OPEN ACCESS Freely available online

IJESP International Journal of Environmental Sustainability and Protection

ISSN 2737-5447
Volume 4, Issue 3
https://ijesp.iikii.com.sg/
International Journal of Environmental Sustainability and Protection

Article

Mobile Water Quality Sensors in Monitoring Hotspots of River Surface Water Pollution

Yi-Lin Zhou *, Wen-Hui Wu

Environmental Protection Bureau of Tainan City Government, Tainan 701044, Taiwan; 8714416@mail.tnepb.gov.tw
* Correspondence: flysky5108@gmail.com

Received: Oct 2, 2024; **Revised:** Oct 25, 2024; **Accepted:** Oct 25, 2024; **Published:** Nov 7, 2024

Abstract: Mobile water quality sensors in monitoring hotspots of river surface water pollution allow for an efficient and flexible inspection. Traditional fixed monitoring stations often fail to capture the dynamic changes in water pollution, whereas mobile sensors are used to monitor large water bodies and detect abnormalities in pollution hotspots in real-time. Utilizing the advantages of mobile sensors and data processing methods, river pollution inspection can be carried out effectively. Experiment results show that the sensitivity and accuracy of pollution monitoring are enhanced, enabling timely remediation actions.

Keywords: Mobile Sensors, Water Quality, River Pollution Monitoring, Environmental Analysis

1. Introduction

Surface water pollution of the river is a global environmental concern and is common and severe in industrial regions, urban areas, and zones of intensive agriculture [1,2]. Traditional water quality monitoring requires fixed monitoring stations for point sampling and analysis [3,4]. However, these methods have limited coverage and delayed data updates, making it difficult to fully capture dynamic changes in pollution [5]. To address these challenges, using mobile sensors to monitor water quality has attracted research interest [6,7]. Mobile sensors can be used for real-time monitoring of pollution in vast stretches of rivers, making them appropriate for inspecting and managing pollution hotspots [8,9]. Many statistical methods have been developed to monitor and assess water quality based on measured data using the multivariate statistical method [10], fuzzy inference [11], and the water quality index (WQI) [12]. In this study, we explore how to apply mobile sensors in monitoring the water quality of river surface water to illustrate advantages and challenges. Table 1 shows various pollution measures and their applications considered in this study.

Table 1. Water quality measures used for various applications.

Application	Industry	pH	Conductivity (EC) (μS/cm)	Dissolved Oxygen (DO) (mg/L)	Chemical Oxygen Demand (COD) (mg/L)	Usage
Agricultural Channels	—	6.5−8.5	500−1,000	2−4	—	Using pH to determine over−standard wastewater; EC and DO in drainage time
River Water Bodies	—	6.5−8.5	300−2,000	4−9	20−100	Using pH to determine over−standard wastewater; EC and DO in drainage time
Livestock Industry	—	6.5−8.5	1,500 − 5,000	< 2	100−600	Using COD to determine over−standard wastewater; EC in drainage time
Inspection and Law Enforcement	PCB Manufacturing / Metal Surface Treatment / Electroplating	6.5−9	500−5,000	—	20−80	Using pH and COD to determine over−standard wastewater; EC in drainage time
Inspection and Law Enforcement	Textile Dyeing and Finishing	6.5−8.5	300−1,000	—	50−150	Using COD to determine over−standard wastewater; EC in drainage time

Inspection and Law Enforcement	Food Manufacturing	6.5−8.5	1,000 − 10,000	—	20−80	Using pH and COD to determine over−standard wastewater; EC in drainage time
Industrial District Drainage	—	6.5−8.5	300−5,000	1.5−4	20−80	Using pH and COD to determine over−standard wastewater; EC and DO in drainage time

2. Materials and Methods

GPS equipment was used to determine the coordinates of the sampling point. We used water sampling devices with a long handle such as telescopic water containers or cylinders, or other equipment with similar functionality to collect surface water. Water samplers were suspended by a rope for sampling. For sampling water samples under the surface, the Kemmerer water sampler and the Dorn water sampler were used. Collected water samples were filtered using an on-site filtration device which included plastic or Teflon holders and filter membranes. The membrane filter made of polycarbonate or cellulose acetate with a pore size of 0. µm to 0.45 µm, or equivalent was used to filter water samples for dissolved iron, manganese, and other analyses.

A thermometer with a measuring precision of 0.1°C was used. The pH meter with a precision of 0.01 and a temperature compensation function was used. In sampling water, plastic or glass bottles were used. For water quality monitoring, MWQ100 and MWQ200 were employed as mobile water quality sensors.

3. Results

We deployed 10 mobile water quality sensors. To enhance the efficiency, the measuring points were continuously adjusted. Communication and transmission of the 10 sensors were maintained to ensure continuous monitoring. The installation locations and applications of the mobile water quality sensors are presented in Tables 2−4, and the deployment records of the sensors are shown in Figs. 1 and 2. The mobile water quality sensors in Tainan City were deployed in the following areas.

