# Runoff Characteristics of Non-Point Source Pollutants (NPS) from Vinyl House Area

**S.H.Choi, S.M.Lee, K.H.Kwon, S.W.Kim, K.S.Min**
*Department of Environmental Engineering, Kyungpook National University, Daegu, Korea*

**Abstract:** Unlike point source pollutants, non-point source pollutants (NPS) are discharged by rainfall. Because of seasonal and regional reason, it is very difficult to manage quantity of pollutants. Also runoff of non-point source pollutants is influenced by geological conditions, land use. Specially, non-point source pollutants of agriculture are difficult to understand characteristics of runoff and discharge irregular. Pollutant from agriculture area is a primary reason of polluting rivers and underground water. Because there isn't a facility that dealing with pollutants from agriculture area. That's why river pollution is increased. It is important to manage non-point source pollutants from agriculture area. According to type of corps, land use and cultivation method differ in agriculture area. So runoff characteristics of non-point source pollutants are different each other. Because of Basin area of the house area is covered with vinyl, rainfall runoff occurred quickly. Therefore it is important to consider runoff duration, runoff rate, runoff characteristics for monitoring vinyl house.

**Keywords:** Non-Point Source Pollutants(NPS), EMCs, Vinyl house area.

## 1. Introduction

Non-Point source pollutants (NPS) are transported by runoff from both urban and agricultural lands in the most significant source of water quality problems in the United States. Agricultural sources are responsible for impairment of more than one half of the rivers and lakes in the United States.

Non-point source pollutants (NPS) such as sediment, nutrients, pesticides and fertilizers are transported across the land surface by runoff and through the soil by percolation water. NPS is affected by site specific land characteristics such as soil type, land management and topography. Climatic factors such as rainfall intensity, event duration, and time since antecedent rainfall event/dry days are also important.

Non-point source pollutants are discharged from unspecific sites unlike cities, roads, farmland, mountains and construction sites. Therefore, in order to manage non-point source pollutants, understanding runoff characteristics of non-point source pollutants and applying the appropriate reduction facility are needed.

The study was initiated to investigate the characteristics of the NPS pollutants loads during runoff events, estimate the event mean concentrations (EMCs) of runoff flows from vinyl covered green house area through intensive monitoring and analyze relationships between EMCs and runoff flow characteristics.

## 2. Methodology

### 2.1. Monitoring sites and method

In order to evaluate runoff characteristics of non-point source pollutants from vinyl house, monitoring was executed about runoff rainfall from 2008 through 2009.

Total two monitoring sites were selected to collect runoff data from vinyl house area. They are located in Yongam-myeon, Seongju-gun, Gyengbuk, and Geungang-dong, Dong-gu, Deagu, Korea. The area of the two monitoring sites is respectively 2670 $m^3$, 4029 $m^{3.}$

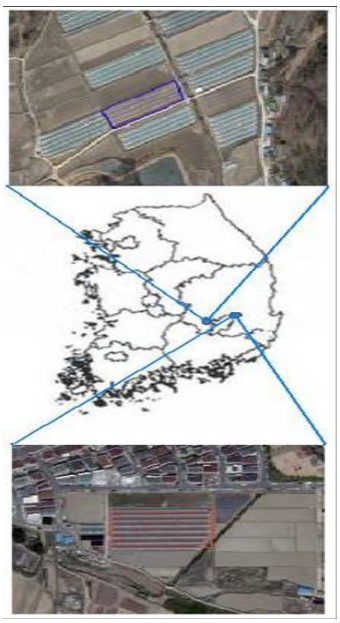


**Figure 1. Monitoring locations.**

Monitoring data were analyzed to describe NPS discharge characteristic including event mean concen- trations (EMCs), runoff rate, and suspended solids(SS), organic variables(BOD, COD), organic and inorganic

nutrients(T-N, $NH_4$-N, $NO_3$-N, T-P, $PO_4$-P) were analyzed according to the Standard Methods(1998).
The sampling interval was started at the time of the start of the First-flush Runoff. After rain ended, sampling was conducted until runoff was completely finished.
According to using characteristics of land, runoff of non-point source pollutants is various. Also it is influenced by rainfall intensity and geological features. In order to understand characteristics of non-point source pollutants, condition of rainfall, rainfall duration, pollutants of rainfall was considered too. Fig 1 shows two monitoring sites.

