time, based on the information they collect," (Jensen, 2020)

Jensen highlights several areas where AI can play a role in tackling environmental challenges, from designing more energy-efficient buildings to monitoring deforestation to optimizing renewable energy deployment. This can be on a large scale – such as satellite monitoring of global emissions, or a more granular scale – such as a smart house automatically turning off lights or heat after a certain time," he adds.

With the development of the times, the popularization of computers, the Internet, sensors, and surveillance video, artificial intelligence has become the focus of people's attention, the research and investment in artificial intelligence at home and abroad is also more and more, about 140 artificial intelligence startups have been acquired by information giants such as Google, Microsoft, Apple. Artificial intelligence plays a great role in various fields such as the education, medical field, the field of construction, and the field of data measurement. Wastewater is generated mainly from human activities, industrial manufacturing processes, and agricultural operations, which include cleaning, cooking, physiological excretion, industrial wastewater discharges, and irrigation of agricultural land, among others, water pollution in addition to the impact of human life, for the living organisms in the water, the water around the ecosystem also has a more serious impact (Von, 2020).

There are many types of gaseous pollutants, such as nitrogen oxides (NOx), which are produced when fossil fuels are burned, and sulfur oxides (SOx), which can be removed by either SCR (traditional selective catalytic reduction) or selective non-catalytic reduction (SNCR), which is more costly, but the effects of which are now widely recognized. SOx compounds can cause serious damage to human health, inducing health problems including bronchoconstriction, respiratory distress. There are various technologies for SOx treatment, and many of them are nowadays well capable of treating Sox gas emissions, such as ceramic filters, ammonia scrubbers, and particulate bed filters integrated with co-removal air pollutant systems.

In this paper, the systematic literature research method was used to study the application and impact of artificial intelligence technology on environmental protection and monitoring and its challenges and also its future role in achieving sustainable development.

The Application of Artificial Intelligence in Sewage Treatment

River water management has always been one of the important parts and challenges in environmental protection, due to the increasing number of industrial zones worldwide in the past decades, human activities have entered the environment in large numbers, thus affecting water bodies. Pollution of river water has become one of the centers of concern around the world, and the management of sewage is closely related to the water used by residents in their daily lives, the water used in agriculture, and the monitoring of water quality is the key to the management of sewage. Artificial neural network modeling (ANN) comes from the source of the human brain nervous system simulation, it can help researchers from highly complex relationships or highly complex data to find the relationship, in the processing of information, fast and accurate arithmetic is far ahead of humans. There are a variety of modeling methods using ANN algorithms to predict Water Quality Index (WQI) such as Backpropagation Neural Network (BPNN), which has achieved significant results and simplified the calculation of WQI.

To specifically monitor water pollution and take timely measures for early warning, artificial intelligence technology is gradually applied to the field of water pollution monitoring, bringing innovation and change, for example, for the Up-flow Anaerobic Sludge Bed/Blanket (UASB) reactor to deal with low concentrations of domestic sewage when there are many influencing factors (Han, Kexin, Zhang Qiong, Feng Yan, Li Xiyao, & Peng Yongzhen. 2021). It is difficult to determine the relationship between the various influencing factors, as well as it is difficult to carry out appropriate control and prediction of the treatment effect of the problem, in the artificial neural network theory, the basic structure of the prediction model of UASB treatment of low concentration of domestic wastewater based on BP artificial neural network is established, and the pilot experiment is simulated, and the results show that the predicted value and the experimental value coincide well, and play a simulation and prediction effect, and at the same time optimize the operation state. The establishment of this model for UASB treatment of domestic sewage process systems to achieve intelligent control provides a simple and practical way, with good research and engineering practical value; in the river and lake ecology, artificial intelligence is applied to automated monitoring and early warning technology, such as water quality intelligent detection of unmanned boats, can be intelligent and automatic scanning of the pollution field of the water body of the river and lake, the source of the pollution source of the independent traceability, the realization of automatic collection of water samples, real-time analysis of water quality and other functions.. It applies to the daily river patrol of the river and lake chief system, emergency management of sudden water pollution, and supervision and management of river outfalls.

Application of Artificial Intelligence in Air Cleaning

The rapid development of human civilization, has so many problems, such as fuel energy which is the main source of human energy, its extraction and use of the process of the natural environment has a great impact, which is significant for the impact of the air, fossil fuels will produce a lot of harmful gases to pollute the environment, such as oxides of nitrogen, oxides of sulfur, the environment and the human body is very harmful, so it is necessary to effectively clean the air.

