Development of Information Technology of Water Quality of Urban Rivers - Case Study of Cikapundung River, Bandung, Indonesia

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***Abstract*— The important of urban river water quality data publication increases due to the stakeholders interest in improving the environment condition. The Cikapundung River as one of the river that passes through the heart of Bandung City, Indonesia, became one of the popular rivers for improvement pilot site. Bandung City has not yet developed the information technology (IT) system to publish the river water quality, therefore in this activity; the research was conducted to develop the suitable system of the information technology. Direct interview and surveys were conducted to acquire the potential user inputs and perspectives on the IT system. The result of the research shows that parameters of water quality that attract stakeholders are mostly the domestic source-related pollutants. Modeling of the dissolved oxygen (DO) and biogeochemical oxygen demand (BOD) can give benefit to inform the river water quality condition under the controlled inputs. In the early stage, the most suitable style of the IT system development for the Cikapundung River is website-based integrated to the Bandung City homepage. The information of the river water quality would be given in tables, pictures, and graphs. The IT managers consist of three parties of the Bandung City government, i.e. Environmental Protection Bureau, the Planning-Development Board, and the Information Section.**

Keywords— information technology; urban river water quality

I. INTRODUCTION

Changes regarding environmental management in recent years in line with changes in information technology, both in the management method and the contributors. Increased knowledge considering the environment quality has given a better understanding of the management problem for many people. The abundance information available to the public has resulted in increased attention and participation of many parties to participate in environmental management. Management methods that dominated formerly dominated by the formulation of a centralized government now have to involve public participation in the form of attention and action through various means, notably a complete information system and easily accessible.

The management of information is increasing complex. For water quality in particular, three main factors lead to that complexity the lack of understanding of environmental interaction and interdependency [1]. In the system of information exchange and updating of data is very important, particularly in relation to the formulation of management measures accordingly. Especially with regard to the condition of the river that passes through some areas of administration, whether local, regional, and national levels. Therefore, the information system for the quality control of the river would be very appropriate if it is handled by an agency that covers a watershed authority.

One method to assess the river water quality is by means of simulation results of a model verified with the measurement data obtained from in the field. Modeling is a method that is easy, inexpensive, and saves time. The use of river quality model is very useful to predict the future condition using kinds of scenarios, so that the river environmental management can be formulated prior to the occurrence of pollution, environmental damage, or other disasters.

Modeling of river water quality was introduced by Steeter Phelps equation using oxygen depletion curve equation (oxygen sag curve) which is using coefficients, i.e. deoxygenation rate and reaeration rate. These rates are environmental condition dependent values; therefore the specific research to find the suitable rates is needed. Furthermore, to make simulation simpler, the development of software of river water quality model is necessary. In the other hand, the increasing of environmental conservation awareness needs a system of information which is useful, informative, up to date, complete, and easy to be analyzed. To develop such system, a comprehend research needs to be conducted, especially to gather information considering data collection system, its publication, and distribution. These information would be very useful also for environmental education in order to increase awareness and enforcement to young generation, especially students in conserving the environment. Besides that, information of the river water quality would be

also useful for researchers, government, and other stakeholders for many kinds of purposes. To have an effective system of the environmental system, the need of development of its concept is urgent.

Recently, the function of rivers located in Bandung City turns into the discharge place of domestic and industrial wastewater. The water quality in Bandung Basin becomes deteriorated, especially in Citarum River. The dominant pollution source is domestic activities. The West Java Environmental Protection Agency estimates that the domestic wastewater was discharged from 3.5 million people directly and indirectly into the urban rivers around Bandung City. The domestic wastewater reaches up to 60% of total wastewater pours into the rivers [2].

The use of system analysis and mathematical modeling for formulating and solving river pollution problem is of relatively recent vintage and has been used widely during the last three decades. Seeing the mounting public pressure at water bodies the need to protect it from pollution is essential where mathematical modeling is the best alternative as accepted by the decision makers. Water quality modeling has proved as a reliable and economic method of assessing pollutant distribution in surface waters and can be effectively used in management decisions [3]. Bandung City has not yet developed the information technology system to publish the river water quality, therefore in this activity; the research was conducted to develop the suitable system of the information technology.

