# Strategy for the Deployment of Water Internet of Things (WIoT) in Taiwan

*Chen-Yang Hsu, Shu-Yi Peng, Chen-Hua Chu, Fan-Lun Chen
Green Energy and Environment Research Laboratories
Industrial Technology Research Institute, Hsinchu, Taiwan
e-mail: ambrosehsu@itri.org.tw

**Abstract—According to the advancement of information networks and sensing technology, the Internet of Things (IoT) is the new trend of future technology and information. In view of the increasing maturity of water quality sensor technology and the rapid advancement of information and communication technology in recent years. Previously, water quality sampling required a lot of labor and expensive equipment for data collection. This study has developed water quality sensor component installations in areas with potential water pollution. Establishing Taiwan's water quality sensing system through a sensor connecting network monitoring Taiwan's water environment and using a solution framework, and 4 strategies to lay the foundation for the development of smart cities.**

***Keywords- Internet Of Things; Water Quality Sensing; Pollution Hotspots; Pollution Source Tracking; Environmental Governance***

## I. INTRODUCTION

In Taiwan, the water quality and environmental testing relies on a large amount of manpower to collect samples manually. The Taiwanese administration utilizes the "Sampling Unit" and then send them to the "Testing Unit" for testing with laboratory standard instruments. If it is confirmed that the pollutant exceeds the standard, the "remediation unit" will control the environment, and if it is confirmed that there was a pollution violation, the "environmental enforcement unit" of the government will inspect and punish the illegal manufacturer [1].

The above mentioned existing environmental testing industry is quite time-consuming and labor-intensive, and the time and spatial resolution of the monitoring data is insufficient, making it rather difficult to grasp the trend of water quality changes at any time and affecting the timeliness of back-end environmental governance and environmental enforcement.

Environmental quality gradually gains awareness of practitioners. The usage of big data to achieve environmental governance, real-time monitoring, protection of water quality by early warning, response to abnormal situations, and to provide efficient solutions have become the next stage of environmental governance trend amongst Taiwan's smart cities [2].

## II. COMPREHENSIVE WATER SENSING PLAN

In recent years, online water quality analysis and sampling technologies have become increasingly sophisticated. With the advancement of data analysis, big data processing, and wireless transmission technologies, Environmental Protection Administration (EPA) Taiwan has established a set of total solutions for the environmental pollution monitoring ecosystem including the environmental survey, environmental sampling, environmental inspection, environmental remediation, and environmental enforcement. The use of smart sensing of high-resolution water quality spatial and temporal data, low-cost sensing equipment, big data analysis, and automatic control completes the last piece of the environmental pollution monitoring ecosystem (See Figure 1).

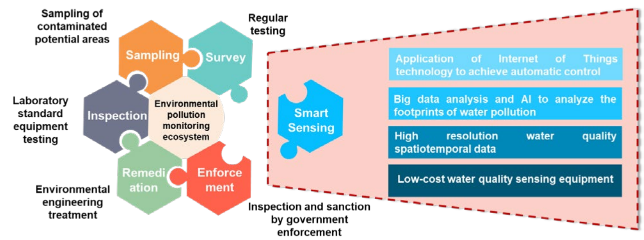


Figure 1. WIoT Smart Monitoring Map

With the widely distribution of Water Quality IoT (WIoT) sensors in Taiwan, it allows us to monitor the characteristics of water quality and background concentration of the sensing area all day. From environmental information disclosure to environmental governance, water quality monitoring and management applications are implemented to reduce the manpower required by the environmental protection bureaus in counties and municipalities, effectively improving environmental quality.

## III. METHODS AND SOLUTION

The objective of this study was to investigate the establishment of the WIoT Data Analysis System and miniaturized water quality monitoring system device for the purpose of monitoring water quality in Taiwan.