In terms of air protection, through the optimization and upgrading of intelligent algorithms, the monitoring station can more accurately monitor all kinds of pollutants in the environment. Secondly, between multiple monitoring stations, the joint analysis system constructed by artificial intelligence technology can quickly locate the pollution source and wind direction, thus reducing the error and omission rate of monitoring stations and improving the overall effect of the monitoring network.

Artificial Intelligence Techniques in Soil Conservation

Soil is a leaky medium with vitality, which is vital to maintain the balance of the ecosystem and the utilization of water resources, and as a natural buffer in the environment, it helps to mitigate the impact of natural disasters, but as the depth of coal mining becomes deeper and deeper, the damage to the soil becomes more and more serious, and the ensuing water intrusion into the ground becomes more and more obvious day by day (Liu and Han 2023).

In predicting soil water content weight, hybrid modeling treatment is a classical combination of neural network (Back Propagation Neural Network) and Adaptive Boosting Algorithm (AdaBoost), which can achieve up to 100% prediction accuracy in model prediction, with the recent technological revolutions and industrial changes, Back Propagation Neural Network and Adaptive Boosting Algorithm (AdaBoost) methods and steps can be used in the prediction of different soil water contents. methods and steps can be used to create practical prediction models in different mining areas, thus effectively reducing the phenomenon of water intrusion into the soil and achieving the purpose of soil protection.

The use of artificial intelligence decision-making technology, combined with soil moisture, meteorological data, and other multifaceted information, can not only effectively reduce the phenomenon of water intrusion into the soil, but also provide intelligent analysis and prediction of farmland irrigation.

Benefits of AI-based environmental monitoring

When compared to conventional methods, using AI for environmental monitoring has a number of advantages. First, AI-based environmental monitoring systems have the capacity to evaluate enormous volumes of data from numerous sources, giving an accurate picture of the state of the environment in real time (**Zhang et al., 2021).** This enables authorities to decide wisely and act quickly to protect both the environment and the general population. Furthermore, by automating the processes of data collection and analysis, AI-based environmental protection and monitoring systems can lower the cost of monitoring programs (**Chang, 2019; Himeur et al., 2022**). This can save significant resources and allow environmental programs to grow in scope and scale. With less chance of errors and inconsistencies, AI-based environmental systems can collect and analyze data with better accuracy and precision than conventional approaches.

Notwithstanding the advantages of AI-based environmental monitoring, a number of issues need to be resolved in order to assure its successful adoption. The quality of the data used for analysis represents one of the major obstacles. For AI systems to make precise predictions and choices, they need accurate and trustworthy data (**Hameed et al., 2017**). Inadequate data quality can result in inaccurate predictions and judgments as earlier stated, which can have a negative impact on the environment and public health. The availability of data presents another difficulty. It is challenging to construct precise and trustworthy AI-based monitoring systems since many regions of the world lack adequate data on environmental factors. In addition to technological constraints, political and economic issues can also have an impact on the availability of data. The ethical implications of AI-based environmental monitoring must also be taken into account. The application of AI for environmental issues raises concerns regarding data ownership, privacy, and the possibility of data misuse.

Potential environmental impact of AI models in environmental protection and monitoring

While the benefits of AI models in environmental protection and monitoring are significant, it is important to look out for unintended environmental consequences. AI technologies, particularly those involving extensive computational processes, can have considerable environmental foot prints that must be carefully managed to ensure overall sustainability. One of the primary concerns is the substantial energy consumption associated with training and operating AI models (**Bloomfield et al., 2021**). Data centers that support AI computations consume vast amounts of electricity, often sourced from non-renewable energy had become a source of concern t environmental protection (**Rostirolla et al., 2022**). This high energy usage can lead to increased carbon emissions, counteracting the positive impacts that AI applications might have in protection, monitoring and mitigating environmental issues. Recent reports from major technological companies underscore this issue. Google's efforts to reduce its climate footprint are being undermined by its increasing reliance on energy intensive data centers to power its new AI products (**Abebe, 2023**). According to Google's annual environmental report, its greenhouse gas emissions have surged by 48 % over the past five years, with electricity consumption by data centers and supply chain emissions being primary contributors (**Google, 2024**). In 2023 alone, Google's emissions rose by 13 % compared to the previous year, reaching 14.3 million metric tons of CO_2, up from 9.7 million metric tons