### 2.2. EMCs and Calculating Pollutant Mass Loadings

The pollutants which flow out rainy season differ from loads. So we have to measure concentration of pollutants in time interval which is fixed. But runoff and concentration of non-point source pollutant changes at real time, representing the specific rainfall with arithmetic average is difficult. So to measure load of pollutant in rainfall, Event mean concentration (EMC) is used. EMC is calculated by equation (1).
Where, EMC: event means concentrations (mg/L)
C(t): sample concentration when time is t (mg/L)
Qtru(t): sample volume of collected in time t (L)

$$EMC(mg/L) = \frac{Discharged\ mass\ during\ on\ event}{Discharged\ volume} = \frac{\int_0^T C(t) \cdot Q_{TRu}(t)dt}{\int_0^T Q_{TRu}(t)dt} \quad (1)$$

Equation (2) is loads of pollutant about land use per unit area. this equation is calculated And calculated loads of pollutant becomes the data which is important to estimate affects in water system

$$Pollutant\ loading\ per\ watershed\ area(g/m^2) = \frac{EMC(g/L) \times Q(m^3)}{Area(m^2)} \quad (2)$$

## 3. Results and Discussion

### 3.1. Analysis of Rainfall and Runoff Characteristics

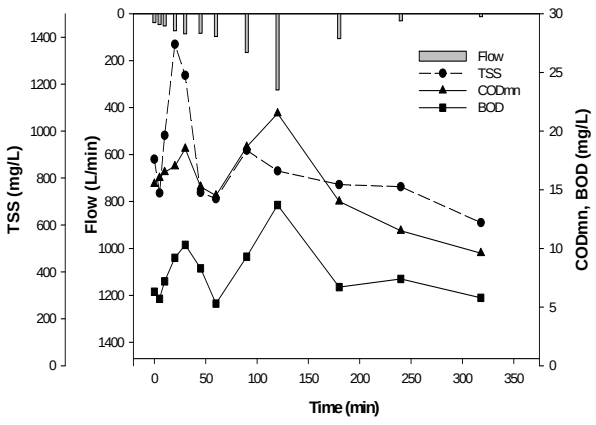
This study which was monitored at two sites was conducted from 2008 March until 2009 September. And total 29 times were conducted. Below 10 mm of 29 times was 10times, 10~20 mm was 4times, 20~30 mm was 5times, 30~40 mm was 3times, upper 40~50 mm was 4 times. And 24 times of 29 times occurred outflow. Specially, we can know that outflow was occurred upper 20 mm.
Table 1 shows about we monitored rainfall characteristics of 24 times. Antecendent dry day (ADD) of two sites were 2.0 ~ 15.0 day, total rainfall were 2.4 ~ 72.6 mm, rainfall duration time were 1.9 ~ 19.3 hr, average rainfall intensity were 0.4 ~ 5.5 mm/hr, runoff rate were 0.40 ~ 7.90. specially, runoff rate of monitoring site which is located in Geungang-dong is lower than another monitoring site. Runoff rate is effected by many things such as terrain and geological features. Fig 2 shows concentration of pollutants and outflow from vinyl house area. we can know that high concentration occurred in time of First-Flush. And concentration suddenly decreased from start of runoff to 60 min. also according to increase flow, concentration of BOD, COD suddenly increased. In case of T-N, T-P wasn't affected.

**Table 1. Analysis of runoff event.**

| | Total rainfall (mm) | Avg.rainfall intensity (mm/hr) | Rainfall duration (hr) | ADD (days) |
|---|---|---|---|---|
| n | 24 | | | |
| Minimum | 2.4 | 0.40 | 1.9 | 2.0 |
| Maximum | 72.6 | 7.90 | 19.3 | 15.0 |
| Mean | 29.5 | 3.08 | 10.6 | 5.3 |
| Standard deviation | 20.5 | 2.15 | 4.93 | 3.7 |

### 3.2. EMCs

Because It is important to calculate EMCs for understanding runoff characteristics, this study carried out calculating EMCs by using equation(1) and statistical analysis of EMCs. Table 2 shows EMCs of monitoring sites.
The result of monitoring sites was TSS 24.2 ~ 1629.9 mg/L, BOD 4.2 ~ 53.5 mg/L, COD 8.6 ~ 72.1 mg/L, T-N 1.9 ~ 10.4 mg/L, T-P 0.1 ~ 7.9 mg/L. and standard deviation of TSS, BOD, COD, T-N, T-P was 416.3, 10.6, 13.0, 2.3, 2.2 mg/L.





