WEP Warwick Evans Publishing

Transactions on Environment, Energy and Earth Sciences
ISSN: 2960-1924, eISSN: 2960-2300 | Volume 3
GRET 2024

Application and Effect Evaluation of Remote Sensing Technology in the Monitoring of Water Pollution

Hanbo Gao *

Department of International Engineering, Tianjin Chengjian University, Tianjin, 300380 China

* Corresponding author: 1812010909@stu.hrbust.edu.cn

Abstract. Remote sensing technology has shown significant advantages in water pollution monitoring, which can achieve large-scale and real-time water quality monitoring. This paper introduces the remote sensing technology mainly used in water pollution monitoring and analyzes the application cases of different polluted waters. Remote sensing technology mainly includes optical, thermal infrared, and radar remote sensing. Optical remote sensing monitors the concentration and distribution of pollutants by analyzing the spectral reflection characteristics of water bodies; Thermal infrared remote sensing detects thermal pollution according to the change of water temperature; Radar remote sensing uses electromagnetic wave reflection to identify oil pollution, water level changes and other information, which is not limited by weather conditions. It is suitable for water pollution monitoring in cloudy and rainy areas. At present, remote sensing technology has been successfully applied in different water areas, such as industrial pollution, agricultural non-point source pollution and domestic sewage pollution. Remote sensing technology can quickly identify pollution sources and monitor the diffusion range of pollutants, providing scientific basis for environmental protection departments and supporting environmental protection decision-making. However, some limitations exist, such as insufficient accuracy and weather influence. In the future, it is necessary to optimize the algorithm and sensors further to improve the ability to monitor trace pollutants to better protect the water environment.

Keywords: Remote Sensing Technology; Water Pollution; Environmental Monitoring; Spectral Analysis.

1. Introduction

Water is the resource for human survival. The problem of water pollution is becoming more and more serious, which poses a great threat to the ecological environment and human health. Traditional water pollution monitoring methods often have limitations, and it is difficult to achieve large-scale, real-time and dynamic monitoring [1, 2]. As an advanced monitoring method, modern remote sensing technology makes it possible to monitor water pollution in large area and in real-time [3, 4].

Remote sensing has shown great potential in water pollution monitoring with its unique advantages of non-contact and large-scale synchronous observation [5]. Remote sensing monitoring of water pollution refers to using remote sensing platforms such as ground, aviation and aerospace to detect rivers, lakes, reservoirs and oceans. The change of the reflection, emission and absorption characteristics of the water body is diagnosed, and the spectral information of the water body is quickly acquired. It can effectively monitor and analyze the extent, scope, and sources of water pollution [6]. Infrared scanner, multi-spectral scanner, microwave system and laser radar are commonly used in water pollution remote sensing.

The purpose of this study is to explore the utilization of remote sensing technology in diverse water pollution monitoring scenarios. Through the research and analysis of typical cases of industrial pollution, agricultural non-point source pollution and domestic sewage pollution. The successful experience and challenges in practical application are summarized. At the same time, the effects of remote sensing technology and traditional monitoring methods are compared. To objectively evaluate the effectiveness and reliability of remote sensing technology in water pollution monitoring. In the process of discussion, this study summarizes the history of development and shortcomings of the existing remote sensing water pollution monitoring methods. Finally, based on the existing research results, the future development direction of remote sensing water pollution monitoring is prospected. Some suggestions are put forward to improve further and optimize the utilization of remote sensing technology in the monitoring of water pollution. To contribute to the protection of water resources and the improvement of water environment quality.

2. Remote Sensing Technology for Water Pollution Monitoring

2.1. Optical Remote Sensing

2.1.1. Multispectral remote sensing.

Several sensors with different bands are used to observe the ground, and different bands have different responses to different substances in the water body. For example, the visible band can reflect the color change of water, and the near-infrared band can be used to distinguish water from land. By analyzing the reflectivity data of different bands, the turbidity and chlorophyll a content of water can be monitored. O as to judge the eutrophication degree of the water body and the concentration of the suspended particles. For example, when the content of chlorophyll a in water is high, there will be obvious absorption characteristics in specific bands. The region of eutrophication can be identified by multi-spectral remote sensing images.

2.1.2. Hyperspectral remote sensing.

It has extremely high spectral resolution and can obtain continuous spectral information. This enables it to more accurately identify various substances in the water body by analyzing the spectral characteristics of specific substances. Its concentration can be monitored quantitatively.