### A. Miniaturized water quality monitoring system device

Compared with the traditional water quality measurement equipment, the new generation of WIoT sensors are highly mobile and can be quickly installed for applications. There are two usages of fixed-point sensing and drifting downstream, which have the following benefits: easy to operate, low setup-cost, and come with wireless data transmission. (See Figure 2)


| Item | Details |
|---|---|
| Sensor Categories | pH : 0 – 14 (±0.1 pH)<br>EC : 300-4000 μS/cm (±15%)<br>DO : ±1.0mg/L<br>Temp : ±0.5℃ |
| Detection Frequency | 1 minute |
| Size | 215*160*62.5 |
| Communications | GSM/LoRa |
| Applicable Environments | River Water, Irrigation Water, Factory Discharge Areas |
| Features | Swift Analysis, Small footprint, Low Power Consumption, Affordable Price |

Figure 2. Water Quality Monitoring System

The measuring items include pH, EC, Temp., and dissolved oxygen. This method can be widely extended to various fields of measurement applications, such as factory outfalls, potentially polluted agricultural land, aquaculture, rivers, sewage drains, water purification plants, etc. With rapid deployment and its low-cost, it can assist standard large monitoring stations to achieve the benefits of point and line sensing in water networks.

### B. *Water Quality IoT (WIoT) Data Analysis System*

In order to maximize the effects of online water quality monitoring, this study designed a solution framework suitable for an IoT water quality monitoring network (See Figure 3).

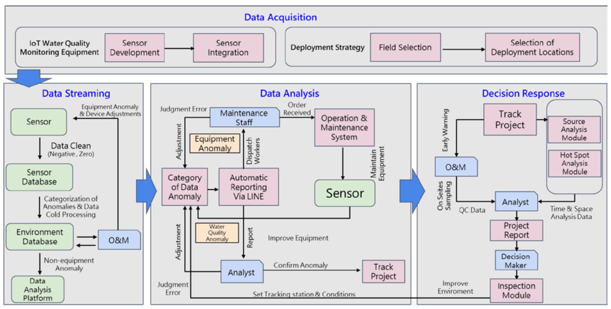


Figure 3. WIoT Monitoring And Management Framework

The purposes of the framework are as flows: (1) Establish a systematic structure of water quality environmental governance. (2) Automate the tracking of data analysis. (3) Standardize the management of abnormal water quality incidents. This framework suggests systematic processes for obtaining data, streaming, and analyzing back-end decision-making and response measures. At the data acquisition end, appropriate IoT water quality monitoring devices must be selected depending on the purpose of monitoring. Also, a deployment strategy must be implemented to include suitable installation locations. Such mechanism ensures all acquired data can satisfy the purpose of monitoring [3].

## IV. Discussion

EPA Taiwan is committed to promote the WIoT. With the development of component research and development, field deployment, data analysis, and value-added application. EPA Taiwan is aiming to deploy 170 self-developed water quality monitoring devices by 2023 to control the quality of water bodies and trace the source of pollution discharge.

The comprehensive smart water quality monitoring system (See Figure 4) can also be expanded into the field of agricultural, industrial, and livelihood, such as industrial wastewater pollution sensing, potential pollution source sensing, smart aquaculture, agricultural water safety, irrigation water sensing, watergate switching, smart sewage treatment and control, and drinking water sensing, etc. In the future, with the gradual increase of demand, it is expected to drive the overall environmental IoT industry chain and create emerging markets.

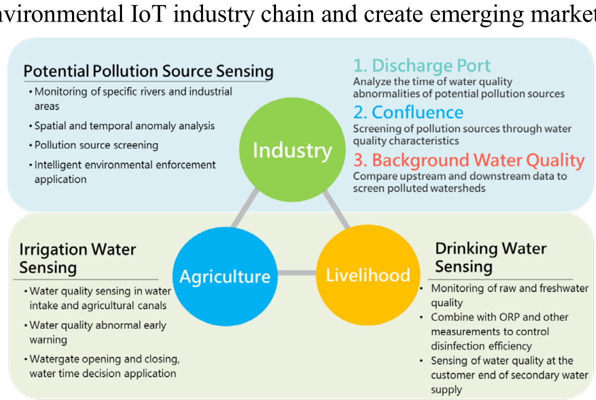


Figure 4. Application Scenarios

Water quality data analysis model could achieve the goals such as prediction and early warning, pollution traceability, hot zone analysis, etc. The establishment of WIoT environmental governance program enables analysis of water quality data characteristics, combined with cross-sector data analysis, it can determine the hot zone of water pollution and achieve upstream traceability and downstream warning.

