MONITORING STRATEGIES FOR WATER PROTECTION IN INDUSTRIAL CONTEXTS

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Abstract: Despite the Earth's abundant water resources, potable water scarcity persists due to pollution from multiple sources. The escalating demand for water across households, agriculture, industry, and other sectors, compounded by economic growth and population expansion, forecasts a worsening situation. Climate change further exacerbates these challenges, heightening concerns over water pollution and scarcity. Water, fundamental to the sustenance of diverse life forms on Earth, underpins all biological processes. Water pollution, characterized by changes in physical, chemical, and microbiological properties resulting from hazardous substances, poses significant threats to the quality and hygiene of drinking water and its suitability for various applications. Efforts to safeguard water resources necessitate ongoing vigilance and strategic management informed by legal frameworks and contemporary understanding. Mitigating water pollution requires a multifaceted approach encompassing monitoring, addressing root causes, pollutant reduction, purification, conservation, and robust regulatory mechanisms.
Keywords: water, protection, pollution, monitoring, environment

1. ECOSYSTEM PRESERVATION AND WATER CONSERVATION IN THERMAL POWER PLANTS

Representing a complex of environmental elements necessary for the survival of the living world (organisms), ecological factors are indispensable for organisms, forming an inseparable unity critical for existence (Jovanović, 2002). Living communities cannot be viewed separately from their environment; thus, an even larger ecological organizational unit, the ecosystem, emerges. An ecosystem constitutes a functional unity of the living community and its habitat, encompassing living and non-living nature in a defined space (Ricklefs & Miller, 2000). It represents a segment of space with living beings and the environment where matter circulation and energy flow occur (Jovanović, 2002). Nowhere has human knowledge been so quickly and functionally increased and transmitted as in the case of water (Kimmerer, 2013). This knowledge, grounded in scientific principles, has facilitated societal advancements, overcoming developmental thresholds, and fostering further progress (Ricklefs & Miller, 2019). The importance of water is not only in the function of the origin, evolution, and maintenance of global life but also in its great mobility, ability to transfer matter and energy, and power of destruction and creation (Kimmerer, 2013). Precisely the contradictions in relation to the state of quality and scarcity of fresh water resources, on the one hand, and growing social dependence, on the other hand, impose the obligation to reexamine this understanding (Nešković, 2011). Over time, the relationship between water resources and human society experiences a marked progression in complexity - first locally and regionally, and then globally (Ricklefs & Miller, 2000). Thus, through the agrarian and industrial revolution and social development, fresh water became a first-class ecological, economic, and social category, i.e., a universal resource and capital of every social community, of essential importance for meeting biological, production, and aspirational needs (Nešković, 2011). That is why the problem of its provision and protection arises as an increasingly important issue of the future - the quality of the environment and the quality of life of modern society (Nešković, 2011). Pollutions are unwanted changes in the physical, chemical, and biological properties of the constituent parts (that is, basic media) of the environment - (air, water, soil), which can adversely affect living beings and damage their ecological systems (Biočanin, 2011). Endangerment of the hydrosphere and water pollution occurs worldwide as a side effect of modern economic and demographic development, growth of industrial production, technology development, modernization in agriculture, and population concentration through the growth of cities and urban agglomerations (Biočanin, 2011). Thermal power plants make a significant contribution to air pollution, also known as the "invisible killer," with a significant negative impact on health (Biočanin, 2011). Such pollution mostly affects the population, the state health budget, and the economy as a whole due to productivity loss (Biočanin, 2011). During the use of water for the process needs of the thermal power plant, it is contaminated with various waste materials and chemicals, or it is heated, thus altering its physical and chemical characteristics (Kimmerer, 2013). The wastewater generated in this way, either continuously or occasionally, is collected and evacuated through several systems (cooling water drainage collectors, atmospheric sewage, fecal sewage) or through the ash and slag transport system to the ash landfill (Kimmerer, 2013).