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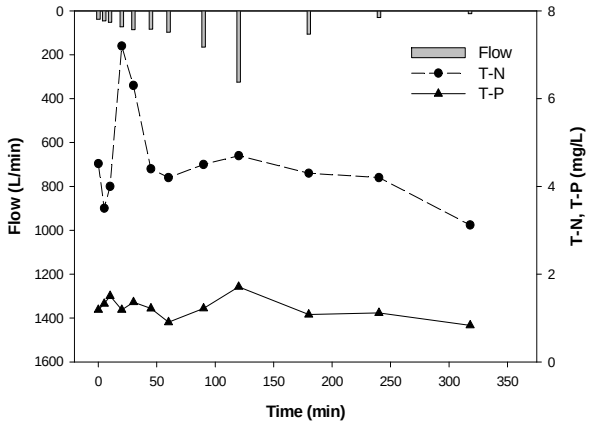


**Fig 2. The variation of flow and water quality.**

**Table 2. EMCs of monitoring sites.**

| | TSS (mg/L) | BOD (mg/L) | COD (mg/L) | T-N (mg/L) | T-P (mg/L) |
|---|---|---|---|---|---|
| Minimum | 24.20 | 4.20 | 8.60 | 1.900 | 0.100 |
| Maximum | 1629.90 | 53.50 | 72.10 | 10.350 | 7.900 |
| Median Mean | 344.04 | 13.21 | 21.10 | 5.071 | 2.247 |
| Standard deviation | 416.34 | 10.62 | 13.04 | 2.347 | 2.212 |

### 3.3. Pollutant Mass Loadings of Each Monitoring Site

In order to understand pollutant Mass Loadings correctly, calculating pollutant Mass Loadings per unit area is needed. Table 3 shows pollutant Mass Loadings per unit area. in case of TSS, 0.0584 ~ 55.3767 g/m$^2$, BOD 0.075 ~ 1.1380 g/m$^2$, COD 0.0123 ~ 1.5333 g/m$^2$, T-N 0.0040 ~ 0.3067 g/m$^2$, T-P 0.0002 ~ 0.2352 g/m$^2$.

**Table 3. Pollutant mass loadings of each monitoring site.**

| | TSS (g/m$^2$) | BOD (g/m$^2$) | COD (g/m$^2$) | T-N (g/m$^2$) | T-P (g/m$^2$) |
|---|---|---|---|---|---|
| Minimum | 0.0584 | 0.075 | 0.0123 | 0.0040 | 0.0002 |
| Maximum Median | 55.3767 | 1.1380 | 1.5333 | 0.3067 | 0.2352 |
| Mean | 8.5723 | 0.2329 | 0.4302 | 0.0880 | 0.0457 |
| Standard deviation | 15.6857 | 0.2761 | 0.4751 | 0.0826 | 0.0604 |

### 3.4. Non-Point Pollutant Unit Loads

This study calculated Non-Point Pollutant unit loads which uses data during 10 years of monitoring sites from vinyl house area. and we found out concentration of pollutant, rainfall distribution. Also we compared with pollutant loads of domestic and foreign country. Table 4 shows pollutant loads of calculating in this study. We know that BOD, COD, TSS, T-N, T-P were 4.33 kg/km$^2$.day, 8.42 kg km$^2$.day, 126.05 kg/ km$^2$.day, 1.68 kg/ km$^2$.day, 1.07 kg/ km$^2$.day. comparing with pollutant loads by land use which is applied from our country, BOD was calculated highly. But in case of T-N, T-P was calculated lower than other sites. comparing with pollutant loads calculating in USA. BOD was calculated similarly. But in case of TSS, T-N, T-P was similar with parking lot.

