OPTIMIZING STORM DETENTION AND TREATMENT FACILITY TO CONTROL NONPOINT SOURCE POLLUTION IN STEEL COMPANY

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Abstract: Due to stormwater runoff along Pohang Bay at typhoon Rusa and Maemi in 2002 and 2003, P steel Company requires a counter measure for all future typhoons. P steel Company will have the challenge of both determining the benefits of their existing treatment facility and deciding what additional practices they will need to achieve the goal. In order to reduce the nonpoint source pollution during rainfalls, P steel Company is considering the installation of stormwater pits and the construction of a stormwater treatment plant. This study analyzed the reduction effect of nonpoint source pollution achieved through such measures using the Storm Water Management Model (SWMM). As a result, we found that the installation of stormwater pits (storage capacity 60mm/day) and stormwater treatment plant have reduced the pollution load (SS) by 38 to 87% compared to the existing state, and the concentration of SS in outflow also satisfied 20mg/L or lower.

Key words: Nonpoint-source pollution, SWMM, Stormwater

INTRODUCTION

Impacts caused by storm water discharges from primary metals facilities will vary. A number of factors will influence to what extent the activities at a particular facility will affect water quality. These include: geographic location, hydrogeology, the amounts and types of materials stored outside, the types of processes taking place outside, the size of the operation, as well as the characteristics of a particular storm event. Although operations at primary metals facilities may vary considerably, the elements with potential impact on storm water discharges are fairly uniform and consistent. Facilities may include considerable areas of raw and waste material storage such as coal, coke, metal, ores, sand, scale, scrap, and slag. Processes generally involve furnaces for heating and melting metals or for producing coke, any of which may result in significant particulate emissions. Due to the nature of their operations some facilities will have large areas of exposed soil and heavy vehicle traffic which can lead to erosion. Especially in such a large factory as P steel Company, due to its wide impervious area, a sudden increase of stormwater runoff may occur during rainfall, and nonpoint source pollutants may flow into public waters, causing water pollution problems at typhoon.

P steel Company is one of the largest steel makers in the world with total area size of 891ha, and steel production capacity of 12 million tons. The researched area was iron and steel making area, a part of P steel Company with the area size of 461.82ha (P steel Company, 2003). To review the water treatment system of P steel Company; the wastewater generated from the industrial processes is primarily treated in each individual treatment facility, which is then finally treated in the wastewater treatment plant before it is discharged. The site has the separated sewer system, and most of the stormwater runoff, especially the initial stormwater runoff flows into and treated in the wastewater treatment plant, so nonpoint source pollution are being efficiently controlled. However, whenever a typhoon brings heavy rainfalls, the stormwater runoff from the iron ores and coal yard would exceed the capacity of the treatment plant, discharging most of it to Hyeongsan River.
situation must be improved.

Accordingly, on behalf of management of nonpoint source pollution for P steel Company, this study tries to derive effective alternatives to the installation of detention and treatment facilities, and find the optimum management practices for nonpoint source pollution control by analyzing the pollution reduction effects of the alternatives using the Storm Water Management Model (SWMM).

CONSTRUCTION OF MODEL FOR CATCHMENT USING SWMM

Scheme of SWMM

The United States Environmental Protection Agencies (USEPA's) Storm Water Management Model is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. Both single-event and continuous simulation can be performed on catchments having storm sewers, or combined sewers and natural drainage, for prediction of flows, stages and pollutant concentrations. Extran Block solves complete dynamic flow routing equations (St. Venant equations) for accurate simulation of backwater, looped connections, surcharging, and pressure flow (Huber and Dickinson, 1988).

