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Towards an Information System of Modeling and Monitoring of Cikapundung River, Bandung, Indonesia

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Abstract

Growing recognition of the need for water safety makes river water quality monitoring information and modelling usage more important to be accessed by many stakeholders. Cikapundung River which is located in the heart of Bandung City has its water for many purposes. In the other hand, the water of this river suffers as a result of wastes disposal from existing activities on its banks. Several agencies conduct regular monitoring, both discharge and water quality of this river. However, the monitoring results are not published openly. The data can only be obtained by visiting the monitoring agency. This procedure may result a non-optimal usage of the data, and can even be harmful when unsafe water is used for consumption need. An information system of monitoring data and modelling of Cikapundung River water quality is proposed to improve the method of data publication. Modelling of Cikapundung River water quality is also developed to have simple software for DO and BOD calculation simulation. The modelling is using Streeter-Phelps equation for DO calculation and first-order reaction of Phelps law for BOD calculation. The deoxygenation rates used in the software were obtained from the laboratory experiments, i.e. 0.01-0.37 per day.

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Keywords: River water quality; information system; river management stakeholders; DO-BOD software

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1. Introduction

In addition to being a commodity, the water resources provide important services and environmental benefits to the human society in particular and to the ecosystem at large [1]. Cikapundung River passes the heart of Bandung City, plays an important role in forming an image for the city as well as roles as water resource. The river has many functions, such as recreation area, drinking water source, and main drainage canal. Unfortunately, Cikapundung River water quality suffers with the untreated wastewater discharged from various kinds of activities. The water of this river flows southward and releases to Citarum River. The problems of water quality degradation in the Citarum River increases from the year to year due to the increasing of the pollutant loads particularly from Bandung region located in the upper areas of the river basin when released without treatment [2].

Many kinds of efforts have been conducted to recover the Cikapundung River water quality. The community living close to the river also carried out events to clean up the water. The government built some facilities to improve the water quality in several places. However, the pollution of Cikapundung River is still continuing. The water safety plan has also been tried to the Cikapundung River water. The Bandung City of Environmental Protection Agency (EPA) conducts the periodic measurement, water sampling, and laboratory analyzing to obtain the water quality for monitoring purpose. Yet, the results have not been used optimally to formulate the management strategy or other further analysis. Monitoring the surface run-off and physicochemical parameters of a river on a regular basis provides valuable insights into eco-hydrologic condition of the river basin [3].

The river water quality modeling is also rarely used in the frame of river improvement. In terms of water quality evaluation, traditional methods like water sample collection, indicator analysis and grade evaluation can only provide water quality status at the sampling point instead of large area of waters, while large-scale field sampling will consume a large amount of manpower, materials and financial resources [4]. Usage of modeling is now very popular for management formulation in other country. In recent year, research in urban water management has experienced a transition from traditional model applications to modeling water cycles as an integrated part of urban areas [5]. 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 [6]. However, the lack of water quality model data and suitable coefficients of local rivers make this method less popular in Indonesia. To perform mathematical modeling of aquatic chemicals, four ingredients are necessary (1) field data on chemical concentrations and mass discharge inputs (2) a mathematical model formulation (3) rate constants and equilibrium coefficients for the mathematical model and (4) some performance criteria with which to judge the model [6]. Usually, modeling for local rivers are conducted using built software. It takes coefficients from literatures. Thus, the outcome is not useful.

Evaluating this condition, all activities appear not integrated and not sustained. Many facilities are built but not optimally used. The same activities were repeatedly conducted without any coordination between them. Information concerning actions, events, monitoring results data, and other available services, especially in the efforts to improve the river quality, was sometimes undistributed. Therefore, the comprehensive media to disseminate these kinds of information is needed, including the facility in using the built river water quality model.

The evolution in environmental management in the last decades parallels the evolution of information technology, in terms of changes in approaches and players [7]. Changes regarding environmental management, including the river restoration, 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 role of information is to help promote, develop and establish more formal management framework that are supposed to modify and steer the behavior of people or organizations in the desired direction, such as laws or economic mechanisms [8].

Based on the need of an integrated accessible media of the Cikapundung River water simulation and information, therefore in this research, the concept of information system of modeling and monitoring of Cikapundung River was

developed. Information technology in water and wastewater utilities continues to progress from solely providing operational support toward serving as an enabler for a larger variety of business challenges. Information technology, in essence, is constantly evolving, thereby making it difficult to manage [9].