**Table 4. Unit pollutant loads from Vinyl house(kg/km2.day).**

| | TSS | BOD | $COD_{MN}$ | T-N | T-P |
|---|---|---|---|---|---|
| Vinyl house area | 126.05 | 4.33 | 8.42 | 1.68 | 1.07 |

**Table.5. Non-Point pollutant unit loads from landuses in Korea(Ministry of Environment, 1999) (kg/km2.day).**

| Land uses | BOD | T-N | T-P |
|---|---|---|---|
| Paddy field | 2.3 | 6.56 | 0.61 |
| Field | 1.6 | 9.44 | 0.24 |
| Forest | 1.0 | 2.20 | 0.14 |
| Urban | 85.9 | 13.69 | 2.10 |
| Pasture | 35.1 | 5.37 | 1.72 |
| Golf course | 1.0 | 3.56 | 2.76 |
| Others | 1.0 | 0.06 | 0.03 |

**Table 6. Non-Point pollutant unit loads in USA (NFWMD, 1994, Novonty and Olem, 1997) (kg/km2.day).**

| Location | Land use | BOD | TSS | T-N | T-P |
|---|---|---|---|---|---|
| Florida | Low density residential | 2.71 | 8.60 | 1.36 | 0.14 |
| | Multi-family residential | 12.93 | 105.67 | 2.17 | 0.60 |
| | Commercial | 16.55 | 180.11 | 2.91 | 0.63 |
| | Highway | 26.84 | 301.22 | 1.92 | 0.77 |
| | Industrial | 14.37 | 213.73 | 3.05 | 1.46 |
| | Open land | 0.95 | 5.96 | 0.71 | 0.05 |
| | Wetlands | 4.27 | 7.46 | 1.50 | 0.07 |
| | Pasture | 4.56 | 181.53 | 1.72 | 0.15 |
| | Agriculture | 4.92 | 613.26 | 4.81 | 0.29 |
| | Woodland | 1.38 | 17.63 | 0.85 | 0.04 |
| | Freeways | - | 268.27 | - | 0.29 |

| | | | | | |
|---|---|---|---|---|---|
| **Wisconsin, Milwaukee urban land use** | Industrial | - | 262.25 | - | 0.41 |
| | Commercial | - | 262.25 | - | 0.41 |
| | Parking lots | - | 124.14 | - | 0.21 |
| | High density residental | - | 133.45 | - | 0.31 |
| | Medium density residential | - | 59.19 | - | 0.16 |
| | low density residential | - | 3.02 | - | 0.01 |
| | park | - | 0.82 | - | 0.01 |

## 4. Results and Discussion

This study selected reogion which influences nakdong river. And understood runoff characteristic of pollutant and calculated loads, unit pollutant loads. In order to use fundamental data of non-point source pollutants management, we have monitoring total 29 times from 2008 March to 2009 September. The result is as below.

1) In case of increasing flow, concentration of BOD, COD was increased. And concentration of T-N, T-P seldom was changed.
2) The result of monitoring sites was TSS 24.2 ~ 1629.9 mg/L, BOD 4.2 ~ 53.5 mg/L, COD 8.6 ~ 72.1 mg/L, T-N 1.9 ~ 10.4 mg/L, T-P 0.1 ~ 7.9 mg/L. in case of TSS, between minimum value and and standard deviation of TSS, BOD, COD, T-N, T-P was 416.3, 10.6, 13.0, 2.3, 2.2 mg/L.
3) In order to understand pollutant Mass Loadings correctly, calculating pollutant Mass Loadings per unit area is needed. Table 3 shows pollutant Mass Loadings per unit area. in case of TSS, 0.0584 ~ 55.3767 g/m$^2$, BOD 0.075 ~ 1.1380 g/m$^2$, COD 0.0123 ~ 1.5333 g/m$^2$, T-N 0.0040 ~ 0.3067 g/m$^2$, T-P 0.0002 ~ 0.2352 g/m$^2$.
4) This study calculated Non-Point pollutant unit load which uses data during 10 years of monitoring sites from vinyl house area. and we found out concentration of pollutant, rainfall distribution. We known that BOD, COD, TSS, T-N, T-P were 4.33 kg/ km$^2$.day, 8.42 kg/ km$^2$.day, 126.05 kg/ km$^2$.day, 1.68 kg/ km$^2$.day, 1.07 kg/ km$^2$.day. comparing with pollutant loads by land use which is applied from our country, BOD was calculated highly. But in case of T-N, T-P was calculated lower than other sites.

## 5. Acknowledgment

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