II. METHODOLOGY

A. Cikapundung River Water Quality

In the beginning of the research, the river water quality needs to be analyzed. Bandung has 46 rivers and tributaries that pass through the city. The Environmental Protection Bureau of Bandung City takes samples and analyzes them regularly. The data is then being studied to determine their condition. Examination of the river water quality is conducted by using STORET Index method.

B. Modeling and Information System Development

In this study, a river water modeling was developed by acquiring the potential users opinion. Parameters and interface of model were obtained by distributing questionnaire to those potential users. The software was then being composed according to the user need. In addition, the integration should be done with the data processing software, spreadsheet for ease of analysis, especially in showing trends in the water quality of the river. Integration was done with the map will be applied to this software in actual conditions. River to be used for the integration of these maps is Cikapundung River.

The investigation on the information system integrated with the software was then being conducted, including determination on potential operator, coordinator, and information flow.

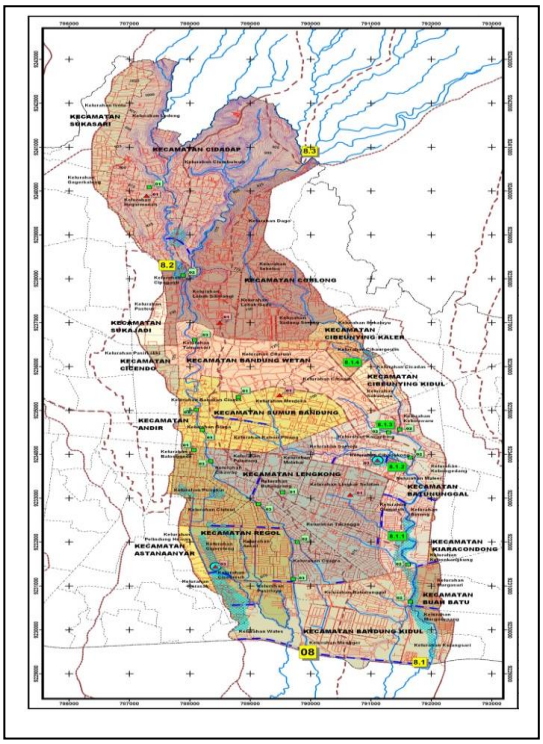

Fig. 1. Map of Cikapundung River.

C. Research Location

For the case of Cikapundung River, this research is focused on the segment between Babakan Siliwangi area and Asia Afrika Street. The segment is selected because this segment is the main concern of the Bandung City Government to be rehabilitate. Fig 1. show the map of the Cikapundung River in the segment of Bandung City.

III. RESULTS

A. Cikapundung Water Quality

BPLH (Environmental Protection Agency) of Bandung City gave an assessment of the rivers that pass through the city of Bandung using Water Quality Status. Status of water quality is the level of water quality conditions that indicate polluted conditions or good condition at a water source in a given time by comparing the water quality standards set. To set the quality status of water can be used two methods: Method and Method STORET Pollution Index, but the method commonly used is a method STORET. By using the method STORET knowable parameters still meet or has exceeded the water quality standard.

In determination of each river condition, scoring is used based on the US-EPA STORET assessment method that classifies the water quality into 4 classes, i.e.:

A Class : very good, score = 0 (comply to the standard)

B Class : good, score = -1 ~ -10 (slightly polluted)

C Class : medium, score = -11 ~ -30 (medium polluted)

D Class : bad, score = –31(heavy polluted)

According to Indonesia regulation of PP No. 82 year 2001, the water quality is classified into 4 (four) classes:

Class I, allocation of water can be used for the raw water of drinking water, and or other uses that require the same water quality with the usability

Class II, allocation of water can be used for infrastructure / facilities water recreation, freshwater fish farming, animal husbandry, water to irrigate crops, and or other uses that require the same water quality with the usability;

Class III, allocation of water can be used for freshwater fish breeding, animal husbandry, water to irrigate crops, and or other uses that require the same water quality with the usability;

Class IV, water allocation can be used to irrigate crops or other uses that require the same water quality with the usability.

STORET Index calculation gave the results that by comparing the river water quality to PP 82 of 2001 on the Management of Water Quality and Water Pollution Control, Class I, II, and IV, all the rivers are considered classified in the category of heavy polluted.