Construction of model

Distribution of sub-catchments and channel network of the study area is shown in Fig. 1. The study area was divided into 16 drainage zones based on the treatment area divisions by channel networks and surface slopes. For sub-catchments, informations such as catchment area, slope, roughness, impervious percentage, and land use were input. For Conduit, informations such as conduit length, diameter, slope, shape, roughness were input. For the parameters related to depression storage and infiltration, the values in the references were applied, and then calibrated to exhibit the runoff characteristics of catchment during the calibration of the model. For the information related to water flow and quality, the actual measured values were applied for average water flow and quality and temporal variation. For the pollutants buildup and washoff parameters, after the values in the literature were applied, they were corrected during the model calibration process.

Fig. 1. Division of sub-catchment and channel network in the study area.
The model was calibrated for the water flow and quality during dry weather and wet weather. Fig. 2 shows the comparisons between actual measured values and the simulated values for flow volume and water quality, and we can find that the overall trends of both flow volume and water quality are well simulated.

Fig. 2. Calibration of Model.

MANAGEMENT PRACTICES OF NONPOINT SOURCE POLLUTION

As a method of nonpoint source pollution control during rainfall, P steel Company plans to install a stormwater pit for prevention of rapid runoff and removal of pollutants, and also construct a stormwater treatment plant. This study tries to derive the optimum management practices for nonpoint source pollution by analyzing the pollution load reduction effect between different alternatives using the Storm Water Management Model.

Proper storage capacity for stormwater pit

A stormwater pit temporarily keeps stormwater runoff during a rainfall to prevent rapid outflow of stormwater, and the storage water in the pit is transferred to the treatment plant after the rain stops. The proper storage capacity of the stormwater pit was determined from analyses of the rainfall data of Pohang-city and pollution reduction effects for different storage capacities using SWMM.

First, after an analysis of the Phonag’s rainfall data during the recent 43 years (1961 to 2003), we
found that 4,168 days (97.6%) of the total 4,271 wet days had less than 60 mm of rainfall, and 27 days (0.6%) had over 100 mm.

Next, to analyze the pollution load reduction effects by the installation of the stormwater pit, we set up alternatives according to the storage capacity of stormwater pit, and simulate the runoff characteristics of each alternative using the SWMM.

(a) Case 1: The storage capacity of the stormwater pit: 60 mm/day
(b) Case 2: The storage capacity of the stormwater pit: 100 mm/day

The rainfalls applied for model simulation are shown in Fig. 3.

Fig. 3. Hyetograph of simulated rainfalls

Fig. 4 shows the runoff characteristics for each alternative at the final discharge in the wastewater treatment plant. If we look at the runoff characteristics for a rainfall of 30 mm/event (Fig. 4 (a), (b), (c)), the existing state exceeded 100 mg/L of SS, when inflow exceeded the treatment capacity. However, Alternatives 1 & 2 showed a good water quality of less than 30 mg/L over the whole period. During heavy rainfalls of over 60 mm/event, the concentration in outflow was considerably reduced by the installation of the stormwater pit. However, once the capacity of the stormwater pit and the treatment plant are exceeded, the concentration in outflow rapidly increased.
To analyze the nonpoint source pollution reduction effects of each alternative during rainfall, we compared the total pollution load for each alternative. The total pollution load was determined by the following formula, where the outflow volume per unit time is multiplied by the concentration of pollutants.

- Total pollution load(kg/event) = \( \sum C_i \times Q_i \)
As shown in Fig. 5, the differences of pollution load reduction effects are not great between alternatives. When you review the average pollutants reduction effects compared to the existing state, COD was reduced by 37% for alternative 1 and 42% for alternative 2, and SS was reduced by 35% for alternative 1, and 40% for alternative 2.

Therefore, considering the fact that about 97.6% of yearly rainfall events are 60mm or lower, and the pollutants reduction effects of alternative 1 and 2 are not very different, our recommendation for the proper storage capacity of the stormwater pit is about 60mm/day.

