Integration of Water Quality Components to a Watershed Runoff Model

流域流出モデルにおける水質構成要素の統合について

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Introduction The present study tries to establish a watershed water quality model by adding water quality components such as dissolution type and LQ type to a watershed runoff model. Those water quality components were simplest and broadly used for modeling water quality parameters, such as Nitrogen flow, or COD. The model is crucially important as a tool for decision maker on reducing pollutant flow in a developing watershed consisting of broad rural lands and rural villages.

Objectives of the study

- ✓ To formulate spatial variability of water quality by using land use distribution
- ✓ To develop watershed water quality models
- ✓ To test the watershed water quality model.

Study Area Cidanau watershed (221.1 km^2) is one of priority watersheds in Indonesia to be given special attention for its handling and management, because of the high population pressure, the recent economic growth, and the developments in the catchments. It is located at 6^{o}7'-6^{o}18' South and 105^{o}51'-106^{o}3' East, and surrounded by densely populated area of Banten Province, such as Cilegon Industrial Area, Anyer Beach, Serang, and Pandeglang District. Runoff discharges and daily rainfall are observed on daily basis at several points during 1995-2004 periods, though not all the points have continuous observation. Water quality samples are taken also on weekly basis at KTI Weir, and occasionally at many points in the watershed, as presented in Fig.1.

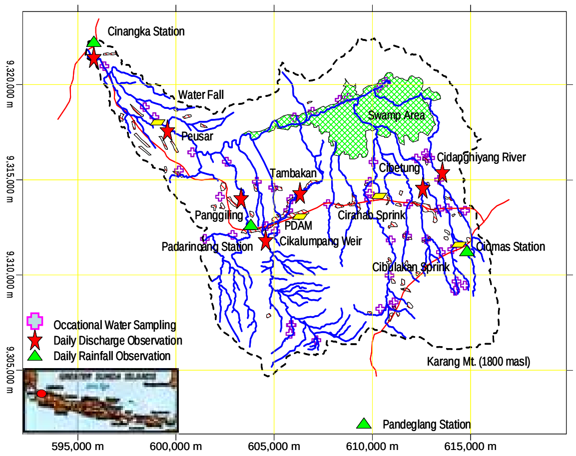

Figure 1. Cidanau Watershed

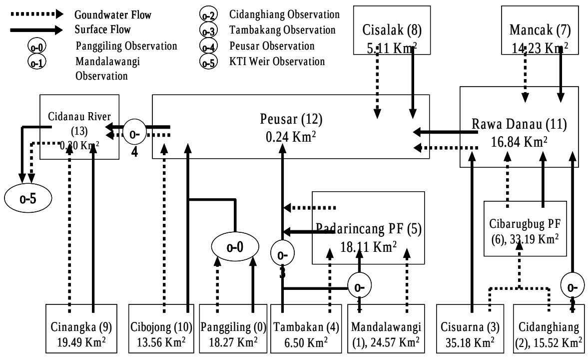

Figure 2. Water movements of each sub catchments

Methodology

Structure of watershed runoff model The watershed runoff model consists of fourteen modified tank models corresponding to the sub-catchments in Fig.2. It produces good enough model performance (Tab.1.) and reasonable groundwater daily fluctuation.

Tabel 2 Runoff Model Performances

Observation Name	ME	MRE	BE	Periods
Panggiling (o-0)	0.35	0.66	0.48	Sep 00 - Aug 01
Mandawangi (o-1)	0.54	0.24	0.04	Sep 00 - Oct 01
Cidanghiang (o-2)	0.52	0.52	0.13	Sep 99 - Aug 00
Tambakang (o-3)	0.24	0.62	0.58	Sep 00 - Oct 01
Peusar (o-4)	0.52	0.30	0.15	Aug 02 - Aug 03
KTI Weir (o-5)	0.65	0.54	-0.12	Sep 96 - Aug 04