1. Chiangjun River: Bridgeheadzi Port Unknown Bridge
2. Zengwen River: Chianan Irrigation System Shanhua Branch
3. Sanye River: Unknown Bridge
4. Erhjen River: Downstream of Bao’an Industrial Zone
5. Yanshui River: Mugaliaowan Drainage Line Unknown Bridge
6. Qigu River: Liu Cuo Drain Unknown Bridge
7. Sanye River: Wangliao Bridge
8. Yanshui River: Yongkang Drain Unknown Bridge
9. Chianan Irrigation System: Annan Bridge

The sensors were installed near factory drainage outlets or pollution/emission hotspots to monitor potential pollution. The sensors were also placed to monitor pollutants upstream, midstream, and downstream. Locations in river sections or water bodies frequently have experienced fish die-offs or sporadic increases in pollution during specific seasons. Using the Water Science Internet of Things Platform, water quality changes were monitored in real-time to trace pollution sources and respond to emergencies. MWQ100 frequently experienced malfunctions and water ingress issues in the initial deployment. For successful monitoring, the main unit was upgraded to an offshore fixed installation to reduce failures. The electrode was protected using a bucket shield to minimize abrasion from sand and gravel. After the upgrade, the maintenance frequency due to malfunctions was significantly reduced.

Table 2. Sensor deployment locations.

Application Type	Number of Applications	Application Area	Installation Date	Installation Point Name (Code)	Application Method and Purpose
Environmental Inspection Application	5 units	Chiangjun River − Bridgeheadzi Port Unknown Bridge	September 28, 2022	S01	Mobile installation in the tributary drainage of Guantian Industrial Park. Potential pollution factories: Yi Hua, An Dian, Taiwan Cogeneration.

Environmental Inspection Application	5 units	Zengwen River − Chianan Irrigation System Shanhua Branch	September 28, 2022	S02	Mobile installation in the upper reaches of Zengwen River. Key targets: Daliangcheng, Zhengsheng, Jiayi, Yangming.
Pollution Emission Hotspot Identification	3 units	Qigu River − Liu Cuo Drain Unknown Bridge	September 27, 2022	S06	Mobile installation at Liu Cuo Drain. Key targets include Nanbao Resin, Nanhui Plant.
Low Dissolved Oxygen Fish Die−off Rivers	2 units	Chianan Irrigation System − Annan Bridge	September 27, 2022	S09	Mobile installation at Anshun Drain downstream. Fish die−offs reported in June 2022.
Environmental Inspection Application	2 units	DaWan District Tributary Drain − Yongren Bridge	July 14, 2023	Sanye River	S01
Environmental Inspection Application	2 units	Guantian Industrial Park − Bridgeheadzi Port Unknown Bridge	July 14, 2023	Chiangjun River	S09
Pollution Emission Hotspot Identification	1 unit	Mugaliaowan Drainage Line − Unknown Bridge	July 14, 2023	Yanshui River	S10
Low Dissolved Oxygen Fish Die−off Rivers	2 units	Liu Cuo Drain − Liu Cuo Bridge	July 14, 2023	Qigu River	S04
Regular Violating Enterprises	2 units	Rende Industrial Zone Downstream − Rende Gate No. 2	July 14, 2023	Sanye River	S02

Table 3. Environmental monitoring results (1).

Installation Date	**September 28, 2022**
Installation Location	Qiaotouzi Port Reservoir − Unknown Bridge (S01)
River Basin	Jiangjun River
Machine Number	TW010100EW100105
	
Mobile Sensor Installation Completed	Solar panel installation status

Table 4. Environmental monitoring results (2).

Installation Date	**July 14, 2023**
Installation Location	Tributary Drain in DaWan District − Yongren Bridge (S01)
River Basin	Sanye River
Machine Number	TW010200EW300599

Mobile Sensor Installation Completed	Solar panel installation status

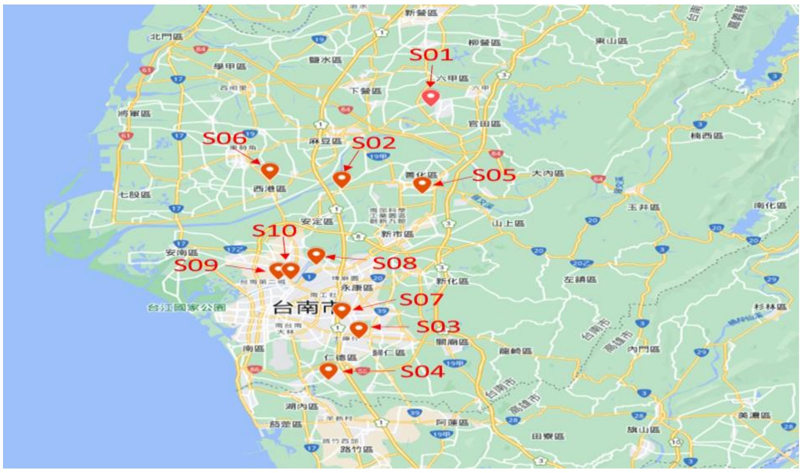

Fig. 1. Water quality sensor locations in 2022.