**Installation of wastewater treatment facility and stormwater treatment facility**

P steel Company has the separated sewer system, and most of the stormwater runoff, especially the initial stormwater runoff flows into and treated in the wastewater treatment plant, but during heavy rainfall, polluted stormwater runoff from the iron ores and coal yards exceeds the capacity of the treatment plant, and directly discharged to the receiving water without proper treatments, deteriorating water pollution.

Accordingly, this study reviewed the case that the wastewater is treated in a newly-installed wastewater treatment facility while the stormwater runoff is treated in the existing wastewater treatment plant retrofitted(Alternative 3). To quantify the pollution reduction effects of Alternative3, we simulated the runoff characteristics of alternative 3 in comparison with Alternative 1.

**Table 1. Comparison of each alternative**

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Case 3</th>
<th>Case 1</th>
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<tbody>
<tr>
<td>Storage capacity of pit</td>
<td>60mm/day</td>
<td>60mm/day</td>
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<tr>
<td>Treatment of Wastewater</td>
<td>Newly-installed wastewater treatment plant (Q=50,000 m$^3$/day)</td>
<td>Existing wastewater treatment plant (Q=80,000 m$^3$/day)</td>
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<tr>
<td>Treatment of Stormwater runoff</td>
<td>Retrofit of existing wastewater treatment plant(Q=200,000 m$^3$/day)</td>
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Fig. 6 shows the outflow characteristics of each alternative at the final discharge in the treatment plant. Alternative 3 showed 20mg/L or lower SS concentration during 30mm/event and 60mm/event conditions as well as the rainfall from typhoon Maemi. However, Alternative 1 exceeded 100mg/L of SS concentration for rainfalls of 60mm/event or more. As the Typhoon Rusa brought a big rainfall of 394.5mm/event, both alternatives showed more than 100mg/L of SS concentration.
Fig. 6. Result of simulation for each alternative (treatment outflow).

Fig. 7 shows the nonpoint source pollution reduction effects of each alternative. The average
pollution reduction effects of Alternative 3 was 27% for COD and 40% for SS. In particular, its pollution reduction effects for heavy rainfalls such as 60mm/event and typhoon Maemi were high, so we can conclude that with Alternative 3, we can secure relatively stable water quality in heavy rainfalls as well.

![Fig. 7. Total pollution load for each alternative.](image)

**CONCLUSION**

P steel Company has the separated sewer system, and most of the stormwater runoff, especially the initial stormwater runoff flows into and treated in the wastewater treatment plant, resulting in relatively good management of nonpoint source pollution. During heavy rainfalls, however, polluted stormwater runoff from the iron ores and coal yards exceeds the capacity of the treatment plant, and directly discharged to Hyeongsan River. This may be attributed to natural disasters such as typhoons, but P steel Company, as a world-class company, tries to achieve perfect environmental management through optimum nonpoint source pollution control by complementing their existing treatment system.

As a means to reduce the nonpoint source pollution during rainfall, we have derived the installation of stormwater pits and stormwater treatment plant. We analyzed the pollution load reduction effects of these alternatives using SWMM.

- By the installation of stormwater pits, pollution load(SS) could be reduced by up to 35% compared to the existing facility with Alternative 1 (storage capacity: 60mm/day), and 40% with Alternative 2 (storage capacity: 100mm/day). Further, in case of rainfalls of 30mm/event or lower, good water quality of 30mg/L or lower was estimated.

- In addition to the stormwater pit installation, through a separate treatment of wastewater and stormwater runoff, we could reduce the pollution load(SS) by about 66% compared to the existing situation, and for most simulated rainfalls except typhoon Rusa, good water quality of 20mg/L or lower was estimated.

**REFERENCE**

County of Sacramento(2002), *Best management practices for industrial storm water pollution control, Sacramento, USA*.

*Federal register, Final NPDES Storm Water Multi-Sector General Permit for Industrial Activities; Notice*(1995), EPA, USA


Wisconsin Department of Natural Resources(1994). Industrial storm water pollution prevention planning, Wisconsin, USA.