International Journal of Grid and High Performance Computing
Volume 17 • Issue 1 • January-December 2025

Study on Industrial Wastewater Pollution Monitoring Technology Based on NB-IoT Wireless Communication Technology

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ABSTRACT

This study establishes a coupling model between Narrowband Internet of Things (NB-IoT) wireless communication technology and the degree of industrial water pollution, evaluating the influence of NB-IoT on industrial water pollution monitoring precision. Results show that NB-IoT wireless communication technology significantly increases the precision of industrial water pollution monitoring to 0.96 compared to traditional wire communication technology at 0.65. Additionally, the precision of industrial water pollution monitoring also changes with the economic scale, with an economic scale of 800,000,000,000 making the precision reach 0.89. Overall, this study suggests that wireless communication technology based on NB-IoT is more conducive to ecological environment protection through improved industrial water pollution monitoring.

KEYWORDS

Industrial Wastewater, Water Pollution, NB-IoT Wireless Communication, Ecological Environment, Coupling Model

INTRODUCTION

The industrial revolution directly led to the accumulation of materials and the innovation and progress of industrial technology, which accelerated the process of human civilization and led to the pollution and destruction of the ecological environment (Dangana et al., 2021). With the continuous progress of industrial science and technology, the energy source has gradually changed from trees to fossil energy such as oil, coal and natural gas. Fossil energy not only promotes industrial production but also aggravates the global greenhouse effect and ecological environment pollution (Rehman et al., 2022). Therefore, the cost of industrial and economic development is always the consumption of resources and energy and the pollution of the ecological environment. Ecological environment pollution monitoring has thus become important to the sustainability of the ecological environment.

Industrial development has brought many economic and social benefits, but at the same time, the problem of ecological environment pollution is becoming increasingly serious. Water pollution and greenhouse gas pollution have become major challenges that cannot be ignored in the process of industrialization (Celik, 2020). With the acceleration of global industrialization, industrial wastewater pollution has become one of the urgent environmental problems in the world. Wastewater

DOI: 10.4018/IJGHPC.374211

contains many substances harmful to the environment and human health, and its pollution level and harmfulness should not be underestimated. Industrial wastewater usually contains a variety of harmful components, and these pollutants have their own diverse characteristics. Heavy metals such as lead, mercury, cadmium, arsenic and chromium are common and dangerous pollutants in industrial wastewater. These heavy metals are not only difficult to degrade in water, but they also accumulate through the food chain, which eventually threatens the health of human beings and other organisms (Singh et al., 2023). Secondly, organic chemicals, such as petroleum, solvents, phenolic compounds, and others are often highly toxic, and some organic substances can persist in water, even penetrate groundwater through water, leading to long-term environmental pollution. In addition, industrial wastewater often contains a lot of nutrients such as nitrogen and phosphorus (Singh et al. 2021). Although these elements are necessary for the growth of plants and microorganisms in water, excessive nitrogen and phosphorus will lead to eutrophication of water and ecological disasters such as algal blooms, which will further lead to the deterioration of water quality and the massive death of aquatic organisms (Mishra, 2023). Therefore, it is particularly important to monitor and control the discharge of industrial wastewater in time.

At present, the monitoring technology of greenhouse gas pollution depends on the real-time monitoring device of CO_2 gas content, while the monitoring technology of industrial sewage lags (Ddiba et al., 2024). Traditional industrial wastewater monitoring methods rely mainly on manual inspections and laboratory analysis. The most used sewage monitoring technologies include a chemical analysis identification method, substance content identification method, wired communication monitoring technology, among others. Both the chemical analysis and substance content identification methods need to be sampled in advance and sent to the laboratory. The sewage samples delivered to the laboratory are treated with drugs before monitoring the content or composition. The two methods take a long time and require complicated operation steps, which is not conducive to the large-scale and rapid monitoring of industrial sewage. These methods have many limitations, such as low efficiency, high cost, and inability to monitor in real time. In addition, since industrial wastewater discharge points are usually distributed in different geographical locations, it is difficult for traditional methods to achieve comprehensive monitoring of wastewater discharge sources (Sathya et al., 2022).

Although the wired communication monitoring technology for industrial water quality is still widely used, it faces an important problem of low accuracy and poor data reliability (Park et al., 2020). Wired communication monitoring technology usually relies on fixed transmission lines for data transmission. There is a lot of electromagnetic interference and noise in industrial environments, which leads to the distortion of monitoring data. Due to the long-term exposure of equipment to extreme conditions such as temperature, humidity, and chemicals, the failure rate of equipment is high. At the same time, the wired monitoring system also has the problems of poor timeliness and lack of flexibility. Another limitation of traditional wired monitoring technology is the lack of real-time remote monitoring ability. In some industrial areas far away from cities or with difficult conditions, there may be difficulties in the arrival and inspection of field personnel, which prevent monitoring equipment from being found and handled in time. In contrast, modern wireless communication and intelligent sensor technology can be more convenient for remote monitoring, data acquisition, and real-time feedback, improving the flexibility of monitoring and emergency response ability (Sofi et al., 2022).

With the development of technology, more and more industrial water quality monitoring systems are turning to more advanced technologies such as wireless communication, big data analysis, and artificial intelligence to improve monitoring accuracy, data reliability, and system flexibility and expansibility. Finding a high-precision industrial water quality monitoring technology has become an important research direction to solve industrial sewage treatment problems. The rapid development of the Internet of Things (IoT) and wireless communication technologies provides new opportunities to address these issues. Narrowband Internet of Things (NB-IoT) is a communication technology characterized by wide coverage, low power consumption, and high reliability that is suitable for