2. ADDRESSING ENVIRONMENTAL DEGRADATION: CHALLENGES AND SOLUTIONS

Environmental degradation encompasses endangerment, pollution, degradation, and destruction of the environment, manifesting as any unwanted change in the composition of physical, chemical, and biological components (media) of the environment - air, water, and soil (Ricklefs & Miller, 2019). This occurs when polluting substances, polluting energy, or force fields appear in the air, water, and soil in undesirable places, times, and quantities, leading to the disruption of ecological systems' integrity (Ricklefs & Miller, 2019). Protection and improvement of the environment entail a comprehensive approach involving measures, procedures, and conditions aimed at preserving and safeguarding natural and human-made environmental values and protecting individuals from the adverse effects of harmful substances, polluting energies, and detrimental force fields. Additionally, it includes initiatives to enhance the quality of the environment and human health (Marsenić et al., 2004). Among the primary chemical water pollutants are nitrates, ammonia, phosphates, cyanides, polyphosphates, metals, polychlorinated hydrocarbons, detergents, pesticides, radionuclides, and others (Kolbert, 2019). These pollutants find their way into wastewater, which is categorized into three main types: wastewater from human settlements, industry, and agriculture, with some of it ultimately reaching watercourses and water facilities supplying the population with water (Savić & Terzija, 2018).

3. WATER UTILIZATION IN THERMAL POWER PLANTS: IMPACTS AND MANAGEMENT STRATEGIES

The field of water protection is dynamic and expansive, requiring ongoing regulation and adaptation in response to the evolving state of water bodies, advancements in science and technology, and accumulating experiences and knowledge (Marsenić et al., 2004). The aim is to continually enhance measures and regulations to safeguard water from pollution and degradation. Water protection is both necessary and achievable. Its necessity is underscored by the direct threat posed to human survival by endangering the hydrosphere and contaminating water sources (Kimmerer, 2013). However, humans also hold the potential to act as healers, given their responsibility as rational beings to the broader living world and future generations (Hawken, 1994). In the process of generating electricity from coal, a significant volume of water is essential for various purposes within thermal power plants. Water serves as a working fluid for electricity production, a transport medium, a cooling agent, for fire suppression, for internal plant washings, and for employee sanitation needs (Kimmerer, 2020). However, the utilization of water in these processes inevitably leads to pollution, resulting in the generation of substantial quantities of contaminated wastewater (Savić & Terzija, 2018). Moreover, runoff and terrain washing within thermal power plant premises also contribute to the accumulation of polluted water, necessitating purification before discharge into rivers (Marsenić et al., 2004).

4. MONITORING WASTEWATER: ENSURING ENVIRONMENTAL HEALTH AND SUSTAINABILITY

Environmental monitoring entails the continuous observation and assessment of environmental conditions through systematic measurement of parameters at specific points, employing consistent methods and conditions across space and time (Ricklefs & Miller, 2000). This process enables the timely detection and management of anthropogenic impacts on the environment, facilitating informed decision-making and pollution control measures (Kimmerer, 2013). Anthropogenic environmental changes are monitored through specialized systems designed to analyze and track environmental conditions. These monitoring systems are crucial for detecting and addressing pollution and its effects effectively (Jovanović, 2002). Accumulation monitoring, for instance, focuses on measuring the buildup of specific pollutants, such as toxic metals and pesticides, within environmental systems (Savić & Terzija, 2018). Environmental monitoring systems encompass various subsystems, each dedicated to monitoring specific environmental components and factors. These subsystems include atmospheric monitoring, hydrosphere monitoring, soil monitoring, biosphere monitoring, as well as pollution source monitoring and monitoring based on physical, chemical, and biological indicators (Marsenić et al., 2004). Controlled waste removal involves the organized collection and disposal of waste in designated pathways to final disposal sites, such as solid waste containers, sewage systems for wastewater, and chimneys for flue gases (Biočanin, 2011). In contrast, uncontrolled waste disposal occurs outside regulated procedures, posing significant risks to human health, ecosystems, and the environment at large (Kolbert, 2014). Hazardous waste, when improperly managed, can contaminate air, water, and soil, threatening human and ecological well-being (Kolbert, 2019). Surface and groundwater quality is assessed through monitoring relevant parameters, providing insights into the state of water bodies and facilitating flood forecasting and watercourse management (Ricklefs & Miller, 2019).

