Development web and mobile application and open data platform for water quality management in Pak Phanang river basin

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Abstract. This paper aims to develop web and mobile application and open data platform to facilitate the community researchers use for monitoring the water quality management in Thailand. The paper developed a mobile and web application to collect and represent WQI data. Besides that, this paper elaborated the open data platform for sharing the WQI data to the other public sectors with two formats are people-readable format and machine-readable format. The population of this research is the community researchers who live in the Pakpanang river basin, including in local authorities, volunteers, and academic researchers. This paper also pays attention to the third parties are living in the outside area, which uses the WQI data. The experiment found that the overall user satisfaction of those participate in this project is in a good rank. The top three ranks of the function usage are: the first rank is a monthly report of the WQI data function. The second rank is a sending the WQI data by the volunteer function, and a calculating the WQI data by the academic researcher function. Finally, The third rank is open data usage function. Also, the measurement station increased from twenty to twenty-two stations. The volunteers expanded from the local authorities, volunteers, and academic researchers to students and teachers. For the future, this paper tries to apply a minimisation method for optimising The WQI parameters and also classify the proper parameters for each measurement station.

1. Introduction

Water quality management has represented as a significant indicator for the sustainable development agenda that consists of 17 goals with 169 specific targets and 230 indexes, which is going to achieve the goals within 15 years. A set of related parameters such as dissolved oxygen, electrical conductivity, nitrogen, phosphorus, and pH can use for evaluating water’s quality. In Thailand, increasing population, human activities, and land use activities such as economic, agricultural and industrial are the major causes of water quality problems. The Thailand Pollution Control Department (PCD) informed that the water quality of water resources in Thailand is in fair condition. However, the surface water quality receiving pollutants which discharged from industrials, agriculture or population areas. From the survey by PCD, there is no surface water in Thailand categorised as "excellent" quality, and It appeared to be worse especially in terms of dissolved oxygen (DO) and total coliform bacteria (TCB) indicators. Focuses on Pak Phanang river basin which locates in the south of Nakhon
Si Thammarat province, Thailand. The basin covers the thirteen districts of three provinces are Nakhon Si Thammarat, Phatthalung and Songkhla province. In an aspect of water quality management, this area has more complex and diverse from a population, water-use, land use, and chemical material. It has led to effects on the livelihood of the people in the basin.

According to PCD’s report shown a total water quality index in Pakpanang river basin. The basin was classified as "Poor Quality", which is contaminated water from agricultural communities such as orchards, rubber and palm plantation. A decreasing in water quality in Pak Phanang river basin brought to set up a community researcher for managing the water quality which is a collaboration among local authorities, farmers, fishers, and academics (School and University) [1]. However, to manage a network of community researchers is not easy. Usually, It encountered the failure from a simple issue such as its too complicated work procedures. Another factor is Information Technology which is a potential tool to facilitates water quality management. Lian Guey Ler and Philippe Gourbesville [2] suggested a framework of ICT for implementing smart water management. This framework has three main elements, including hardware, software, and water information system. Sensors and its adapters to deals data acquisition are categorised as hardware, while the water information system means that a significant water data management and analysis, and software that is support services and applications. Another case, Thammarak and friends [3] explained various forms of IT such as mobile application, web application, big data analysis and open data to support water quality management in the aspect of people and data.

Moreover, Sarah Parkinson and Ricardo Ramírez [3] applied the sustainable livelihoods framework for assessing the contribution of ITs. C. S. Laspidou [4] studied IT and stakeholder participation for improved urban water management. The article has shown that using relevant IT and social computing can be instrumental in raising awareness of stakeholders on the significance of the water sector and can be used to change behaviours and attitudes among citizens. Emily Kumpel and friends [5] implemented a mobile application to facilitate water quality data collection within the national public health agency in Senegal. The results showed that using a mobile application can improve the effectiveness and sustainability of water quality management.

Therefore, this paper aims to develop web and mobile application and open data platform to improve the water quality management in Thailand. The remaining of this paper has organised as follows: Section 2 describes the Background Section 3 represents the methodology. Section 4 reports the results and discussion. Section 5 summarises the conclusion and future works.

2. Background

2.1. Water Quality Management
The Australian and Queensland Governments developed water quality management through the GBR Reef Water Quality Protection Plan (RWQPP) in 2003. The plan covers the fundamentals of water quality, water quality modelling and systems analysis of streams, reservoirs, and estuaries, and practical water quality topics and problems [6]. Water quality management involves the maintenance of water resources on a sustained basis, by achieving a balance between economic development, environmental protection, and urban life. From the study, water quality management concerns Three significant elements: implementation plans and enforcement plans, and an anti-degradation statement to protect existing high-quality waters.

