Ⅱ－24 Catchment-based Assessment of Nonpoint Source Pollution in the Kamafusa Lake Area

Tohoku University Student member Baolin SU
Tohoku University Member So KAZAMA
Tohoku University Fellow Masaki SAWAMOTO

1. Introduction

The Non-Point Source(NPS) pollutants of a catchment are considered most possibly originated from the area near to the stream networks, because the most of agricultural lands like paddy field and cropland are usually distributed on such area. In the Kamafusa Lake catchment, the forest (82%) is located mainly in the upper part of the catchment, and on the contrary, most of agricultural land (11%) and urban area (2%) are located on lower part of the catchment. In this study, a method called buffer analysis is used to assess which area (lower or upper part) is most possibly area contributing the NPS loads.

2. Methods

The concept of buffer analysis is come from geographic information system(GIS), which is usually used to analyze the influencing or relevant scope from specific geographic feature, such as line or point features on a map. This study tries to use buffer analysis technique to find where is the most possibly place which NPS loads originate from.

Four kinds of NPS pollutants are adopted in this study. They are: 1) chemical oxygen demmand (COD), 2) suspended solid (SS), 3) total nitrogen (TN) and total phosphorus (TP), and 4) Escherichia Coliform (E.Coli), which used to represent the NPS pollution level of organic matters, sediments, nutrients and pathogens respectively. Their annual loads are calculated by multiplying annual runoff and average pollutant concentration.

The buffer area data of three sub-catchments used in the following analyses is obtained by using of GIS software. Through GIS software, we select the stream networks as the object of buffer area generation, and use different buffer radius from 20 to 700 meters(Figure 1). Then the correlation between NPS loads in sub-catchment and buffer area is calculated based on linear regression.

3. Results and Discussions

(1) Correlation of NPS loads and buffer area of whole catchment

Focusing on the whole sub-catchment and not considering the upper or lower part of sub-catchment, the correlations of NPS loads and buffer area among three sub-catchment are studied. Figure 2 shows the correlation variation with the buffer radius. The results show that the R-squared values decrease with increasing the buffer area (buffer radius) for all NPS pullutants. This means that the correlation of NPS loads with buffer area decreases as increasing the buffer area of whole sub-catchment. Figure 2 also shows that there is relatively higher correlation to load of COD, SS and TP than that of TN and E.Coli.

The correlation of E.Coli load is very low. In other words, there is no correlation between E.Coli load and buffer area changes from the view of whole sub-catchment. This is reasonable because E.Coli load is only generated from urban and agricultural area where are affected greatly by human activities, such as waste discharge and manure utilization. Based this point and Figure 2, we can deduce that the TN load is mainly generated from agricultural area and urban area (lower part of the catchment).

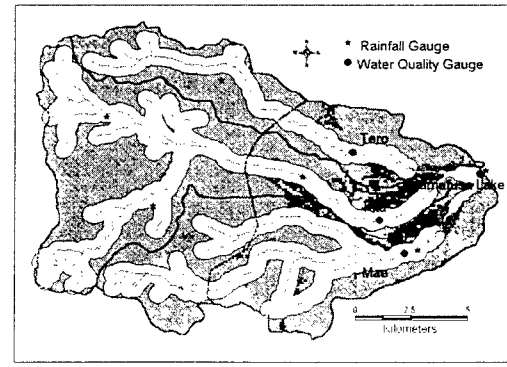

Figure 1 Buffer area (Radius=400meters)

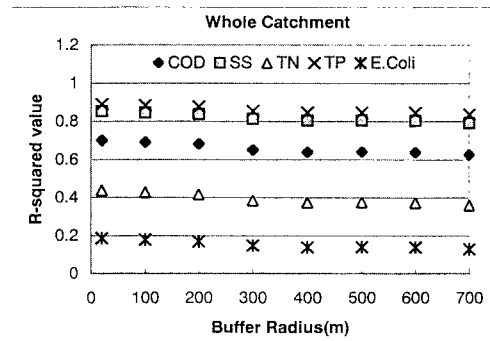

Figure 2 Correlation of NPS loads versus buffer area in whole sub-catchment

(2) Correlation of NPS loads with buffer area of agricultural and forest

By dividing the each sub-catchment into two main parts-agricultural area (lower part) and forest area (upper part) according to the distribution of main land use type, the correlations of NPS loads with buffer area of agricultural area and forest area can be studied. The results are shown in Figures 3 and 4 respectively.

