ORIGINAL RESEARCH PAPER

Chemistry

SMART LABORATORY INFORMATION SYSTEM FOR WATER QUALITY MONITORING

KEY WORDS: Laboratory Information System, Water Quality Monitoring, Location-based Application, Mobile Application, Web Application

Kitti Phojuang	Environmental Science Program, Faculty of Science, Chiang Mai University, Chiang Mai, 50200, Thailand. Center of Excellence for Innovation in Analytical Science and Technology Chiang Mai University, Chiang Mai, 50200, Thailand.
Sirprapa Wattanakul*	College of Arts, Media and Technology, Chiang Mai University, Chiang Mai, 50200, Thailand.; Center of Excellence for Innovation in Analytical Science and Technology Chiang Mai University, Chiang Mai, 50200, Thailand. *Corresponding Author
Supara Grudpan	College of Arts, Media and Technology, Chiang Mai University, Chiang Mai, 50200, Thailand.; Center of Excellence for Innovation in Analytical Science and Technology Chiang Mai University, Chiang Mai, 50200, Thailand.
Wasin Wongwilai	Center of Excellence for Innovation in Analytical Science and Technology Chiang Mai University, Chiang Mai, 50200, Thailand. Science and Technology Research Institute, Chiang Mai University, Chiang Mai, 50200, Thailand.
Kate Grudpan	Environmental Science Program, Faculty of Science, Chiang Mai University, Chiang Mai, 50200, Thailand.; Center of Excellence for Innovation in Analytical Science and Technology Chiang Mai University, Chiang Mai, 50200, Thailand. Department of Chemistry, Faculty of Science, Chiang Mai University, 50200, Thailand. Science and Technology Research Institute, Chiang Mai University, Chiang Mai, 50200, Thailand.

ABSTRACT

Smart Laboratory Information System for water quality monitoring is developed. The system could employ simple conventional sensors and test kits. The system architecture consists of two major parts, namely web application, and mobile application. It is comprised of six features: authentication and member management system, project management, map location management, water parameter calculation, parameter result tracing and messaging system. The system can manage the tasks for the four steps of water quality monitoring process: planning, sampling, analysis with evaluation and reporting. With the system, three layers of persons: administrator, a team leader and working persons (called "collectors" in the system) involve different tasks. The center lab can communicate with those persons working in the field to recheck and/or repeat the experiments. The system also provides location-based application. The system serves as a platform with emerging technology to offer various advantages.

INTRODUCTION

Water quality monitoring is important for the protection and prevention of quality water sources. Water Quality Monitoring has then played important roles in various aspects. Monitoring provides the information that permits rational decisions to be made describing water resources and identifying actual and emerging problems of water pollution, formulating plans and setting priorities for water quality management, developing and implementing water quality management programs, evaluating the effectiveness of management actions [1]. Water quality monitoring is defined by the International Organization for Standard (ISO) as: "the programmed process of sampling, measurement and subsequent recording or signaling, or both, of various water characteristics, often with the aim of assessing conformity to specified objective" [1].

Conventional methods of water quality monitoring may involve the following processes: surveying the study areas; selecting sampling sites; collecting and preparing samples; transporting samples; sample storage; performing laboratory analyses. These processes can be time-consuming, with the result that there is a considerable delay of days to months between sampling and reporting of the results. There has been some development to overcome various tedious tasks in the above mentioning monitoring scheme. Such the development includes mobile unit/vehicle and some via geographic information system (GIS) [2, 3]. The systems are usually expensive and need skill/experience operator. It is then of interest to develop Smart Laboratory Information System for water quality monitoring by recent information technology which should be easily available and cost-effective.