in 2019. Similarly, Microsoft's 2024 environmental report highlighted a substantial increase in greenhouse gas emissions, particularly Scope 3 emissions, which grew by over 30 % due to the expansion of data centers and increased consumption of hardware components necessary for their AI research (Microsoft, 2024). Although Microsoft managed to reduce its Scope 1 and 2 emissions by 6.3 % compared to the year 2020, the rise in Scope 3 emissions emphasizes the environmental challenges posed by AI infrastructure. Moreover, the hardware used in AI, including servers and data storage systems, requires manufacturing processes that often involve the extraction of rare earth elements (REE) and other non-renewable resources (**Gundeti et al., 2023**). For example, rare minerals like Erbium, Holmium, Terbium, Gadolinium, Lanthanum, and Europium are vital in the manufacturing of optical fibre, capacitors, HD drives, and semi- conductors, among other materials (**Leal Filho et al., 2023**). The associated extraction and processing phases can lead to environmental degradation, especially at end-of-life (landfilling, incineration, and open dumping), resulting. into ecological damage, soil and water pollution, and increased carbon footprints (**Balaram, 2019**). During extraction, the machinery used generates significant dust, emissions, and wastes (such as radioactive elements and other heavy metals), which could easily dissipate, leading to long-term environmental damage (**Willenbacher, 2022).** It was estimated that 63,000 m^3 of sulfuric and hydrofluoric acid residues and 1.4 tons of radioactive waste were generated from refining one ton of REE oxide in China (**Willenbacher, 2022**). This has resulted in a push for eco-friendly approaches for mineral extraction and processing, as well as discouraging single use of extracted metals (**Nwaila et al., 2022**).
AI models offer significant advancements in environmental protection, their potential environmental impacts must be diligently managed.

The Imperativeness of AI in Environmental Protection and Monitoring

AI addresses the limitations of traditional, manual monitoring methods by leveraging massive datasets from diverse sources, such as satellite imagery, IoT sensors, and acoustic recordings.

Benefits and Roles

- **Enhanced Data Investigation & Real-Time Monitoring:** AI algorithms process vast amounts of data from sensor networks, drones, and satellites to provide continuous, real-time insights into environmental conditions, such as air and water quality, soil health, and pollution levels. This speed is crucial for timely interventions during incidents like pollution spikes or industrial accidents.
- **Exact Predictive Modeling:** Machine learning models analyze historical data and current trends to forecast future environmental changes, including climate patterns, extreme weather events (floods, wildfires, hurricanes), and disease outbreaks. These predictions allow for proactive risk mitigation and better preparedness strategies.
- **Optimized Resource Management:** AI helps optimize the management of natural resources by evaluating feeding patterns and suggesting effective usage strategies.
  - **Agriculture:** Precision farming uses AI to optimize irrigation, fertilization, and crop rotation, reducing waste and environmental degradation.
  - **Energy:** AI optimizes renewable energy systems by predicting demand and managing power distribution, reducing reliance on fossil fuels and lowering carbon emissions.
- **Biodiversity and Ecosystem Protection:** AI-powered tools like computer vision and bioacoustic monitoring evaluate images and sounds from camera traps and sensors to identify and track species, monitor habitats, and combat illegal activities like poaching or logging.
- **Informed Policy and Decision Making:** By providing clear, data-driven insights, AI supports policymakers and conservationists in developing effective environmental strategies and ensuring compliance with regulations.

Challenges and ethical consideration

While the application of AI in environmental protection and monitoring has demonstrated significant potential, several limitations must be addressed to realize its full benefits.

1. One prominent limitation is the dependency on high-quality and extensive datasets (Olawade et al., 2024a). AI protection models require large volumes of accurate and representative data to train effectively, and the availability of such data can be a significant constraint. Additionally, data biases can result in skewed predictions and perpetuate existing inequalities, underscoring the need for careful data curation and preprocessing.
2. Overfitting is another critical challenge, where protection models perform exceptionally well on training data but fail to generalize to new, unseen data. Balancing model complexity to avoid overfitting while still capturing intricate patterns in the data is an ongoing challenge in AI development. Furthermore, the interpretability of AI protection models, especially deep learning models, remains a

vexing issue (Olawade et al., 2024b). These protection models often operate as "black boxes," making it difficult to understand and trust their decisions, which is particularly crucial in high stakes fields like environmental science.