Now a day, there are many approaches to water quality management; for example, S.E. Jørgensen defined the approach based on the methodological perspectives of three basic management approaches: Preventive, Corrective, and Sustainable. [7]. Ching Gung Wen and Chih Sheng Lee applied a neural network approach to multiobjective optimisation for water quality management in a river basin in Taiwan [8]. Amin Elshorbagy and Lindell Ormsbee used the OO-SD modelling approach for surface water quality management in southeastern Kentucky, USA [9].
2.2. Water Quality Index
Water quality is a technique that provides a ranking of the composite effect of individual parameters of water quality to the overall water quality [10]. Generally, the Water Quality Index approach [11] has three steps: Parameter Selection, Determination of Quality Function and Sub-Indices Aggregation with Mathematical Expression. From the study, there are many parameters to use for assessing the surface water that shown in Table 1.

| Case                              | WQI Parameters                                                                 |
|-----------------------------------|--------------------------------------------------------------------------------|
| Goa (India) [12]                  | pH, Total Dissolved Solids (TDS), Total Hardness (TH), Total Suspended Solid (TSS), Calcium, Magnesium, Chloride, Nitrate, Sulphate, Dissolved Oxygen and Biochemical Oxygen Demand (BOD) |
| A Dokan Lake [13]                 | pH, Dissolved Oxygen, Turbidity, Conductivity, Hardness, Alkalinity, Sodium, Biochemical Oxygen Demand, Nitrate and Nitrite |
| Ambazari Lake [14]               | pH, electrical conductivity, total dissolved solids, total hardness, alkalinity, calcium, magnesium, sodium, potassium, chloride, sulphate, nitrate, fluorides and iron |
| Kuwait Bay [15]                  | pH, turbidity, Total Suspended Solids (TSS), dissolved oxygen, nitrate (NO3), and phosphorus (PO4) |
| Sankey tank and Mallathahalli lake [16] | pH, electrical conductivity, total dissolved solids, total hardness, alkalinity, calcium, magnesium, sodium, potassium, chloride, sulphate, nitrate, fluorides and iron. |

In Thailand, the pollution control department defined the five parameters to assess the water quality include Biochemical Oxygen Demand (BOD), Total Coliform Bacteria (TCB), Fecal Coliform Bacteria (FCB), Total Suspended Solids (TSS) and Dissolved Oxygen (DO).

2.3. Information Technology for water quality management
Now a day, Information Technology has become essential tools in water management. IT applications have a high capacity to save data in various forms such as texts, audio, photographs and videos. It can collect and save information in a digital format, including transfer information and knowledge through a wide range of networks. Also, it can design well-structured information systems from raw data and; interpersonal discussion and communication [17]. The explosive growth of mobile technology and telecommunication has opened new opportunities for developing new applications for water management. For example, A. Jonoski [18] presented study demonstrates the benefits of using a mobile phone and web applications for bi-directional communication between authorities responsible and citizens as end-users. Emily Kumpela and friends implemented a mobile phone application to facilitate water quality data collection within the national public health agency in Senegal [5].

Another application of IT is Web Application, which is a dynamic web page that has a long time to apply in water management sectors such as web-application for monitoring system [19], a web application for DSS [20], and web application for IoT [21]. Besides, Open Data also raised to influential in a modern IT’s application. Open Data is data that can use freely, unlimited to use. The key elements of Open Data are availability, reusability, re-distribution, and universal participation. The current year have only seven datasets in Thailand that related to water quality management. Unfortunately, the
dataset of Pakphanang river basin is not available. The open data formats are available today consist of xls, xlsx, pdf, CVS, JSON and some non-structure content (image and video).

3. Methodology

3.1. Population and Sampling method
The population is the community researchers who live in the Pak Phanang river basin, including in local authorities, students, government sub-departments, volunteers, and academic researchers. This paper also pays attention to third parties are living in the outside area. The paper applies a random sampling method and creates questionnaires as a tool to collect data. The questionnaire is consisting of three main parts: (1) necessary information about respondents such as age, address and job position. (2) the respondent's satisfaction, and (3) The respondent's behaviour who was using the IT and open data platform.