Smart Laboratory Information System for water quality monitoring is designed to facilitate the water quality monitoring team which the operator who is inexperience in the monitoring method can participate with the team. However, the team requires at least one member who knows/experiences in the water quality monitoring method to supervise team members/collectors in the remote location. Mobile and Web technology are proposed to fulfill this objective. Regarding that mobile and GPS technology allow the feature to support location-based applications [4, 5] such as Google Map API can guild direction and to verify the arrival of the user to the location with the friendly user interface. Furthermore, it provides a more effective way to reach the sampling site for water analysis/evaluation and for communication with the team for guidance which can reduce time- consuming compared to the conventional method. In terms of system development, there are open sources providing for mobile and web application development. Based on available technology and tools which are easy to access and develop can be a solid solution for practical problems in the different discipline area such as the chemical analysis [6, 7].

The execution of the developed system was aimed to involve the 4 main steps of water quality monitoring, i.e., planning, sampling, analysis with evaluation and reporting.

MATERIALS AND METHODS

The proposed System Architecture (see Figure 1) consists of two major parts; Web application and Mobile application. The web application is mainly used to support Administrator and Team leader to organize the Water Monitoring projects. PHP is used as a server-side scripting language for creating a dynamic webpage, and it is flexible to integrate additional component as several open sources support their development on PHP integration. Another part of Mobile to support Collectors for on-site collection is developed on the Android operating system which provides open source development platform with the flexibility to add external components as well. On both parts of the system, Google API package is added particularly for accessing Google map features with geography data in Thailand. Google spreadsheet is used to store results related chemical parameters which is submitted from mobile application by each collector because it can be shared to team members or even export to Excel spreadsheet for further analysis/evaluation process.

The System Architecture, as illustrated in Figure 1, is comprised of 6 features:

Feature 1: Authentication and member management system
Feature 2: Project management
Feature 3: Map location management
Feature 4: Water parameter calculation
Feature 5: Parameter result tracing
Feature 6: Messaging system

Table 1. summarizes the functions and the involvement of tasks by the layers of those who will engage i.e., the administrator (the person who has responsibilities to initial project team and members), the team leader (the person who takes charge of the project to manage collectors during team planning and on-site collection) and the collector (the person who is assigned to work on-site for sampling collection), while operation execution is illustrated in Figure 2 .It can be seen that the operations #1, #6 and #7 involve web application, while the operations #2, #3, #4, #5 and #7 refer to mobile application.

With the developed system, the steps for Chiang Mai Moat water quality monitoring could be illustrated: Step 1 Planning with the operation execution #1, #2, #3, #4 and #5 in Figure 2; Step 2 Sampling with the operation execution #6.1 and #7 in Figure 2; Step 3 Analysis and Evaluation with #6.2, #6.3, #6.4 and #6.5, in Figure 2; Step 4 Display with #1-#7 (Figure 2). It should be noted that during the work in #6.2-#6.5, some photos and relevant information may be put into the system too.

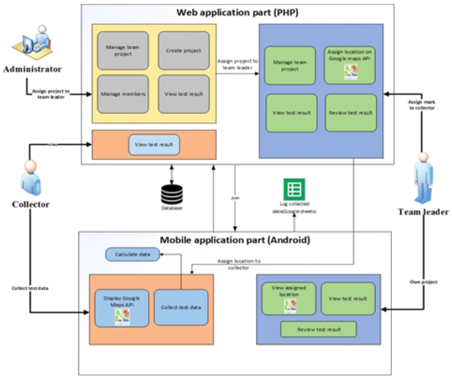


Figure 1: System Architecture.

Table-1 Features of the team collaboration system for mobility water monitoring application.