2. Methodology

2.1. Cikapundung River

The Cikapundung River was selected as this research object since the river represents the urban river in Indonesia that has a typical condition of its water quality. Since 2011, the Cikapundung River was declared as the icon of Bandung City. Declaration of 'Clean River' was being inaugurated in the river bank of this river. Many research activities were being conducted concerning the Cikapundung river's improvement efforts, both in the social-economy and engineering aspects [10], [11]. Figure 1 shows the location of Bandung City, whereas Fig. 2 shows the Cikapundung River location in Bandung City.

Fig. 1. Bandung City location [12].

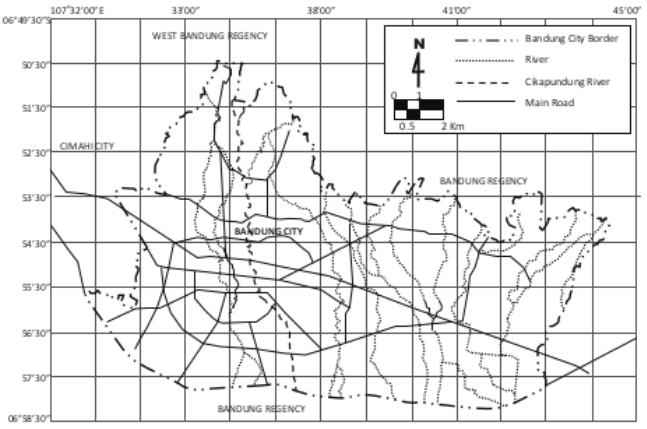

Fig. 2. Cikapundung River location.

2.2. The rugby ball method

This research adopted the rugby ball methodology developed by Argelo and Boterman [8]. The representation of the framework as a rugby ball is powerful tool in communicating the methodology. It provides an image that easily remembered and recognized, which is helpful in the communication. The rugby ball methodology consists of 5 phases, i.e. exploration, initiation, elaboration, concluding, and completion.

The Fig. 3 symbolizes the processes to develop the information need in the Cikapundung River water quality management, as well as integrating modeling and monitoring aspects in it.

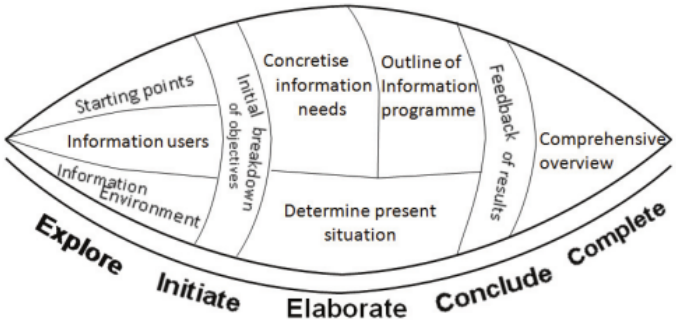

Fig. 3. Rugby ball framework for specification of information needs [8].

2.3. Survey on the stakeholders' interests

To strengthen water resources management, the capacity building is important. It will generate and analyze data, develop sustainable water management plans, use conflict resolution techniques, or encourage stakeholders participation – should target water management institutions, local non-government organizations, water users' association, and religious groups [13]. Questionnaire was distributed to the stakeholders as potential users of the information system, especially the modeling and monitoring services. Data collected by distributing the questionnaire were:

- type of information that can be contributed into the media
- kind of information needed from the media
- objective of stakeholders in publish and acquire the information
- interaction between stakeholders and communities

2.4. Linking the monitoring data

Water monitoring as in important information production process is in much of the literature on water management described as a rather technical task [8]. The design of a water quality monitoring network is considered as the main component of water quality management including selection of the water quality variables, location of sampling stations and determination of sampling frequencies [14].

Water resource development and management in large areas require an understanding on the basic hydrologic processes and simulation capabilities at the river basin scale [15]. This research attempts to integrate the monitoring data of Cikapundung River into the information system.