3. Resource intensiveness is another challenge, as training and deploying sophisticated AI protection models demand substantial computational resources. This requirement can be a barrier for smaller organizations and developing countries, limiting their ability to leverage AI technologies effectively. Ethical concerns also pose significant challenges, with AI models potentially reinforcing biases present in training data (Olawade et al., 2023). Ensuring fairness and addressing ethical implications is crucial, especially in applications where equitable outcomes are essential.
4. Security risks, including susceptibility to adversarial attacks, where small, carefully crafted changes to input data can deceive the model, are a growing concern. Ensuring the robustness and security of AI protection models against such attacks is imperative. Additionally, the environmental impact of large-scale AI training, which consumes significant energy resources and contributes to carbon emissions, is becoming increasingly evident. Developing more energy-efficient AI solutions is necessary to mitigate this impact in the environment becomes necessary.
5. Data Privacy Concerns**:** The massive amounts of data that AI collects raise questions about how to use store and protect data. Protecting student information will be an important issue as AI's presence in the learning process increases.
6. Accessibility Issues: On the one hand artificial intelligence (AI) technologies make education more accessible and open to more students on the other hand economically disadvantaged students have less access to the right tools and technology. In order to support equal access to education and knowledge of environmental education it is crucial to close the digital divide.
7. Job Challenges: AI is very useful in every field of organization and education. However, there are some considerations related to job loss. With the advancement of automated AI, every work will be done with the help of AI, which leads to unemployment and has the potential to replace human effort. For example, China is using robots in car factories instead of human laborers for car manufacturing. The same AI may change the human job.

Despite these challenges, the future scope of AI in environmental protection and monitoring is promising. Advancements in AI algorithms, improved data collection techniques, and increased computational power are expected to enhance the accuracy and efficiency of AI protection tools in generating data in order to protect the environment.

Strength of this review

This study provides an overview of the principles, applications, and limitations of AI in environmental protection and monitoring, distinguishing itself from other review studies through several key merits. First, it highlights specific applications, strengths, and limitations in environmental protection and monitoring.

Secondly, the study addresses both technological and ethical challenges comprehensively, emphasizing the importance of responsible AI development. By discussing issues such as data dependency, overfitting, interpretability, and security risks, alongside ethical considerations, it provides a holistic perspective on the challenges and opportunities in the field.

Lastly, the study outlines a clear future scope for AI in environmental monitoring, identifying key areas for future research and development. This forward-looking perspective encourages ongoing innovation and collaboration among researchers, policymakers, and industry stake- holders to enhance the effectiveness and equity of AI applications in environmental protection..

Conclusion

In conclusion, the integration of AI in environmental protection offers transformative benefits across various domains, including sewage treatment, air quality monitoring and soil conservation. These advancements contribute significantly to environmental protection, public health, and sustainable development. AI's capability to provide precise predictions and real-time monitoring enhances the efficiency and effectiveness of environmental management practices. However, it is crucial to acknowledge the potential drawbacks associated with the deployment of AI technologies. One significant concern is the substantial energy burden imposed by data centres and the supply chain, leading to increased greenhouse gas emissions. Additionally, the extraction of resources, such as REEs for AI hardware, results in considerable environmental degradation, including habitat destruction, soil and water pollution, and toxic waste generation.

The shortage of skilled professionals in the environmental sector, particularly in the developing countries, poses another challenge to fully harnessing AI's potential. Data access, control, and privacy issues must be addressed to prevent the misuse of AI systems for personal gain, such as market manipulation or disaster prediction exploitation. Robust data governance frameworks are essential to mitigate these risks and ensure equitable and ethical use of AI technologies. Despite these challenges, the future of AI in environmental protection is promising.

For future research, there is a critical need to focus on the ethical implications and environmental impact quantification of AI technologies. Standardized methods to protecting the environmental footprint of AI systems and exploring the ethical dimensions of their deployment will ensure responsible and sustainable use. Future research and policy-making should also focus on creating frameworks that ensure the sustainable use of AI technologies, maximizing their benefits while minimizing their ecological footprints.

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REFERENCE

Abebe, W.T., Endalie, D., (2023). Artificial intelligence models for prediction of monthly rainfall without climatic data for meteorological stations in Ethiopia. J. Big Data 10 *https://doi.org/10.1186/s40537-022-00683-3*.

Balaram, V., 2019. Rare earth elements: A review of applications, occurrence, exploration, analysis, recycling, and environmental impact. Geosci. Front. 10, 1285–1303. *https://doi.org/10.1016/j.gsf.2018.12.005.*

Bloomfield, P., Clutton-Brock, P., Pencheon, E., Magnusson, J., Karpathakis, K., (2021). Artificial Intelligence in the NHS: Climate and Emissions☆,☆☆. Clim. Change Health 4, 100056. *https://doi.org/10.1016/j.joclim.2021.100056*

Chang, W.Y., (2019). A data envelopment analysis on the performance of using artificial intelligence-based environmental management systems in the convention and exhibition industry. *Ekoloji 28* (107), 3515–3521.

Google (2024). Google Environmental Report. California. Available at: *https://www.gstatic.com/gumdrop/sustainability/google-2024-environmental- report.pdf* (Accessed August 2, 2024).

