Evaluation of Best Management Practices in An Agricultural Watershed

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Abstract: The effectiveness of best management practices in improving quality of runoff from agricultural land areas has been reported, based primarily on results from plot- and field-scale studies. There is limited information available at watershed scales, particularly with dominant agricultural land use. The objective of this study was to determine whether a program of Best Management Practice (BMP) implementation in an agricultural watershed of northwestern Kangwon Province was effective in reducing storm streamflow concentrations of total phosphorus (TP) and total suspended solids (TSS). Furthermore, we determined the removal efficiency for three proposed BMPs (a sand settling basin, debris barriers, and crop manipulation). Water quality of the small stream in the watershed was monitored from May 2009 to November 2010. The settling basin showed 80% removal efficiency of TSS. But there was no removal efficiency of TSS with debris barriers. The export coefficient from peach orchards was very low compared with other crops. Significant decreases (20 times and 8 times, respectively) in the event mean concentrations (EMC) of TP and TSS were found in 2010 when the BMPs were implemented. Nevertheless, we are not able to conclude whether the decreases in TP and TSS are attributed directly to BMP implementation, since the rain intensity was not the same in 2009 and 2010. Further study is required.

Keywords: *Best management practices, water quality, nonpoint source pollution, event mean concentration*

1. Introduction

Non-point source (NPS) pollution results from various land use practices such as agriculture, construction and waste disposal, urban development and so on (Aabha, 2006). Agricultural non-point source (AGNPS) in particular is a major cause of water quality impairment (Brian, 2008). Runoff from nonpoint sources is considered a serious water quality problem and thus, NPS or diffuse pollution has become an increasingly critical environmental concern. Accurate NPS evaluation can lead to improvement of water quality and watershed management. The use of BMPs can control NPS pollution to meet water quality criteria without disturbing environmental quality (Alder et all., 1993, Novotny and Olem, 1994).

The environmental problem of NPS pollution is a serious issue for watershed management in Korea. The ministry of environment (ME) determined that NPS in Korea accounts for 50% of total pollution in 2007 and expects that it will reach 70% by 2015 based on biochemical oxygen demand (BOD). To decrease NPS, the ME has established a master plan and implemented BMPs within a special NPS management area (ME, 2007).

BMPs have been used for control of pollutants from diffuse sources into receiving waters (Line et al., 1994, 1999; Spooner et al., 1992). But it is difficult to select an appropriate BMP for a particular condition because the extent of pollution is related to uncontrollable climatic events, as well as site-specific conditions such as soil, topography, and land use (Novotny and Olem, 1994). Accurate evaluation of NPS loads is needed to establish BMPs for a watershed.

In this study, we determined the effectiveness of three BMPs which were applied to a small agricultural watershed and assessed whether the BMPs supported to a reduction of NPS.

2. Materials and Methods

2.1 Site Description

The study watershed lies between the latitude 38° 13' to 38° 20' N and longitude 128° 5' to 128°11' E. The main stream is a tributary of the Mandae Stream which is located on the upper Lake Soyang. The slope of the terrain in the basin ranges from 2% to 45%, with the averaged slope being 15%. The watershed has a drainage area 463 ha. The land use in the Naedong basin is 58% forest, 7% paddy, 35% upland. Nine BMPs were constructed in 2009 within the watershed in 2009.

Three BMPs (sand basin, debris barrier, crop change) were selected to determine effectiveness. The sand basin was constructed in September 2009, and the debris barrier in May 2010. In case of crop change, we selected orchards which were cultivated with peach for greater than 5 years (Figure 1).