2.5. Obtaining the coefficient of water quality model

The deoxygenation rate range was determined using the laboratory analysis of oxygen uptake of the river water. At the Cikapundung River, the water samples were collected in 2 points, i.e. upstream and downstream. Between

upstream and downstream stations, the riverbank has very crowded illegal houses. The water samples were collected in dry season and rainy season during 2014-2015.

Laboratory analysis of DO (dissolved oxygen) concentrations were conducted according to APHA's Standard Method [16], i.e. Winkler method. The daily usage of DO, or can be indicated as BOD (biochemical oxygen demand), was measured for 10 consecutive days in order to estimate the rate of deoxygenation. A minimum of 6 observations are usually required to give consistent results [17].

Determination of the deoxygenation rate can be achieved using several methods such as Thomas' method, least square method, Fujimoto method, rapid ratio method and daily difference method. Thomas' and least square methods are the common methods in use [18]. This research uses the slope method of Thomas which gives the BOD constant via least square treatment of the basic form of the first order reaction [17].

2.6. Software development

The river water quality modeling was developed based on the potential users' interest concerning the parameter to be calculated. The software made of Delphi program. It employs mathematical equations suitable for the parameters. The most appropriate user-software interface was also being observed from the potential users.

3. Results and Discussion

3.1. Potential users and information needed

Many potential users come from the government. They are interested both the monitoring results and the usage of software. Some agencies in Bandung and West Java that are concerned to utilize the information system of Cikapundung River 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
- Researchers, lecturers, and students of the university, especially the major of Environmental Engineering, Civil Engineering, Biology, and water resources.
- Engineering consultants

Other potential users are included NGO (non-governmental organization), NPO (non-profit organization), environmentalist group, people community, and industrial/ private community.

Those potential users require various kind of information such as updated condition of Cikapundung River (physically and water quality-quantity), demography data, maps, pollution sources, events, river festivals, etc. Users who are interested in using model and monitoring data stated that their purposes are:

- To determine the policy
- To verify /confirm the pollution phenomena
- To predict the river water quality using scenarios
- To preparation of the EIA (predicted significant impacts)
- To utilize river water

Parameters required in river water quality modeling:

- BOD (biogeochemical oxygen demand)
- DO (dissolved oxygen)
- COD (chemical oxygen demand)
- Nutrients
- Heavy metals

3.2. Deoxygenation rate range and developed software

Table 1 shows the deoxygenation rate obtained from the laboratory analysis. The range of the rate is 0.010-0.370 per day. In general, the values of the rates are relatively low. It appears that the urban river character has low rates due to slow decomposition of the organic matter. The low rate of deoxygenation of the carbon indicates the low content of BOD of the river. Turbulent condition of river flow is also a factor to be considered of low value of k (deoxygenation rate) [19].

Table 1. Cikapundung River's deoxygenation rate 2012-2015 (in day^{-1})

Season	Year	Upstream	Downstream
Dry season	2012	0.016	0.0802
	2014	0.240	0.030
	2015	0.130	0.190
Rainy season	2012	0.100	0.010
	2014	0.240	0.370
	2015	0.120	0.290

3.3. Software of KUALA

To simplify the river water quality model, the interface of the software was designed similar to calculator. It was considered also based on the survey of potential users. The Fig.4 (a) and (b) show the display of the software. 'KUALA' is the software's given name. It simulates the DO and BOD concentration using the Streeter-Phelps and decomposition equations. BOD is actually not a substance, instead, it is a surrogate designed to quantify the potential of oxygen consumption by bacteria to break down organic carbon in the water and therefore is quantified using dissolved oxygen (in mg/L) as the common currency [20].

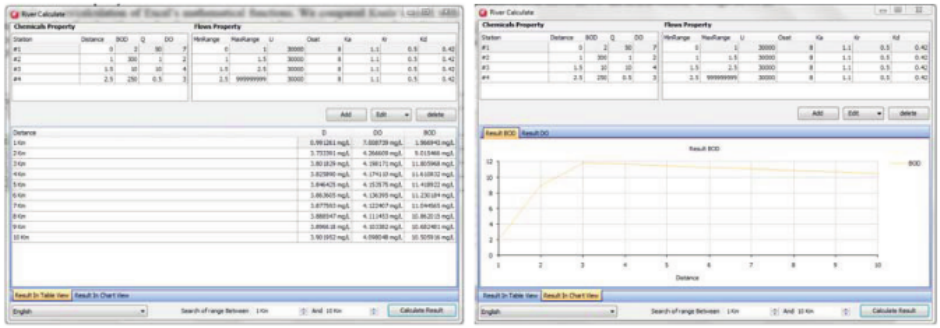

Fig.4 (a) Input data and simulation result of KUALA software, (b) calculation result in graph type.