According to the detail analysis of Cikapundung water quality, the source of pollutant is mainly from the domestic wastewater. Parameters of pollutant that have very high concentration are BOD (biogeochemical oxygen demand), nitrogen, and E.Coli. Many illegal residences are located in the Cikapundung Riverbank. Those houses do not have appropriate treatment and handling for their domestic waste.

B. Potential Users

Survey of the potential and user needs analysis shows that the water quality modeling software could potentially be used by government agencies, private companies, and individuals. Some agencies in Bandung and West Java that have been using river water quality modeling software are:

- Environment Protection Agency of Bandung City
- Environmental Management Agency of West Java Province
- Regional Drinking Water Company of Bandung City
- Research and Development Center Water Works
- West Java Provincial Irrigation Office
- Researcher and lecturer at the university of courses Environmental Engineering, Civil Engineering
- Consultant
- Usage of the software:
- Determination of the policy
- Verification/confirmation of pollution phenomena
- Prediction of river water quality
- Preparation of the EIA (predicted significant impacts)
- Utilization of river water
- Parameters required in river water quality modeling:
- BOD (biogeochemical oxygen demand)
- DO (dissolved oxygen)
- COD (chemical oxygen demand)
- Nutrients
- Heavy metals

The stakeholders are interested mostly in the domestic source related pollutans.

Restoration of the river has to be in many supported by several aspects, i.e.:

- water quality improvement
- water quantity stabilization
- river bank re-establishment
- citizen awareness and education

Maintaining the river condition and to prevent pollution need many activities, educational tools, and infrastructures, such as:

- environmental monitoring
- strict laws
- interactive museum of water, museum of environment
- wastewater treatment plants
- renewable energy system
- secure rainfall catchment area
- intense monitored water dam
- rich and interested curriculum of environmental education for students

C. Water Quality Equations

The equations used in the model river water quality are Steeter-Phelps for dissolved oxygen simulation:

$$D = D_o \cdot e^{\frac{-ka}{u}X} + \frac{Kd.Lo}{Ka - Kr}\left[e^{-\frac{kr}{u}x} - e^{-\frac{ka}{u}x} \right] \quad (1)$$

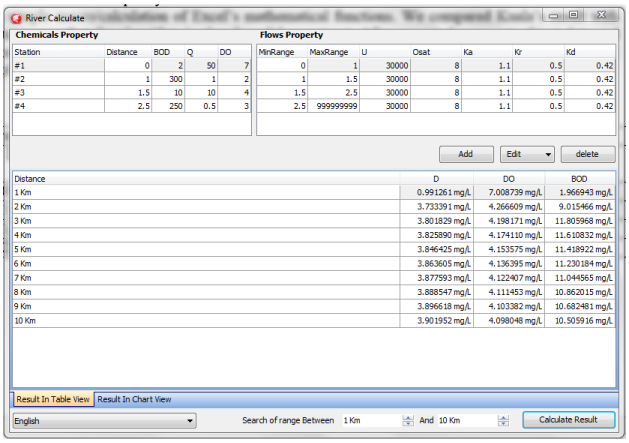

Fig. 2. KUALA software interface, input, and output.

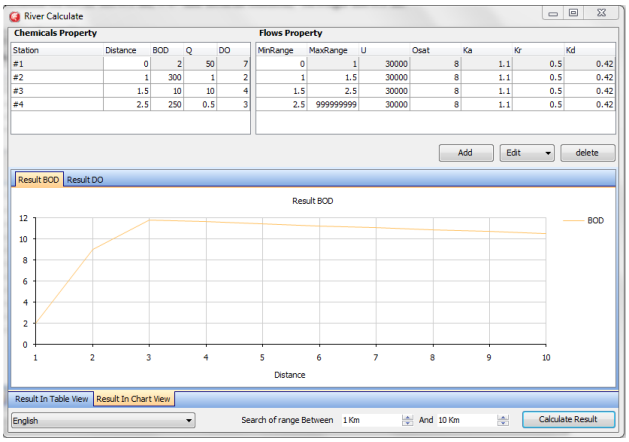

Fig. 3. KUALA software graphic output.