Figure 3 shows the R-squared values of pollutants TN and E.Coli increase largely when focusing only on buffer area of agricultural area (lower part of each sub-catchment). This testifies the previous deduction that TN load is mainly come from lower part of the each sub-catchment.

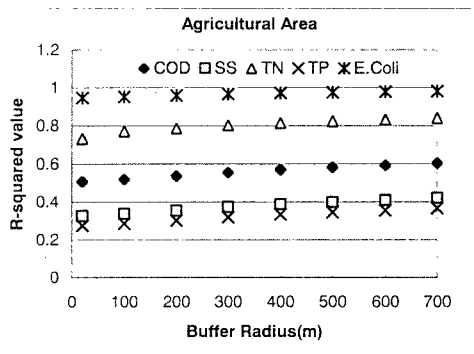

Figure 3 Correlation of NPS loads versus buffer area in agricultural area

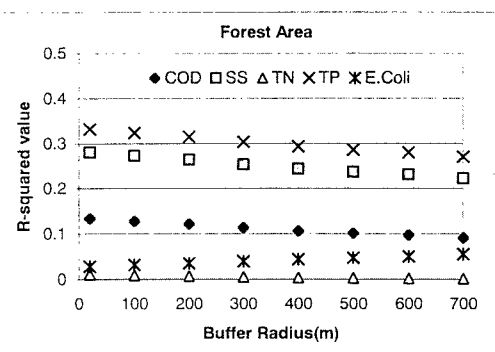

Figure 4 Correlation of NPS loads versus buffer area in forest area

Figure 3 shows the converse results compared with the results in Figure 2. That is, the correlations of all selected NPS pollutants increase with increasing the buffer area of agricultural area. And Figure 4 shows that there are no good correlations of NPS loads of COD, SS, TN, TP and E.Coli with buffer area in forest area. These mean the agricultural area (including small part of urban area) is more important than forest area in contribution to the NPS loads of each sub-catchment and whole catchment.

The correlation of SS load is high when focusing on whole sub-catchment, and the correlation decreases a lot when focusing on agricultural area only. The correlation of SS remains at the same level between Figures 3 and 4 (R-squared values are in range from 0.2 to 0.4). This shows that SS load should be related to both agricultural area and forest area.

The correlation of TP load follows almost the same variation rule as SS load. This shows both upper and lower part of catchment area contribute the TP load. And the same variation rule between SS and TP load testifies the some reported results that TP load has high correlation with SS load.

As shown in Figures 2, 3 and 4, the correlations of COD load maintain at 0.6-0.7, 0.5-0.6 and 0.1 level when considering buffer area of whole sub-catchment, agricultural area and forest area, respectively. It can be concluded that both upper (forest area) and lower (agricultural area) part of the catchment are important to COD load, but the lower part seems contributing more COD load than upper part.

4. Summary

Buffer analysis concept and technique are introduced into the delimitation analysis of NPS pollution. The following findings can be derived:

(1) The agricultural area is most important to the NPS loads;

(2) The annual TN load is mainly come from the lower part of catchment;

(3) The annual COD load is come from both upper and lower part of catchment, but the lower part seems contributing more COD load than upper part;

(4) The annual SS load and TP load follow almost the same variation rule, and the results show high correlation between them; and their loads are originated from both upper and lower part of catchment.

References

1. Atsushi Ichiki and Kiyoshi Yamada, Study on characteristics of pollutant runoff into Lake Biwa, Japan. Wat. Sci. Tech. Vol.39, No.12, pp17-25, 1999
2. Osami Kawara, Katsuya Hirayma and Takao Kunimatsu, A study on pollutant loads from the forest and rice paddy fields, Wat. Sci. Tech. Vol.33, No.4-5, pp159-165, 1996
3. Osami Kawara, Manabu Uehara and Kanako Ibaragi, A study on the water quality of runoff from forest, Wat. Sci. Tech. Vol.39, No.12, pp93-98, 1999