3.4. Concept of information flow

Stakeholders of the river management come from various institutions and communities. Learning from the Cikapundung River activities, the stakeholders consist not only from the government, but also from private sectors, researchers, people communities, environmentalists, etc. These various kinds of societies can be a power to manage the river, not only its water course, but also its basin.

The Fig. 5 depicts the information flow concerning the various data, services, and application from the source to the world wide web. The monitoring data and modeling services are integrated in the system and can be used by users after screening. The screening processes are necessary to filter false information, inappropriate contents, and other unconfirmed data.

Among the stakeholders, there are people communities, NGO, NPO, who also can participate to report pollution or other law breaking activities that can contaminate the river. An increasing uptake of participatory approaches and methods has occurred not only in water management, but also in other public policy fields such as urban planning, health, and technology risk assessment [21].

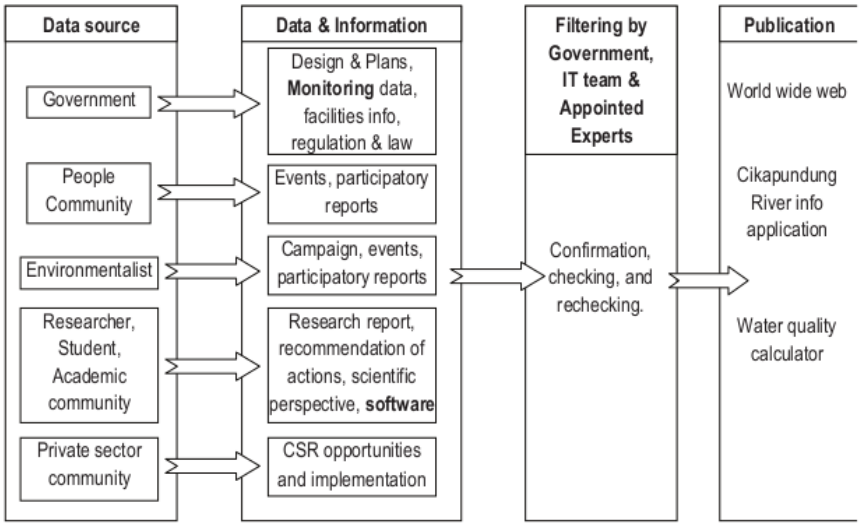

Fig.5 Concept of flow of information from the data source to the publication media.

The objectives of the stakeholders' interface were (i) to identify stakeholders' demands, (ii) to identify the needs and expectations of potential end-users with respect to research outcomes, and (iii) and to obtain feedback from the final outcomes of the integration methodology [22].

The evaluation of planning and management of protected areas has become one of the relevant and intensely debated aspects in national and international forums dealing with nature conservation and management [23]. Therefore, the interface media for stakeholders is essential.

4. Conclusion

The water quality modeling is integrated in the information system of the Cikapundung River, provided with the appropriate deoxygenation rate which is ranged between 0.010 and 0.370 day^{-1}. The model is displayed user friendly similar to scientific calculator. The monitoring data can be published also in the frame of the information system so that it will be able to be used by many stakeholders for many purposes. Not only the modeling service and monitoring data are integrated in the information system. Other data and information from communities enrich the content of this system. Data screening need to be set as one important phase in the information flow.

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References

[1] R. Jayakumar, S. Dhanakumar, K. Kalaiselvi, M. Palanivel, Water Pollution in the Vicinity of Stanley Reservoir by Point and Non-point Source, Cauvery Basin, India, Environmental Management of River Basin Ecosystem, Springer, 2015, pp.491-505

[2] M. A. Fulazzaky, Water quality evaluation system to assess the status and the suitability of the Citarum river water to different uses, Environ. Monit. Assess (2010) 168: 669-684.

