Assessment for the contributions of urban and forest non-point sources in river water quality – Case Study

Edangodage Duminda Pradeep Perera[1], Yoichi Iwami[2], Yoji Chida[3]

1. International Centre for water hazard and risk management (ICHARM) under the auspices of UNESCO, Public Works Research Institute, Tsukuba, Ibaraki, Japan
E-mail: perera55@pwri.go.jp
2. International Centre for water hazard and risk management (ICHARM) under the auspices of UNESCO, Public Works Research Institute, Tsukuba, Ibaraki, Japan
E-mail: y-iwami@pwri.go.jp
3. International Centre for water hazard and risk management (ICHARM) under the auspices of UNESCO, Public Works Research Institute, Tsukuba, Ibaraki, Japan
E-mail: chida@pwri.go.jp

Abstract. Impacts on river basin environment due to alterations in water and material cycles have been concerning recently, due to those impacts, are serious water quality points of view, and especially where the water quality in the basins is at or above the threshold of contamination. Land use changes due to urbanization and intensive agricultural activities significantly impact the water quality of river basins. Point Source (PS) and Non-Point Source (NPS) pollution in river basins should be controlled to maintain the river water quality standards. Recently in many watersheds PS pollution has been managed, however, still NPS pollution is a challenging task for the river basin managers. At this end ICHARM has been developing a basin scale hydrological and material (nitrate, phosphate and suspended solid) circulation model updating the already existing WEP (Water and Energy Process) model which was previously developed by PWRI. This study focuses on NPS pollution loading by urban and forests in two sub-basins of the Takasaki river basin which is a tributary to the Inba-numa Lake in Chiba prefecture, Japan.

Keywords: WEP model, non-point sources, urban areas, forest areas, nitrogen, phosphorus.

1. INTRODUCTION

Excessive loading of pollution into rivers, lakes, reservoirs and estuaries is now becoming a major concern in water quality management, especially where Non-Point Source (NPS) nutrients, N and P (nitrate and phosphate) loadings are dominant. The latest technology and best management practices are able to control point source (PS) pollutions to a satisfactory level; although the controlling of NPS pollution is still challenging. NPS, that is driven by multiple factors and includes diffuse pollution, is exclusively a result of land use changes (Novotny, 1999). Agriculture, urban areas, and forests have been identified as the main cause of NPS pollutant sources in the present study. In this study we tried to utilize the WEP (Water and Energy Processes) model capabilities to study the impacts of forests and urban areas as NPS. The process based WEP hydrologic model was initially developed at Public Works Research Institute in Japan as a tool for analysis of water and energy budgets at catchment scale (Jia et al, 2005), and was later enhanced by incorporating N and P components (Kikuchi et al, 2005) and suspended solid components (Rajapaksha et al, 2009). The present study elaborates the application of the improved WEP model to the Takasaki River basin, Japan (85.6 km^2) to obtained model responses to the NPS nutrient loads.

2. METHODOLOGY

The calibration of the model for its hydrological and nutrient loadings were conducted for 2005 and discussed by Perera et al, 2014. The calibrated model was applied for the selected sub-basins in the Takasaki River to study the impacts of agriculture, urban and forest land uses as NPS. Sub basins were selected according to their representation in each basin as shown in Table 1. NPS contributions are significant during rainfall events. Therefore, the calibrated model was applied to check its performances during a rainfall event in 2014 October where the water quality samplings were collected.

Table 1. Existing land uses at the study area

	Land use type	Total Basin (%)	Basin-A (%)	Basin-B (%)
1	Forest	22.7	**13.9**	**29.1**
2	Rice field	9.1	1.4	1.6
3	Upland farm	33.4	3.4	7.5
4	Building lots	14.7	21.5	7.1
5	Urban area	6.6	**40.8**	**34**
6	Roads	7.9	12.1	10.8
7	Parks	4.9	5.8	7.5
8	Water bodies	0.8	1	2.4
		100	100	100

Figure 1. Selected sub-basins where forests and urban areas are dominant in the Takasaki River basin

3. RESULTS AND DISCUSSIONS

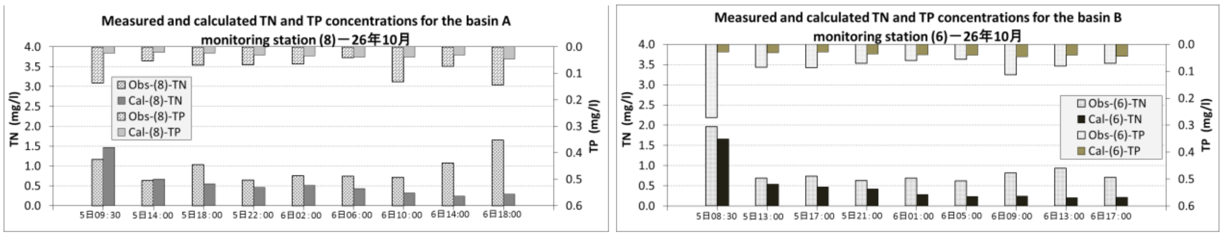

Figure 2 Comparison of simulated and observed results for 2013 October rainfall event

Figure 2 illustrates the comparisons of simulated and observed total nitrate (TN) and total phosphorous (TP) for a rainfall event. The obtained simulation results for the selected sub-basins show a significant underestimation compared to the observed results. In the model set up, the initial distribution of nutrients were considered uniform rate within the whole basin for each NPS. The model calibration was carried out for the Takasaki River outlet and not for the sub-basin outlets as shown in **Figure 1**. Those factors could be the reason for the underestimations shown in the numerical results so far. According to the results, it implies that an in-detail study should be considered to find out actual loadings from each NPS in different areas considered in the model domain with this kind of detailed study in a small basin.

4. CONCLUSIONS

The developed model for NPS nutrient loadings produces useful information for river water quality management. However, to obtain more accurate outputs from the model, further studies should be carried out in field data collection for nutrient loadings for different sources and model tuning.

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