3.2. Sampling Area
Pak Phanang river basin located in the south of Thailand and has more complex and diverse from a population, water-use, land use, and chemical material. This paper defines a measurement station based on a length of Pak Phanang river and several communities which are living in this area. Figure 1 shows existing measurement stations and the sub-district administrations. The pin sign represents measurement stations, and the flag sign represents to the sub-district administrations.

![Figure 1](image)

**Figure 1.** 20 sampling points and 10 sub-district administration.

3.3. Design and Develop IT Application
This paper designs and develops two application and one platform to collect and represent the results of water quality index. Open data platform developed from the Thailand open data framework. This platform defines four filetypes are xls, xlsx, pdf and JSON for people-readable and machine-readable.

3.4. Sampling and collecting method
This paper defines ten parameters are Biochemical Oxygen Demand (BOD), Total Coliform Bacteria (TCB), Fecal Coliform Bacteria (FCB), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Potential of Hydrogen ion (PH), Ammoniacal Nitrogen (NH-N), Total Solid (TS), Salinity (Sal) for assessing the water quality in each station. Every month the community researchers have been used the test kits to assess the water quality and send the results to an academic researcher with a mobile application.
4. Results and discussion

4.1. Mobile application and web application
A mobile application has six functions for the community researchers and one function for the general user. The community researchers can use the application for registering and sending monthly WQI data. Also, they can add and delete the location and notification time. Besides, they can download the monthly report of WQI data. The web application has a complete function for supporting any distinctive level of stakeholder. For example, the community researchers can download any reports and documents are related to the water quality of Pakpanang river basin. The local authorities can download a period report of water quality to create the budget plan, operation plan and risk plan. The academic researchers and administrations can import and export a monthly parameter list to calculate the water quality index. The general user can access WQI data in various formats such as a spreadsheet, pdf, web service, and API.

![Web and Mobile Application](image)

(a) (b)

Figure 2. Web and Mobile Application to collect and represent water. The colour represents a water quality level while blue colour is “Excellence”, Green colour is “Good”, Yellow colour is “Fair”, Orange Colour is “Poor”, and Red colour is “Very Poor.”

4.2. Open Data: People and Machine Readiness
This study provides an open data architecture to support the other public sectors. This platform has two kinds; proprietary and non-proprietary. A spreadsheet, CSV and PDF design for supporting people usage. While, JSON, CSV, and SOAP design for the machine operation. This project provides a monthly WQI dataset that has thirteen elements consist of Location, Location Name, Month, Year, DO, BOD, NH3, FCB, TSS, pH, Sal, WQI and result. Figure 3 shows the JSON file for the machine-readable. Figure 4 shows the xls file for the people-readable.
4.3. Evaluation results

This section presents the evaluation results from the questionnaire. The questionnaire has three parts, including necessary information, user satisfaction and user’s behaviour in the perspective of tool usage and data usage. In this study, the fifteen respondents consist of four user types are an academic researcher (26.70%), community researcher (53.3%), local authority (13.3%) and general user (6.7%). The 86.67% of all respondents are live in Nakhon Si Thammarat, and 13.33% of them comes from others area. Overall satisfaction is in a good rank are 4.00 from 5.00 score. In a part of function usage, the first rank is a monthly report of the WQI data function (66.7%), the second rank is sending a WQI
data by volunteer function (53.3%), and the third is calculating and using open data function (40%) that show in Figure 5.

| Mobile and Web Application Usage |
|----------------------------------|
| Problem Notification              | 30.0% |
| Sending WQI value                 | 53.3% |
| Using Open data                   | 40.0% |
| Using Report and Research         | 33.3% |
| Following WQI data                | 40.0% |
| Calculating WQI                   | 66.7% |

**Figure 5** Mobile and Web application usage.

5. Conclusion and Future Work
In order to improve water quality management in Thailand, this paper aims to design and develop web application, mobile application and open data platform to facilitate the community researchers in the area of Pak Phanang river basin. The paper defined the twenty measurement stations and ten parameters for WQI assessment. Also, the paper developed an open data platform based on Thailand's open data framework. The open data formats consist of four filetypes are xls, xlsx, CVS and JSON. Currently, community and academic researchers have been measured and collected the monthly WQI data. From using a random sampling method and the questionnaire, the overall satisfaction is in a good rank (4.00). In addition, the top three ranks of the function usage are the WQI monthly report function (66.7%), Sending a monthly WQI data function (53.3%) and open data usage function (40%). For the future, this paper focuses on a minimisation method for WQI parameters and classifies proper parameters of each station.

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