Feature	Function name	Administrator	Team leader	Collector
Feature 1: Authentication and member management system	Authentication on a web application	√	√	√
	Edit profile on a web application	√	√	√
	View list of new collector request on a web application	√		
	Select to approve or decline new collector request on a web application	√		
	Create the team on a web application	√		
	Modify the team on a web application	√	√	
	View the selected team information on a web application	√	√	
	Send the register request on a mobile application			√
	Authentication on a mobile application		√	√
Feature 2: Project management	Create the project on a web application	√		
	Search the project on a web application	√	√	√
	Modify the project on a web application	√		
	View the project list on a web application	√		
	View the involved project list on a web application and mobile application		√	√
	View project information on a web application	√		
	View project information on a web application and mobile application		√	√
	View list of water parameter on a web application	√	√	√
	View list of water parameter on a web application and mobile application		√	√
Feature 3: Map location management	Assign work location on Google Maps on a web application		√	
	View direction to an assigned location on Google Maps on a mobile application		√	√
	View other place information by press on a pin on a mobile application		√	√
Feature 4: Water parameter calculation	Add water parameter (chemical/physical) to collect the test data on a mobile application			√
	Delete water parameter (chemical/physical) on a mobile application			√
	Choose the image from camera roll and process for color values (RGB)/desired information			√
	Manage value and RGB/desired information to let the system calculate the test result based on the standard color scale on a mobile application			√

Feature	Function name	Administrator	Team leader	Collector
Feature 5: Parameter result tracking	View detail of test result of selected parameter (chemical/physical) on a web application.	√		
	View detail of test result of selected parameter (chemical/physical) on a web application and mobile application		√	√
	Mark status to recollect on water parameter (chemical/physical) on a web application and mobile application.		√	
	Mark status to finish on water parameter (chemical/physical) on a web application and mobile application.		√	
Feature 6: Messaging system	Send the message to each other via group message within the team on a mobile application.		√	√

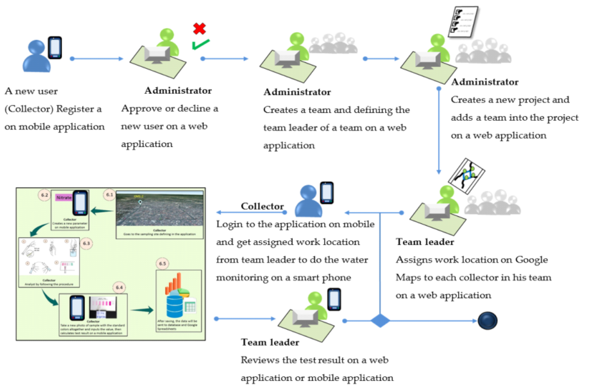
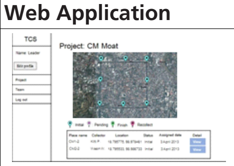
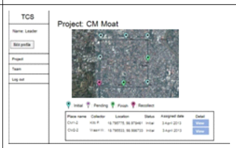
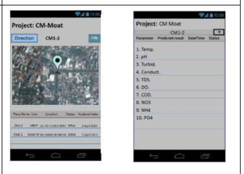
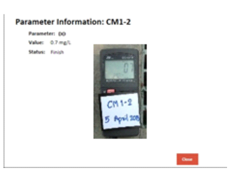
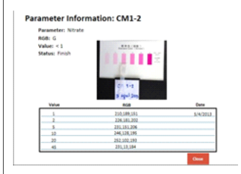
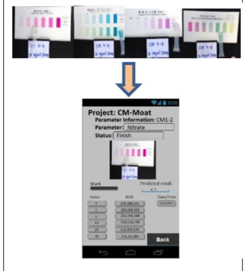
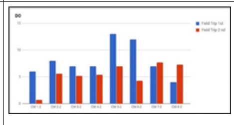
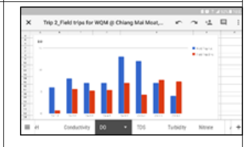
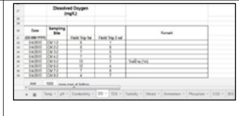
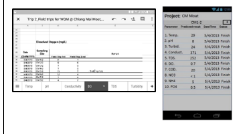
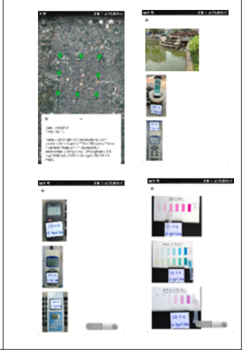


Figure 2 : Operation execution in the developed system for water quality monitoring.

