Estimation of Nonpoint Source Load by Applying Watershed Model

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1. Introduction

This study estimates applicability of stormwater runoff model to the Nakdong River basin in Korea. The result showed the simulation value was nearly same as that of the measured runoff. But the continuous investigation on runoff in various rivers must be proceeded and these basic materials must be accumulated so that researchers in various fields can share them. When this national environment is made, reliable and various researcher results can be produced. When this national environment is made, reliable and various researcher results can be produced. So that estimates unit for the nonpoint source(NPS), classified according to the existing Level-1(large scale) land cover map, by monitoring the measurement results from each Level-2(medium scale) land cover map, and verifies the applicability by comparison with previously calculated units using the Level-1 land cover map. The NPS pollutant loading for a basin is evaluated by applying the NPS pollutant unit to Dongcheon basin using the Level-2 land cover map. In addition, the BASINS/HSPF(Better Assessment Science Integrating point & Non-point Sources/ Hydrological Simulation Program-Fortran) model is used to evaluate the reliability of the NPS pollutant loading computation by comparing the loading during precipitation of the Dongcheon basin in Korea. When comparing the unit estimated using the Level-2 land cover map with previously reported units based on the Level-1 land cover map, the estimated unit is within the range of the units reported by other researchers, yet there is a large difference in the values for each NPS pollutant.

2. Method

The subdivided land cover according to the Level-2 land cover map (i.e. Level-2 land cover classification: orchards, subdivided land cover: vineries, pear orchards, apple orchards, etc.) was determined and precipitation-specific monitoring conducted in each area. To monitor the precipitation and amount of discharge, a rain-intensity gauge and flowmeter were installed at the survey points. The monitoring continued from the start of precipitation to the end of discharge. The rain-intensity gauge used for the field surveys was an RG-20 from Environdata Environmental Monitoring & Management, Australia that uses a Tipping Bucket Mechanism to measure the precipitation at 1-minute intervals. Meanwhile, the amount of discharge was measured using a Flo-Tote3 from McBIRNEY, U.S. that uses an electromagnetic area/velocity flowmeter sensor and performs measurements at 1-minute intervals. The discharge measurement device was installed at the final outlet of the survey point and an initial measurement conducted when there was no external inflow of precipitation discharge. The sample collection and analysis followed the National Institute of Environmental Research revised 'Measurement Method of Precipitation Efflux' and 'Official Test Method on Water Pollution'. When a field survey for precipitation could not be conducted, data from the nearest meteorological observatory was employed. For the Level-2 land cover map, the industry, transfer, orchard, plastic-house, and other farm field areas were monitored from 2008 to 2010, while data from 'Major NPS Discharge Long-term Monitoring' from a preliminary environment research project was used for other Level-2 land cover map.

2.1. Computation of basic unit for NPS

Essentially, the basic unit for NPS refers to the amount of pollutants discharged from a unit land area per unit time. This unit is normally expressed as the NPS load (kg or tons)/area (ha or km^2)/time(year or day). Despite on going controversy, the land-cover-specific basic unit for NPS is commonly used due to ease of application and existing data. The NPS model uses a land-cover-specific basic unit equation that includes land-cover, soil characteristics, and hydraulic and hydrologic factors. Plus, the computation method uses an empirical formula, while the field survey method actually measures the flow and pollution loads in a basin for the basic unit computation.

Table 1. Summary of analysis items and description

Items	Description	Unit
Precipitation	Total precipitation	㎜
Discharge	Total discharge	㎥/sec
Origin load	Total amount of water pollutant	kg/day
Discharge load	Calculated by manual of TMDL	kg/day
Delivery load	Total amount of water pollutant in stream(river)	kg/day

3. Results

3.1. Basic unit computation using Level-2 land cover map

The basic unit for NPS using the Level-2 land cover map is shown in Table 2. The basic unit for NPS from previous studies showed large gaps between the minimum and maximum, and included large errors due to user misjudgment. Plus, the previously calculated basic units for NPS were computed using 5~6 Level-1 land cover map. As a result, it was difficult to apply such previous results to the current subdivided land cover map. Notwithstanding, the basic unit for NPS used in this study was included within the value range from previous studies yet lower than the Level-1 value. Furthermore, the basic unit for NPS used for previous land load computations only utilized precipitation periods with discharge, whereas this study also included precipitation periods without discharge in the basic unit for NPS computation, where the NPS EMCs for the precipitation periods without discharge were assumed to be '0'. Thus, due to this difference, the basic unit for NPS had a lower value than the previously reported Level-1 value.

3.2. Validation assessment of simulation results

To assess suitability of the simulation results, a scatter diagram analysis of the measurement and simulation results was processed. To interpret the calibration/validation of the simulation results, the Nash-Sutcliffe coefficient was applied to understand the degree of prediction of the model. The Nash-Sutcliffe coefficient exists between -∞ and 1. Normally, the Nash-Sutcliffe coefficient is used to quantitatively explain the accuracy of a model as long as there is a comparable measurement. If the coefficient is higher than 0.75, the simulation is considered accurate, whereas if the coefficient is between 0.75 and 0.36, the simulation needs to be complemented.