It can monitor the dissolved organic matter and heavy metal content in the water body. For example, for a water body polluted by heavy metals, hyperspectral remote sensing can determine the types and concentrations of heavy metals by analyzing the absorption characteristics at specific wavelengths.

2.1.3. UAV multispectral remote sensing.

UAV multi-spectral remote sensing solves the problems of narrow sensor band range and long re-entry time in traditional satellite multi-spectral remote sensing. It is seriously disturbed by cloud cover, the rate of image formation is not high, the imaging accuracy is low, and the timeliness is not flexible. UAV multi-spectral remote sensing can reflect the distribution and change of water quality in space and time. Some pollution sources and pollutant migration characteristics that are difficult to reveal by conventional methods are found. But also has the advantages of wide monitoring range, high speed, low cost and convenience for long-term dynamic monitoring. It can not only meet the needs of large-scale water quality monitoring, but also reflect the distribution and change of water quality in space and time. It makes up for the deficiency of single water surface sampling. At the same time, it can also find the distribution of some pollution sources that are difficult to reveal by conventional methods, as well as the migration characteristics and influence range of pollutants. And provide a basis for scientifically arrange water surface sampling points.

Unmanned aerial vehicle (UAV) multi-spectral imaging technology (remote sensing technology) is the main technology in water quality monitoring. Information collection can provide a wide range of coverage and visual expression for water quality monitoring. It has the advantages of high timeliness, strong space-time resolution and strong mobility. However, the shaping expression of spectral images and the inversion relationship between image data and water quality are obtained after using UAV multi-spectral imaging technology. This technology is the key link to realize the application of water quality monitoring. Multi-spectral image mosaic and water quality inversion are the key research contents of the application of UAV technology in water quality monitoring. The application of multi-spectral image mosaic based on UAV technology in water quality monitoring. The ground coverage of the UAV flight band is narrow, the overlap rate of the flight band is low, the brightness difference of the flight band and the positioning accuracy of the POS system of the UAVThe low level problem is the main reason why multi-spectral images of UAV technology need to be spliced and spliced difficultly [7].

2.2. Thermal Infrared Remote Sensing

The temperature information of the water body is obtained by measuring the thermal radiation intensity of the water body. The change of water temperature can reflect many water pollution problems, such as industrial wastewater discharge, thermal pollution and so on.

2.2.1. Monitoring of thermal contamination:

Thermal infrared scanning image mainly reflects the thermal radiation information of the target, which is very effective for monitoring the pollution caused by the hot water discharge from the factory. The position of the hot water discharge port, the distribution range and the diffusion state of the discharged hot water are very obvious on the thermal infrared image. The difference in water temperature can also be recognized on the photograph. Therefore, the emission source of water pollution can be effectively detected by using thermal infrared remote sensing images. For example, the discharge of hot water from a factory or the discharge of cooling water from a nuclear power plant may cause the temperature of a local water body to rise. Thermal infrared remote sensing can quickly detect such temperature anomalies and thus determine the extent and degree of thermal pollution.

2.2.2. Monitoring of oil contamination.

Unpolluted seawater and oil film on the water's surface is different because of their radiation emissivity (I. Even if they are at the same temperature, the radiation temperature is different. By using infrared scanner for aerial remote sensing monitoring, the difference of their radiation temperature can be measured. Thus, showing the distribution of oil pollution on the sea surface. On the thermal infrared image taken at night, the waves turned up by the ship showed a lighter tone, and the image showed a white band. The place where the oil is drained shows a black band. According to the thickness of the oil film, the area and quantity of the oil film can be calculated.

2.3. Radar Remote Sensing

2.3.1. Synthetic Aperture Radar (SAR).

The electromagnetic wave emitted by radar is used to illuminate the ground and receive the reflected signal. SAR has the advantages of not being affected by weather conditions and being able to penetrate clouds, which is especially suitable for water pollution monitoring in cloudy and rainy areas.

Monitoring oil pollution: When oil film appears on the water surface, it will change the roughness of the water surface, thus affecting the reflection of radar signals. SAR can detect this change to determine the extent and degree of oil contamination.

Monitoring of water level changes: By analyzing SAR images at different times, the water level change information of the water body can be obtained. This is of great significance for flood monitoring and water resources management.

2.3.2. Interferometric Synthetic Aperture Radar (InSAR).

Two or more SAR antennas are used to observe the same area. By comparing the phase difference of signals received by different antennas, the elevation information and micro-deformation information of the ground are obtained.