### A. *Selecting Monitoring Stations*

The source of the pollution analysis model consists of 3 components including the decision support system (DSS) layer, the data layer, and other data connections. When the water quality sensors detect anomalies and issue early warnings, companies located in upstream areas of pollution are immediately identified to reduce the scope of the investigation and increase emergency response capability (See Figure 5).

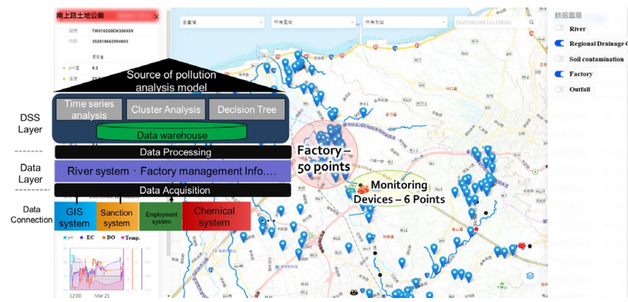


Figure 5. Pollution Source Analysis Module

Monitoring stations that require further analysis are selected based on analysis models of the automatic continuous monitoring and early warning system. The system utilizes Geographic Information System (GIS) analysis functionality to screen sections of the river close to the station. With this, users can confirm whether they would like to change the scope of analysis.

### B. *Screening By Industry*

By default, the system filters factories with high pollution potentials within a 5-km radius of the monitoring station. Users can categorize the data by industry based on the type of pollution, such as Printed Circuit Board (PCB) manufacturing. The system will present an industry list that includes factory names, locations, and addresses on the GIS graphical layer that can be selected and added to the analysis list.

### C. *Materials And Audit Data Analysis*

The system filters factories according to Step B to further analyze their basic data, status of material registration, and past results from the previous audits. Searches can be conducted on their latest data related to water pollution, waste, punitive actions, and registration status in the last 3 years.

### D. *Pollution Hotspot Analysis Model*

The purpose of this model is to measure the degree of impact by water pollution in downstream areas to achieve the critical task of quickly evaluating early warnings. The purpose of this model is to measure the degree of impact by water pollution in downstream areas to achieve the critical task of quickly evaluating early warnings. There are 5 problems promptly following: (1) the time for pollution to reach sensitive downstream areas; (2) the amount of maximum pollution concentration; (3) the total area of pollution; and (4) the duration of pollution concentration; (5) the time that pollution would exceed the safety limitation.

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## V. CONCLUSIONS AND FUTURE WORK

Varied from traditional monitoring, this study utilizes WIoT technology to obtain a large amount of data, which are then used to build new water quality application models, including an alert model and forecast model, through the widespread deployment of sensors.

To achieve early warning according to data anomalies, upstream pollution source tracking, and downstream pollution hotspot prediction, the deployment of large-scale is essential to obtain spatial and temporal high-resolution monitoring data and integrated data from multiple regions with the help of data analysis models.

This study has deployed more than 100 miniaturized water quality monitoring devices and successfully applied the data analysis model to identify cases of data anomalies in water quality for law enforcement. These devices were installed in various locations in Taiwan with potential water pollution, and data collected from the devices has transmitted to a centralized database for analysis.

The data analysis model developed in this study was applied to identify cases of data anomalies in water quality for law enforcement. This allowed authorities to quickly identify and response to cases of water pollution and improve the overall environmental quality of the affected areas.

The successful deployment and application of the data analysis model in this case study validated the recommendations made in this study, proving that miniaturized water quality monitoring equipment can be effectively utilized for early warning and pollution control.

In the future, we will continue to promote the application of WIoT monitoring system in wastewater treatment monitoring (or more) through the field of industrial, medical, and the general public. WIoT equipment can set up early water-quality warning module at the monitoring stations and the adjust the process and treatment unit in real time by analyzing the change of historical data. With the cooperation between government policies, big data analysis models, and the usage of machine learning, they can provide early warnings and smart control functions that would continue to further perfect Taiwan's IoT industry chain.

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