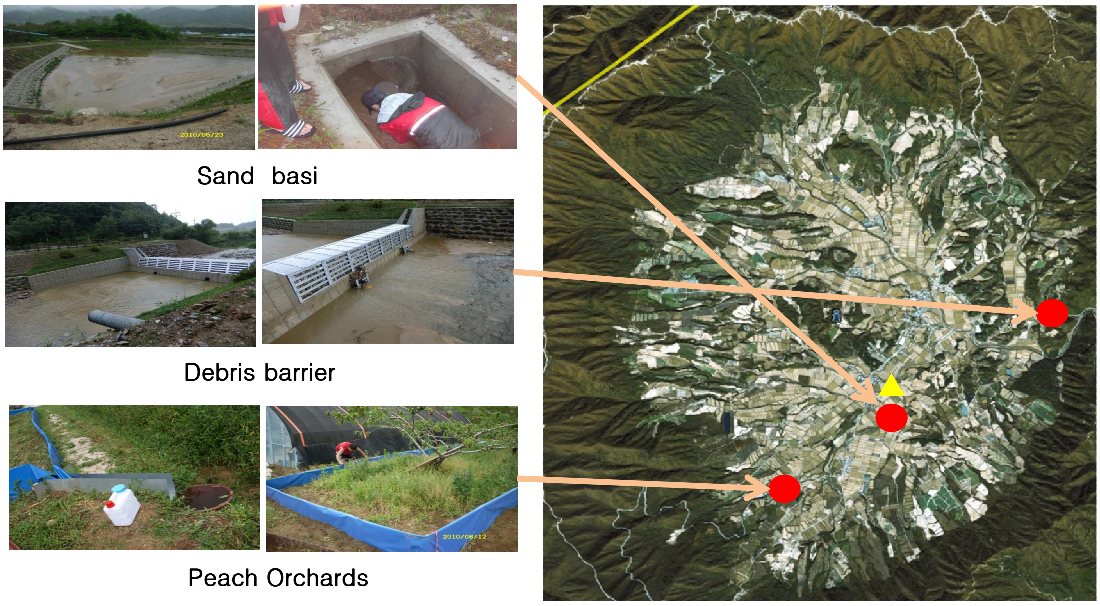

Figure1. Map showing the study sites

2.2 Field Sampling and Analytical Methods

To compare the EMC before and after application of BMPs, water samples were collected from outlet of Naedong Stream every two or three hours during storm event. For the determination of effectiveness of BMPs, water samples were collected in the inlet and outlet of sand basin and debris barrier. A small fence was installed in the orchard to determine discharge of pollutant. Water samples were analyzed according to APHA (1998).

2.3 Event Mean Concentration (EMC)

EMC is a simple method to estimate storm water pollutant loads used by the USEPA Nationwide Urban Runoff Program (1983). Storm water pollutant loadings are based on pollutant loading factors that vary by land use and imperviousness (Wayne County, 1998). Many researches evaluate BMP effectiveness based on event mean concentrations.

An EMC for a single storm event is the total storm load divided by the total runoff volume, although EMC estimates are usually obtained from a flow-weighted composite of samples collected during a storm event.

EMC = Mass of pollutant contained in the runoff event/Total volume of flow in the event

$M/V = \Sigma QtCt/\Sigma Qt$

Where Qt, time variable flow (m^3/time); Ct, time variable concentration

3. Results and Discussion

3.1 Removal Efficiency of BMPs

Averaged removal efficiency of TSS by the sand basin was about 80%. Even though the rain intensity was different in each storm event, there was no difference in the removal efficiency (Table 1). The debris barrier showed no removal of TSS during the three storm events monitored. It is considered that the debris barrier containing volume was not enough to contain the storm water (Figure 2). There was no discharge in events 1 and 2 which had a rainfall less than 40 mm. The export coefficient from the peach orchard was 16.6 kg/ha/yr which is a very low value compared with other crops. (Table 2). The crop change showed the highest TSS removal efficiency among the three BMPs.

Table1. The removal efficiency of TSS by sand basin during the storm events.

Eve nt	Rain intensity (mm/hr)	Input SS (kg/event)	Output SS (kg/event)	Removal efficiency (%)
1	5.5	13,265	2,483	81.3
2	3.0	625	140	77.6
3	2.2	100,136	18,861	81.2
Ave.	3.6	38,009	7,161	80.0