It can monitor the water body changes caused by groundwater exploitation, land subsidence and other reasons. As well as the deformation of dams, dikes and other water conservancy projects, to provide auxiliary information for water pollution monitoring and water resources management.

2.3.3. Miniature SAR.

Micro SAR, or micro synthetic aperture radar, is a radar system with miniaturization, high resolution and all-weather and all-weather monitoring capabilities. It scans the target area by transmitting microwave or millimeter-wave electromagnetic waves, and receives the reflected echo signals. O as to obtain detailed information of the target area. Micro-SAR has the characteristics of being small, lightweight, and low power consumption, which make it suitable for various complex environments and platforms.

River hydrological monitoring: As an important part of the water conservancy field, the monitoring of its hydrological characteristics is of great significance for water resources management, flood control and disaster reduction. Micro-SAR can monitor hydrological parameters such as water level, flow velocity and discharge of rivers in real-time through high-resolution imaging technology. Provide accurate data support for water conservancy departments. In addition, micro-SAR can also monitor the riverbed morphology and channel changes of rivers. It provides a strong basis for river management and planning.

Flood disaster monitoring and early warning: Flood disaster is one of the important challenges in water conservancy. Micro SAR can monitor all day and all weather in bad weather conditions. Obtain the occurrence, development and evolution process of flood disaster in real time. By analyzing and processing the monitoring data of flood disaster, the spread trend and potential risk of flood can be predicted. Provide timely early warning information for flood control and disaster reduction.

3. Enhanced Water Pollution Monitoring through the Application of Remote Sensing Technology.

Remote sensing water environment monitoring has developed from one-time monitoring to continuous dynamic monitoring. It has expanded from qualitative research of individual indicators to multi-objective and multi-level model research and quantitative analysis. It has developed from the application of single satellite data source to the application of multi-data source, multi-temporal and multi-resolution remote sensing data. Remote sensing is playing a more and more important role in water environment monitoring.

3.1. Industrial Water Pollution Cases

Industrial water pollution has the characteristics of centralized pollution sources, stable discharge, diverse types of pollutants and strong toxicity. Industrial wastewater often contains heavy metals, volatile organic compounds and acidic and alkaline waste liquids. The components are complex and have great harm to the water ecological environment. Long-term discharge can easily lead to deterioration of water quality and serious impacts on human health and ecosystems [7].

Due to the wide range and large area of industrial wastewater discharge, the traditional ground monitoring method has some limitations in coverage and timeliness. Remote sensing technology can obtain large-scale and long-term water images through satellites, UAVs and other equipment. And that monitor efficiency is greatly improved. Remote sensing technology can not only quickly identify the location of pollution sources, but also monitor the dynamic process of pollutant diffusion. Analyze the spatial distribution and diffusion law of pollutants. Especially in large-scale water pollution incidents, remote sensing monitoring can provide real-time data in time to assist environmental protection departments in making decisions. Formulate an effective treatment plan to achieve accurate monitoring and management of water pollution.

Take the Haihe River as an example. It is an important river in northern China. It flows through the Beijing-Tianjin-Tangshan Industrial Zone. The long-term discharge of industrial wastewater has had a significant impact on it. In order to monitor the pollution of the river, the Environmental Protection Department has carried out a comprehensive monitoring of the river by using remote sensing technology. Through high-resolution satellite images, researchers can successfully identify pollution sources in rivers. The diffusion range and degree of pollutants are also analyzed. This discovery provides an important basis for environmental protection departments to make decisions and help them formulate targeted control measures. It has effectively curbed the further development of river pollution [8].

3.2. Agricultural Water Pollution Cases

Agricultural water pollution mainly comes from chemical fertilizers, pesticides and livestock wastes carried by farmland runoff. Its characteristics include scattered pollution sources, strong seasonality and diverse types of pollutants. The excessive utilization of chemical fertilizers and pesticides in agricultural fields can easily result in their entry into rivers. , lakes and other water bodies through rainwater runoff. Resulting in eutrophication, increased toxicity of water bodies, and groundwater pollution. At the same time, the discharge of livestock manure and agricultural waste may also bring organic pollution and pathogenic microorganisms. It poses a threat to aquatic ecosystems and human health [8].

3.3. Life-type Water Pollution Cases

Domestic water pollution mainly comes from domestic sewage, garbage, and imperfect urban drainage systems. It is characterized by various pollutants, such as organic matter, grease, heavy metals, plastics, and household chemicals. Pollution sources are widely distributed and persistent. When untreated or inadequately treated domestic sewage is discharged into the water body, it will lead to eutrophication and oxygen depletion. It affects aquatic ecosystems and may endanger human health [9].