5. CHALLENGES IN WASTEWATER MONITORING: ADDRESSING ENVIRONMENTAL RISKS AND SUSTAINABILITY CONCERNS

The accumulation of hazardous waste in environmental media poses a significant global challenge, potentially resulting in environmental disasters and jeopardizing human and ecological well-being. Industrial waste encompasses materials generated during production processes, including industrial byproducts and post-consumer waste (Ricklefs & Miller, 2019). Chemical waste comprises discarded chemical substances originating from various industrial, service, and consumer activities, spanning all three aggregate states. Chemical waste poses environmental risks and requires careful management to prevent adverse impacts on ecosystems and human health (Biočanin, 2011). Assessing the state of wastewater management proves challenging due to the lack of precise statistical data in this domain. While some analyses focus on municipal wastewater, comprehensive data on specific economic entities are often unavailable. Thus, ensuring effective monitoring of pollution parameters, such as air, water, and soil quality, heavy metal and radioactive contamination levels, necessitates consistent oversight and adherence to legal and international standards (Savić & Terzija, 2018). Human-induced global warming exacerbates climate change, leading to various associated risks and consequences. Increased evaporation, reduced precipitation, and heightened water consumption across industrial, agricultural, and domestic sectors contribute to water scarcity, posing significant challenges for sustainable water management (Kolbert, 2019).

Environmental monitoring serves as the backbone of efforts to safeguard our planet's ecosystems and human health (Ricklefs & Miller, 2019). It involves the continuous observation and assessment of environmental conditions through systematic measurement of parameters across space and time (Ricklefs & Miller, 2019). By employing consistent methods and conditions, environmental monitoring enables the timely detection and management of anthropogenic impacts on the environment, facilitating informed decision-making and pollution control measures (Kimmerer, 2013).

6. WIDER PERSPECTIVE ON WASTEWATER MONITORING

Specialized monitoring systems track various environmental components and factors, including the atmosphere, hydrosphere, soil, and biosphere (Marsenić et al., 2004). These systems play a crucial role in detecting and addressing pollution effectively (Jovanović, 2002). For example, accumulation monitoring focuses on measuring the buildup of specific pollutants within environmental systems, such as toxic metals and pesticides (Savić & Terzija, 2018). Such monitoring provides valuable insights into the trends and patterns of pollution, enabling targeted interventions to mitigate its impacts. Controlled waste removal is essential for managing industrial and chemical waste, ensuring that hazardous materials are collected and disposed of safely (Biočanin, 2011). However, challenges persist, particularly in assessing the state of wastewater management. The lack of precise statistical data hampers efforts to understand the full extent of pollution and its impacts (Savić & Terzija, 2018). While some analyses focus on municipal wastewater, comprehensive data on specific economic entities are often unavailable. Effective wastewater monitoring requires consistent oversight and adherence to legal and international standards (Ricklefs & Miller, 2019). This includes monitoring pollution parameters such as air, water, and soil quality, as well as heavy metal and radioactive contamination levels (Savić & Terzija, 2018). Additionally, human-induced global warming exacerbates climate change, leading to increased water scarcity and posing significant challenges for sustainable water management (Kolbert, 2014). Wastewater monitoring is essential for protecting our environment and ensuring the health and well-being of both ecosystems and human populations (Ricklefs & Miller, 2019). By implementing robust monitoring systems and addressing the challenges posed by pollution and climate change, we can work towards a more sustainable and resilient future.

7. CONCLUSION

The management of water resources in industrial settings presents multifaceted challenges necessitating vigilant monitoring and strategic intervention. Despite the Earth's abundant water resources, escalating pollution from various sources threatens water quality and exacerbates potable water scarcity. This situation is further compounded by increasing water demand across households, agriculture, industry, and other sectors, driven by economic growth and population expansion. Climate change adds another layer of complexity, heightening concerns over water pollution and scarcity. Water, essential for the sustenance of diverse life forms, underpins all biological processes. However, pollution, characterized by changes in physical, chemical, and microbiological properties resulting from hazardous substances, poses significant threats to water quality and hygiene, impacting its suitability for various applications. Efforts to safeguard water resources require ongoing vigilance and strategic management informed by legal frameworks and contemporary understanding. Mitigating water pollution necessitates a multifaceted approach encompassing monitoring, addressing root causes, pollutant reduction, purification, conservation, and robust regulatory mechanisms. In conclusion, effective monitoring of water protection in industry is imperative for ensuring the sustainable management of water resources and safeguarding the health and well-being of ecosystems and communities.

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