Where:

D = Deficit oxygen, (mg/l)
X = distant of observation point, (m)
U = average of velocity, (m/s)
K_d = deoxgenation rate coefficient, (day^{-1})
K_a = reaeration rate coefficient, (day^{-1})
K_r = total removal coefficient, (day^{-1})
L_o = BOD concentration in the initial point (X = 0),(mg/l)
D_o = Deficit oxygen in the initial point (X = 0), (mg/l)

and degradation equation for non-concervative pollutant for BOD simulation:

$$L = L_o e^{\frac{-K_r}{U} X} \quad (2)$$

Where:

L = pollutant concentration at point X (mg/L)
L_0 = pollutant concentration at point 0 (mg/L)
X = distant of observation point (m)
U = average velocity (m/s)
K_r = Total removal coefficient (day^{-1})

D. River Water Modeling Software

Software is only one element of a software project. Proper use and acceptance of the tool by staff is as important, if not more important. Figure below shows the three interrelated elements of any software project: business processes, technology, and people. It has already been noted that technology should be selected to fit specific business process needs; this topic is explored in greater detail in subsequent chapters. The people aspects of technology implementation include considerations such as staff involvement in the definition of requirements and software selection, but must carry through to implementation and ongoing use. Training is typically one of the most underfunded and under recognized critical success factors of any software implementation. While most COTS (commercial off- the-shelf) vendors provide training on the mechanics of using their software, additional training is often beneficial to educate end users on the role technology plays in performing their business processes, especially if these processes will change because of the introduction of a new software or technology tool. End-user and software support documentation is also critical to successfully maintain software over time, to provide a way for staff to explore lesser used functionality, and to provide information to new staff that come on as end users after the initial implementation [4].

The software of river water quality was named KUALA. It was composed by using Delphi. Figure 2 and 3 show the interface of KUALA. It calculates DO and BOD to fulfill the stakeholders' interest on the domestic source related pollutant. Dissolved oxygen will give also the indicator of river health, because organic pollutants would be decomposed by the microorganisms which require abundance of oxygen.

The useful software need to be user-friendly and gives helpful information that easy to understand. KUALA also depicts the graphical information of the simulation result, both DO and BOD.

E. Information System Flow and Integration on Website

The Figure 4 below shows the initial draft of information system for Cikapundung River. Monitoring data will be the input data for the River Information System (RIS). Cikapundung Rivers has many communities with their activities and events. Those activities would be a very useful data to be published in the RIS.

The most suitable style of the IT system development for the Cikapundung River is website-based integrated to the Bandung City homepage. The information of the river water quality would be given in tables, pictures, and graphs. It will be helpful when being integrated with GIS (Geographical

Information System). A GIS is a database system that is structured to focus on the location and spatial relationship of its date elements. Data are entered, stored, analyzed, managed, and presented in a manner that refers to, or is linked to, location. A utility GIS is important tool for managing information about the utility's assets and customers. Indeed, wherever location is important or maps are necessary to conduct business for the utility, there is an important role for GIS [4].

For operating the system, several bureaus need to be involved. The most suitable IT managers consist of three parties of the Bandung City government, i.e. Environmental Protection Bureau, the Planning-Development Board, and the Information Section.

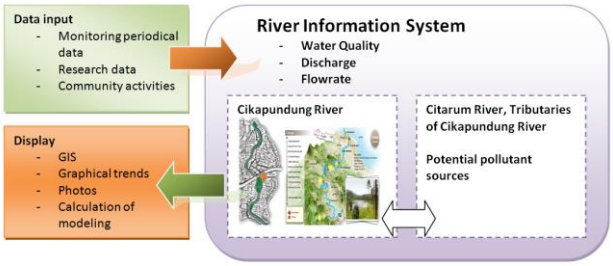

Fig. 4. Cikapundung River Information System flow.

IV. Conclusion

The result of the research shows that parameters of water quality that are needed by stakeholders are mostly the domestic source-related pollutants. Modeling of the dissolved oxygen (DO) and biogeochemical oxygen demand (BOD) was developed in a simple software, named KUALA. It can give benefit to inform the river water quality condition under the controlled inputs. In the early stage, the most suitable style of the IT system development for the Cikapundung River is website-based integrated to the Bandung City homepage. The information of the river water quality would be given in tables, pictures, and graphs. The IT managers consist of three parties of the Bandung City government, i.e. Environmental Protection Bureau, the Planning-Development Board, and the Information Section.

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