Gundeti, R., Vuppala, K., Kasireddy, V., 2023. In: The Future of AI and Environmental Sustainability. 346–371 *https://doi.org/10.4018/979-8- 3693- 0892-9.ch017*

Hameed, M., Sharqi, S.S., Yaseen, Z.M., Afan, H.A., Hussain, A., Elshafie, A., (20170. Application of artificial intelligence (AI) techniques in water quality index prediction: a case study in tropical region, Malaysia. *Neural Comput. Appl. 28*, 893–905

Han, Kexin, Zhang Qiong, Feng Yan, Li Xiyao, & Peng Yongzhen. (2021) A new genus and species of the genus Pseudopalatina. Tertiary anaerobic ammonia oxidation for the treatment of domestic wastewater with nitrate wastewater. *Chinese Environmental Science, 2022, 42*(2): 637-643.

Himeur, Y., Rimal, B., Tiwary, A., Amira, A., (2022). *Using Artificial Intelligence and Data Fusion For Environmental monitoring*: *A review and Future Perspectives*. Information Fusion.

Jensen D, (2020) *United Nations Environment Program's (UNEP's)* Digital Transformation sub- programme.

Leal Filho, Kotter, R., Ö zuyar, P.G., Abubakar, I.R., Eustachio, J.H.P.P., Matandirotya, N.R., (2023). Understanding Rare Earth Elements as Critical Raw Materials. Sustainability 15, 1919. *https://doi.org/10.3390/su15031919*.

Liu Wen, Han Shuoshi (2023). A practical method for ground water burst prediction using a mixed AI model and GIS. *Mine water environment, 42,* 220-229.

Microsoft (2024). 2024 Environmental Sustainability Report. Washington. Available at: *https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RW1lMjE* (Accessed August 2, 2024).

Nwaila, G.T., Frimmel, H.E., Zhang, S.E., Bourdeau, J.E., Tolmay, L.C.K., Durrheim, R.J., et al., (2022). The minerals industry in the era of digital transition: An energy-efficient and environmentally conscious approach. Res. Pol. 78, 102851. *https://doi.org/ 10.1016/j.resourpol.2022.102851*.

Olawade, D.B., Fapohunda, O., Wada, O.Z., Usman, S.O., Ige, A.O., Ajisafe, O., Oladapo, B.I., (2024a). Smart waste management: a paradigm shift enabled by artificial intelligence. *Waste Manage*. Bull.

Olawade, D.B., Wada, O.J., David-Olawade, A.C., Kunonga, E., Abaire, O., Ling, J., (2023). Using artificial intelligence to improve public health: a narrative review. *Front. Publ. Health 11, 1196397*.

Olawade, D.B., Wada, O.Z., David-Olawade, A.C., Fapohunda, O., Ige, A.O., Ling, J., (*2024b). Artificial intelligence potential for net zero sustainability: current evidence and prospects. Next Sustain. 4, 100041*.

Rostirolla, G., Grange, L., Minh-Thuyen, T., Stolf, P., Pierson, J.M., Da Costa, G., et al., (2022). A survey of challenges and solutions for the integration of renewable energy in datacenters. Renew. Sustain. Energy Rev. 155, 111787. *https://doi.org/10.1016/j. rser.2021.111787*.

Von S, (2020). Wastewater characteristics, treatment, and disposal. IWA Publishing. *biological wastewater treatment series volume1,*

Willenbacher, M., 2022. Rebound Effects in the Use of Rare Earth Metals in ICT. Int. J. Environ. Sci. Natur. Res. 30. *https://doi.org/10.19080/IJESNR.2022.30.556277*.

Zhang, W.E., Sheng, Q.Z., Alhazmi, A., Li, C., (2020). Adversarial attacks on deep- learning models in natural language processing: a survey. *ACM Trans. Intell. Syst. Technol. (TIST) 11 (3), 1–41*.

Zhang, X., Shu, K., Rajkumar, S., Sivakumar, V., (2021). Research on deep integration of application of artificial intelligence in environmental monitoring system and real *economy. Environ. Impact Assess. Rev*. 86, 106499.

Zhang, H., Zhang, L., Wang, S., Zhang, L., (2022). Online water quality monitoring based on UV–Vis spectrometry and artificial neural networks in a river confluence near Sherfield-on-Loddon. Environ. Monit. Assess. 194 (9). *https://doi.org/10.1007/ s10661-022-10118-4*.

Zhang, C., (2024). *Fundamentals of Environmental Sampling and Analysis*. China:John Wiley & Sons.

Zhang, C., (2024). *Fundamentals of Environmental Sampling and Analysis*. China: John Wiley & Sons.