Table 2. Basic unit for NPS comparison for Level-2 land cover map (Unit : kg/ km2•day)

Land coverage		BOD			T-N			T-P		
Lvel-1 Classification	Level-2 Classification	Level -2 Class.	Lvel-1 Class.	Ref.	Level -2 Class.	Lvel-1 Class.	Ref.	Level -2 Class.	Lvel-1 Class.	Ref.
	Residential	7.48			8.97			0.48		
	Industrial	25.03			5.70			0.46		
	Commercial	41.21			5.36			0.55		
Sites	Recreational	19.59	85.90	9.16 ~ 106.03	7.80	13.69	0.86 ~ 2520.0	0.84	2.10	0.19 ~ 448.0
	Traffic	11.53			4.08			0.30		
	Public	7.72			4.84			0.35		
Paddies	Rice paddies	6.14	2.30	1.51 ~ 10.96	3.59	6.56	0.08 ~ 13.70	0.50	0.61	0.03 ~ 4.49

Farm Fields	Farm fields	3.41	1.59	1.8 ~ 9.28	0.92	9.44	1.81 ~ 7.17	0.53	0.24	0.08 ~ 1.09
	Mountainous fields	24.07			3.21			4.16		
	Plastic Houses	23.79			8.02			3.72		
	Orchards	1.73			0.82			0.17		
	Other	0.37			1.04			0.17		
Woods and Fields	Forest	0.79	0.93	0.70 ~ 11.65	1.32	2.20	0.30 ~ 7.46	0.03	0.14	0.01 ~ 0.25
Other	Golf	3.35	0.96	0.82 ~ 560.82	4.04	0.76	0.44 ~ 6.48	0.92	0.03	0.03 ~ 0.30
	Other Grassland	1.02			0.59			0.12		
	Mining	24.67			4.16			0.97		

Plus, for the water quality section, the coefficients for the BOD, T-N, and T-P were 0.82, 0.85, and 0.79 respectively, also representing a high suitability. The data used for the calibration, validation, and suitability assessment of the HSPF model was measured between April and July, which is the rainy season. Therefore, the measured flow was higher than usual due to the influence of precipitation. Thus, it would be hard to apply the developed model to the dry season in spring or winter.

The Dongcheon is a tributary of the Byungseongcheon and usually has a small flow. Since Korea has no precipitation in fall and winter, the flow is 1.5~2.0 times lower than usual, resulting in a quite different characteristic compared to that for the rainy season. When the flow is lower than usual, the delivery load is significantly affected by the concentration of inflow matter. Thus, if such results were applied to the model, they would show a far different suitability compared to the results of the present study. Consequently, for a higher reliability of the NPS load computation during precipitation, periodical field surveys need to be conducted to represent the seasonal variation and the model then calibrated/validated based on the results.

3.3. NPS delivery load assessment

The applicability of the NPS load computation using the basin model was analyzed based on comparison. Furthermore, the application of the land cover map subdivision method was assessed for the basin NPS load computation.

According to the delivery load in the Dongcheon basin shown in Table 3, NPS load was influenced by flow variation. Flow variation was changed by permeability of land cover map in basin. Therefore, reliability of NPS load was riding on the sub specialized land cover map. And the basin model simulation had higher values than the basic unit application method.

This was because the model values tended to be higher than the measurement values. However, when applying the basic unit load computation to the delivery load, there was a periodical difference with the basin model values, as the input was based on 2009 National Pollutant Source Data. Therefore, instead of applying the pollutant discharge load data for the simulation period, data from the previous year was applied. When comparing the two results, there was a definite value difference based on the case computation method, yet the correlation between the simulation and the measurement was higher than 0.9, except for Case 4, indicating an identical occurrence tendency. Thus, if the basin model with proper parameters were applied to the NPS load and a deliberate calibration/validation conducted for various measurements, a high level of applicability and highly reliable results could be derived.

Table 3. Comparison of NPS delivery load

Computation method	Item	Case 1	Case 2	Case 3	Case 4
Level-2 Classification unit	BOD	9.44	14.71	212.28	6.33
	T-N	13.91	18.43	13.31	9.84
	T-P	0.53	0.78	20.59	0.40
Basin model	BOD	47.31	85.08	26641.20	129.50
	T-N	72.79	91.10	15028.10	1205.90
	T-P	1.97	2.85	1682.50	34.60

4. Conclusion

Instead of using the existing Level-1 land cover map, this study computed the basic unit for NPS when classifying the land coverage based on Level-2 land cover map field monitoring. The computed basic unit was applied to the Dongcheon basin to compute the basin NPS load. In addition, the basin models BASINS and HSPF were utilized to determine the NPS load for an identical basin, and the two results compared to assess the validity.

1) When using discharged water monitoring data, the basic unit for NPS using Level-2 land cover map was computed. The computed basic units were within the numerical value range of previous studies, yet slightly smaller than the water pollution total amount thresholds. Furthermore, the basic unit values for the Level-2 classifications in the Level-1 classification varied from each other, indicating the need for subdivision of the land cover map.
2) The basic unit using Level-2 land cover map applied NPS load was compared with the NPS load computed using the BASINS/HSPF models. The basic unit application had a

higher value than the basin model simulation. According to the correlations between the cases of simulation and measurements, all the cases showed a fixed occurrence tendency of 0.9, except for Case 4.