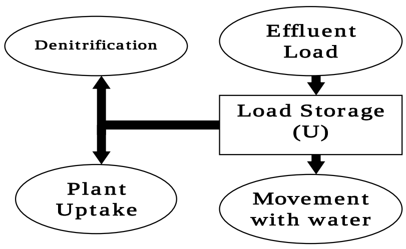

Figure 3 Nitrogen balance in the root zone

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Water Quality Processes Total Nitrogen was selected as the indicator for water pollution, considering the major land use in Cidanau Watershed. In term of Nitrogen transformation, there are several processes that involve in the nitrogen balance in the soil, namely : Denitrification (conversion of nitrate into nitrite and then into gases, N_2 and nitrogen oxides, NO_x), volatilization, and plant uptake, as presented in Fig.3. On the other hand, both of LQ-Type and Dissolution Type of water quality components (Fig.4. and Eq.1-Eq.4) were employed for replication of Nitrogen movement associated with water movement in the hydrological processes. Where, L is the load ($M \bullet L^{-2} \bullet T^{-1}$), U is load storage ($M \bullet L^{-2}$), q_f is discharge ($L \bullet T^{-1}$), C is concentration, SN is dissolved load storage ($M \bullet L^{-2}$), X is water storage (L), and α_1, β_1, α_2, β_2, γ are the calibrated parameters.

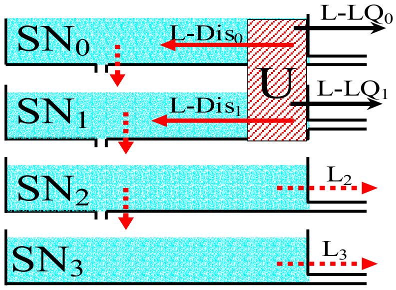

Figure 4 Water quality components

$$L_{LQ} = \alpha_1 \times U \times q_f^{\beta 1} \quad \text{.... (Eq.1)}$$

$$L_{Dis} = \alpha_2 \times U \times X^{\beta 2} / (1 + \gamma C) \quad \text{.... (Eq.2)}$$

$$C = SN / X \quad \text{.... (Eq.3)}$$

Optimization of model parameter Random search method was selected for optimizing the model parameter. Each of sub-catchment was assumed to have different set of calibrated parameters for water quality model, for replicating variability of land use in each sub-catchment.

Result and discussion The calibration process for water quality modeling only employ several points near to outlet of the sub-catchments, because the runoff is simulated on sub-catchments basis. At presents, the model performance was poor, as presented on Fig.4. The model has limitation to replicate low pollutant flow as shown in comparison between observed and calculated Total Nitrogen in Mandalawangi sub-catchments, which showed ill correspondences. The current water quality model didn't consider the temporal variability of Nitrogen balance in the root zone. Nitrogen transformation in river, the swamp, and paddy field area, whose types of land use have capabilities as water purifier, is not replicated well in the model as well. Accordingly, consideration on those factors will be good starting point to improve the model performance.

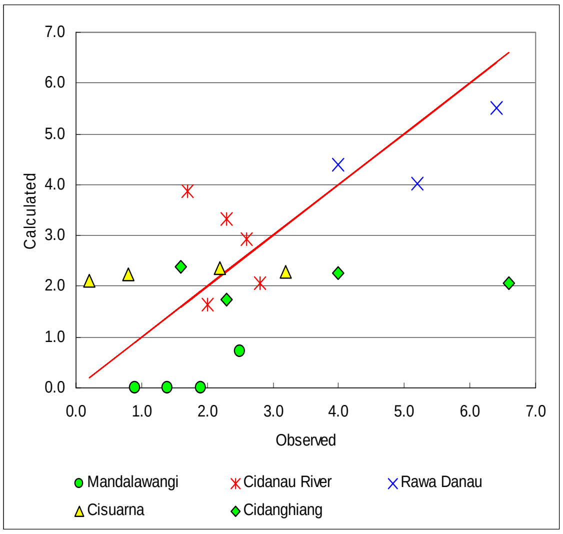

Figure 4 Comparison between observed and calculated Total Nitrogen (mg/l) in several location inside the watershed

Conclution

- ✧ Averaging land use variability inside the sub-catchments works properly on high flow pollutants. The model also can represent spatial variability of water quality in the watershed.
- ✧ It is necessary to increase the model performance and to reduce the number of calibrated parameter, in order to understand water quality processes in sub-catchments.

References

Arien Heryansyah, Akira Goto, and M Yanuar JP. 2004. Runoff Modeling as a Basis of a Water Quality Hydrological Model for Cidanau Watershed, Banten Province, Indonesia. Proceeding of 3rd Seminar : Toward Harmonization between Developments and Environmental Conservation in Biological Production. Serang, December 4-6, 2003.