RESULTS

The developed system is illustrated for Chiang Mai Moat water quality monitoring in Table 2.

Table-2 Illustrating the proposed concept for Chiang Mai Moat water quality monitoring (CM Moat project).

Activity	Web Application	Mobile Application
1. Planning		
2. Sampling		
3. Analysis and Evaluation	3.1 Digital probe meter 	3.1 Digital probe meter 
	3.2 Test kit (Pack test) 	3.2 Test kit (Pack test) 
4. Display 4.1 Format Graph		
4.2 Format Table		
4.3 Format Google Maps		

DISCUSSION

Via the developed system, in the planning step, team building can be organized, via a project administrator, a team leader, and collectors. Each member in the team would be given task(s) which may be different from one to the others. This is flexible. The number of members in each project team can also be different in each project. Water quality monitoring can also be planned differently for each trip, but the goal of the monitoring can still be managed. Apart from personnel, sampling points can be planned without real surveying, but this can be done via Google maps.

During the monitoring operation, the communication between the center lab and those who work in the field can be made. The center lab engages web functions, while mobile applications are for those in the field work. The center lab (administrator and/or team leader) can follow the whole activities of the project and may request those (collectors) who work in the field to recheck or repeat some experiments to make sure for the results.

CONCLUSIONS

The proposed Smart Laboratory Information System for water quality monitoring offers various advantages, namely flexibility in operating (monitoring area/site or different activities) as multifunctional tasks. It provides increasing the efficiency and quality of water quality monitoring. Simple conventional sensors and test kits can be used in this system. The Smart Laboratory Information System should be useful to water quality monitoring. It may be useful to other applications, such as in precision agriculture. Further development is in progress.

ACKNOWLEDGMENTS

The authors would like to acknowledge Peerapong Chompootepa, Worrasete Tansurat, The Thailand Research Fund (TRF) (DPG6080002), Center of Excellence for Innovation in Analytical Science and Technology (I-ANALY-S-T), Cluster of Excellence on Biodiversity Based Economy and Society (B.BES-CMU), College of Arts, Media and Technology (CAMT), Graduate School, Chiang Mai University for support.

REFERENCES:

[1] Bartram, J. and Balance, R. 1996. Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. Chapter 1. TJ Press, Padstow, Cornwall, UK.

[2] Usali, N., & Ismail, M. H. 2010. Use of Remote Sensing and GIS in Monitoring Water Quality. Journal of Sustainable Development, 3(3): 228-238.

[3] Jiping J., Peng W., Wu-seng L., Liang G., Mei L. 2012. A GIS-based generic real-time risk assessment framework and decision tools for chemical spills in the river basin. Journal of Hazardous Materials, 227– 228, 280– 291.

[4] Myles, G., Friday, A., & Davies, N. 2003. Preserving privacy in environments with location-based applications. IEEE Pervasive Computing, 2(1): 56-64.

[5] Rao, B., &Minakakis, L. 2003. Evolution of mobile location-based services. Communications of the ACM, 46(12): 61-65.

[6] Wongwilai, W., Jayawardane, M., Kolev, S. D., Grudpan, K. and McKelvie, I. D. 2016. Comparison of some modern IT equipment as detectors for microfluidic paper-based determination of phosphate, Chiang Mai Journal of Science, 43:176 – 182.

[7] Grudpan, K., Kolev, S.D., Lapanantnopakhun, S., McKelvie, I.D. and Wongwilai, W. 2015. Applications of everyday it and communications devices in modern analytical chemistry: a review. Talanta, 136: 84-94.

[8] KYORITSU CHEMICAL-CHECK LAB., Crop., PACKTEST, 2000. Available online: https://kyoritsu-lab.co.jp/english/seihin/list/packtest/index.html. (accessed on 3 July 2018).