Through remote sensing images, the pollution situation of urban water bodies can be continuously monitored in a wide range. Quickly identify sources and contaminated areas. Multi-spectral and thermal infrared remote sensing can analyze parameters such as suspended solids and dissolved oxygen concentration in water.

For example, East Lake serves as a crucial water source in Wuhan, and in recent years, it has been impacted by the escalating discharge of domestic sewage from the surrounding areas. The problem of lake eutrophication has become increasingly prominent. In order to grasp the water quality of the lake in time, the local government has adopted remote sensing technology to monitor the lake continuously for a long time. Through satellite remote sensing images, researchers have successfully extracted the water body information of lakes. The key water quality parameters such as chlorophyll and sediment content were analyzed. The chlorophyll content in the lake is obviously high, which indicates that the eutrophication of the water body is serious. Based on this discovery, the local government took timely control measures to alleviate the eutrophication of the lake effectively [10].

4. Conclusion

It is found through long-term remote sensing monitoring and field sampling analysis of different types of polluted waters. Remote sensing technology can accurately judge the extent and scope of water pollution. In the industrial polluted water area, the diffusion area of specific pollutants was successfully identified; In the water area of agricultural non-point source pollution, the migration path of pollutants with water flow was monitored; For the water area polluted by domestic sewage, the impact scope of pollution is clearly defined.

Compared with traditional monitoring methods, the results show that remote sensing technology has obvious advantages in large area monitoring. It can quickly provide a macro pollution situation. However, the traditional methods still show some benefits in some indicators monitoring which require high accuracy. These results show that remote sensing technology is important in water pollution monitoring. It can achieve rapid and large-scale monitoring, and provide strong support for timely grasp of water pollution. However, it also has some limitations, such as the monitoring accuracy of trace pollutants needs to be improved. It is greatly affected by natural conditions such as weather.

In practical applications, monitoring methods should be flexibly selected according to specific needs. Or combine various methods to improve the comprehensiveness and accuracy of monitoring. In the future, the algorithm and equipment of remote sensing technology need to be further improved to reduce the interference of external factors. It is suggested to enhance its ability to monitor trace pollutants, for better serving the monitoring and control of water pollution.

References

[1] Wang Bo, Huang Jinhui, Guo Hongwei, et al. Research progress of inland water quality monitoring based on remote sensing. Water Resources Protection, 2022, 38 (03): 117 - 124.

[2] Liu Ying. Remote Sensing Research Method of Water Pollution and Its Application in Water Pollution Monitoring in Shaoxing Area. Zhejiang University, 2008.

[3] WU Tai-xia, XIA Ke, LIU Yi-yao, et al. Research progress on remote sensing monitoring of water ecological environment. China Water Conservancy, 2024, (11): 38 - 44.

[4] Tian Yan. Research on Water Pollution Monitoring Based on Remote Sensing Technology. Shihezi Science and Technology, 2020, (02): 7 - 8.

[5] Xu Jinhong, Deng Mingjing, Liu Guodong. Application of remote sensing technology in water pollution monitoring. Soil and Water Conservation Research, 2007, (05): 324 - 326 + 330.

[6] Li Fengxiao. Study on water pollution cloud monitoring method based on spectral method. Chongqing University of Technology, 2021. DOI: 10. 27753/d. CNKI. Gcqgx. 2021. 000119.

[7] Yi Lina, Xu Xiao, Zhang Guifeng, et al. Study on Mosaic and Inversion of UAV Multispectral Images. Spectroscopy and Spectral Analysis, 2019, 39 (6): 1885 - 1891.

[8] Jin Lihua, Wu Limei, Wang Mingliang, et al. Intelligent interpretation of water body based on high-resolution remote sensing. Surveying, Mapping and Geospatial Information, 2024, 47 (S1): 37 - 39.

[9] Qin Zhihao, Zhang Lijian, Gao Maofang, et al. Application of Remote Sensing Technology in Agricultural Tridimensional Pollution Monitoring. Land and Resources Remote Sensing, 2006, (01): 1-5 + 17 + 93.

[10] Xu Jinhong, Deng Mingjing, Liu Guodong. Application of remote sensing technology in water pollution monitoring. Soil and Water Conservation Research, 2007, (05): 324 - 326 + 330.