[3] R. A. James, R. Purvaja, R. Ramesh, Environmental Integrity of the Tamiraparani River Basin, South India, Environmental Management of River Basin Ecosystem, Springer, 2015, pp.507-523

[4] X. Xiao, X. Jian, W. Xiongfei, H. Chengfang, C. Xuejun, W. Zhaohui, Z. Dengzhong, Evaluation Method of Water Quality for River Based on Multi-Spectral Removal Sensing Data, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-7/W3, 2015, pp. 1517-1523.

[5] M. Mair, C. Mikovits, M. Sengthaler, M. Schöpf, H. Kinzel, C. Urich, M. Kleidorfer, R. Stizenfrei, W. Rauch, The application of a Web-geographic information system for improving urban water cycle modelling, Water Science and Technology 70.11 (2014) 1838-1864.

[6] R. Bhutiani, D. R. Khanna, Ecological study of river Suswa: modeling DO and BOD, Environ Monit Assess (2007) 125: 183-195

[7] F. Dalcanale, D. Fontane, J. Csapo, A General Framework for a Collaborative Water Quality Knowledge and Information Network, Environmental Management (2011) 47:443-455.

[8] J. G. Timmerman, Information Needs for Water Management, CRC Press, New York, 2015.

[9] Water Environment Federation, Information Technology in Water and Wastewater Utilities, WEF Manual Practice No. 33, WEF Press, Alexandria, Virginia, 2010, pp.12.

[10] L. R. Radjabaycolle, Sumardjo, Partisipasi masyarakat terhadap kegiatan pengelolaan Daerah Aliran Sungai Cikapundung di kelurahan Dago Bandung, (In Indonesian) Jurnal Penyuluhan 2014, V0l. 10 No. 1, pp. 43-58.

[11] S. H. Djoeffan, D. Mukhsin, Inventarisasi Sarana dan Prasarana Permukiman di Lembah Cikapundung, (In Indonesian) Ethos, Vol. 1 No. 2, 2003, pp. 87-98.

[12] https://www.welt-atlas.de, accessed in March 2016

[13] L. S- van der Kley, L. Reijerkerk, Water a Way of Life, Sustainable Water Management in a Cultural Context. CRC Press. Pp. 107. 2009

[14] M. Karamouz, A. K. Nokhandan, R. Kerachian, C. Maksimovic, Design of on-line river water quality monitoring systems using the entropy theory: a case study, Environmental Monitoring and Assessment, 2009, 155:63

[15] J. Anushiya, A. Ramachandran, Assessment of Water Availability in Chennai Basin under Present and Future Climate Scenarios, Environmental Management of River Basin Ecosystem, Springer, 2015, pp. 397-413.

[16] American Public Health Association-APHA; American Water Works Association-AWWA; Water Environment Federation-WEF.. Standard methods for the examination of water and wastewater. 21th edition. Washington, 2005.

[17] Lin, S. D. Water and Wastewater Calculations Manual. Second edition. McGraw-Hill. (2007) Pp. 10-41

[18] Adewumi, I., Oke, I. A., Bamgboye, P. A., Determination of the Deoxygenation Rates of a Residential Institution's Wastewater. Journal of Applied Sciences 5 (1) (2005), 108-112.

[19] E. Hendriarianti, N. Kamaningroem. Deoxygenation Rate of Carbon in Upstream Brantas River in the City of Malang. Journal Appl. Environ. Biol. Sci., 5(12) 36-41, 2015

[20] C.H. Chen, W. S. Lung, S W Li, C. F. Lin. Technical challenges with BOD/ DO modeling of rivers in Taiwan. Journal of Hydro-environment Research 6 (2012) 3-8.

[21] Y. Korff, K. A. Daniell, S. Moellenkamp, P. Bots, R. M. Bijlsma. Implementing Participatory Water Management: Recent Advances in Theory, Practice, and Evaluation. Ecology and Society 17(1):30, 2012.

[22] C. Merly, A. Chapman, C. Mouvet, An End-Users Oriented Methodology for Enhanching the Integration of Knowledge on Soil-Water-Sediment Systems in River Basin Management: An Illustration from AquaTerra Project, Environmental Management (2012) 49:111-129.

[23] M. M. Santos, J. Benayas, A Proposed Methodology to Assess the Quality of Public Use Management in Protected Areas, Environmental Management (2012) 50:106-122.

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