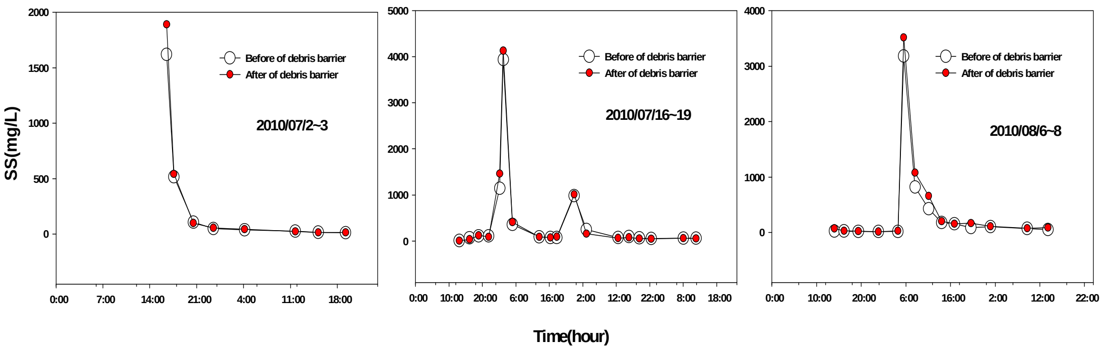

Figure 2. The removal efficiency of TSS by debris barrier during storm events

Table 3. Export coefficent of TSS in the peach orchard during storm events

Crop	Export coefficient of TSS (ka/ha/yr)	Reference
Peach	16.6	This study
Forest	250.00	USEPA, 1976
Wheat	1,440	Lamey et al. 1995
Wheat	1,900	Pennock &de Jong, 1990

3.2 Evaluation of Watershed Applied BMPs

The effectiveness of applying BMPs to the watershed was evaluated by comparing EMCs for TP and TSS in 2009 and 2010. The EMCs for TSS and TP were about 20 times and 8 times higher, respectively, in 2009 than in 2010 (Figure 3). However, it is questionable whether this decrease can be attributed to the BMPs because the rainfall intensity was very different in 2009 and 2010 (Figure 4). Therefore, the evaluation of effectiveness could not be conducted for the watershed.

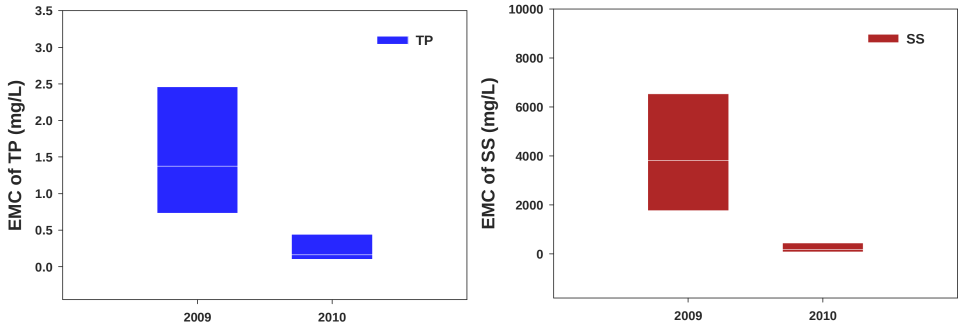

Figure 3.Yearly comparison of EMC of TP and SS in the Naedong Naedong stream

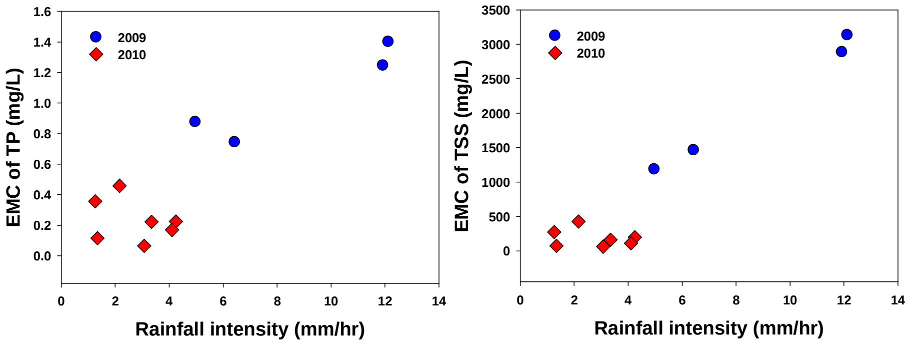

Figure 4. Comparison of EMC of TP and SS in the Naedong stream according to rainfall intensity

4. Conclusions

This study quantified the efficiency of three BMPs and the overall efficiency of nine BMPs within a small watershed. The sand basin showed 80% removal efficiency of TSS. There was no removal of TSS in the debris barrier. The export coefficient from the peach orchard was a 16.6 kg/ha/yr which is very low compared with other crops. The EMCs for TP and TSS in 2010 were lower than in 2009. However, because the rainfall intensity was not similar in 2009 and 2010, the effectiveness of the BMPs for the watershed could not be evaluated. Additional storm event monitoring is required for a BMP effectiveness evaluation.

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