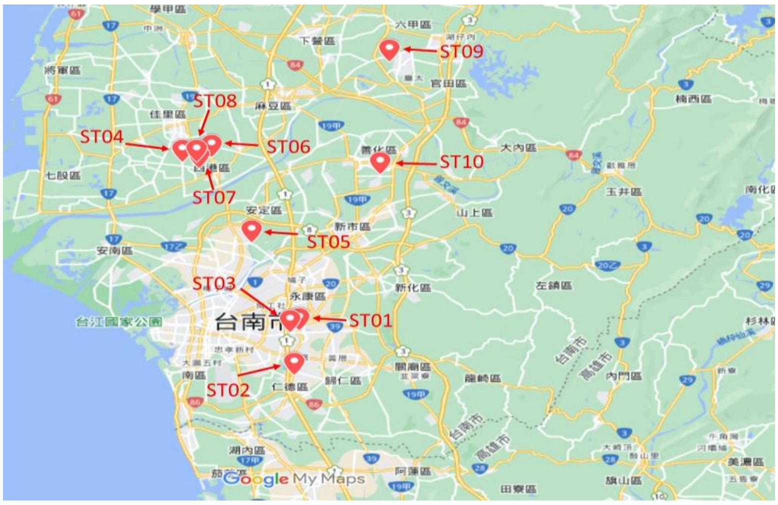

Fig. 2. Water quality sensor locations in 2023.

4. Discussion

The application of mobile water quality sensors in monitoring hotspots of river surface water pollution is practical and efficient. Compared to traditional fixed monitoring systems, mobile sensors provide rapid response and flexible coverage of large water bodies, enabling real-time monitoring and early warning. The case studies demonstrate the advantages of mobile water quality sensor deployment in improving the accuracy of pollution monitoring and addressing timely. With advancements in IoT technologies and data processing, mobile water quality sensing technology plays a crucial role in water quality monitoring and environmental management.

Author Contributions: conceptualization, Y.-L. Zhou, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, W.-H. Wu visualization, supervision.

Funding: This research was funded by the Environmental Protection Bureau of the Tainan City Government (No.1230522).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Lee, J. H., & Bang, K. W. Characterization of urban stormwater runoff. *Water Research* **2000**, 34(6), 1773−1780.
2. Meyer, J. L., Paul, M. J., & Taulbee, W. K. Stream ecosystem function in urbanizing landscapes. *Journal of the North American Benthological Society* **2005**, 24(3), 602−612.
3. Huber, W. C., & Dickinson, R. E. (1988). *Stormwater Management Model, Version 4: User's Manual*. US Environmental Protection Agency, Athens, GA.
4. Mitchell, R. J., McDonald, R. I., & Heller, N. E. The future of water in California: Using scenarios to evaluate management strategies in the face of complexity. *Environmental Management* **2014**, 54(5), 1094−1109.
5. Thompson, S. P., & Yates, A. G. Assessing the effectiveness of agricultural best management practices for reducing phosphorus loading to wetlands. *Environmental Management* **2014**, 54(5), 1100−1109.
6. Bhaduri, B., Harbor, J., Engel, B., & Grove, M. Assessing watershed−scale, long−term hydrologic impacts of land−use change using a GIS−NPS model. *Environmental Management* **2000**, 26(6), 643−658.
7. Jordan, T. E., Correll, D. L., & Weller, D. E. Effects of agriculture on discharges of nutrients from coastal plain watersheds of Chesapeake Bay. *Journal of Environmental Quality* **1997**, 26(4), 836−848.
8. Qin, N., He, W., Kong, X. Z., Liu, W. X., Wang, Y., & Yang, B. Distributions, sources, and ecological risks of selected trace elements in surface water and sediment of the Hanjiang River, China. *Journal of Environmental Sciences* **2014**, 26(1), 118−128.
9. Ahuja, S. Monitoring Water Quality: Pollution Assessment, Analysis, and Remediation. Amsterdam, The Netherlands: Elsevier, 2013.
10. Shrestha, S., & Kazama, F. Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji River basin, Japan. *Environmental Modelling & Software* **2007**, 22(4), 464−475.
11. Chang, N. B., Wen, C. G., & Chen, H. W. Decision support system for planning water reuse system in small and isolated urban areas. *Water Science and Technology* **1998**, 38(11), 15−22.
12. Pesce, S. F., & Wunderlin, D. A. Use of water quality indices to verify the impact of Córdoba City (Argentina) on Suquía River. *Water Research* **2000**, 34(11), 2915−2926.