# Assessment on the effects of soil amendment to the overall performance of urban stormwater low impact development technologies

## Évaluation des effets de l'amendement du sol sur la performance globale des technologies de développement à faible impact sur les eaux pluviales urbaines

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## RÉSUMÉ

Les eaux de ruissellement provenant des autoroutes et des barrières de péage sont drainées par des canalisations et des lignes de drainage. Afin de traiter ce type de ruissellement, des installations de développement à faible impact d'infiltration (LID) devraient être installées. Cependant, les installations d'infiltration débordent généralement lors de fortes pluies en raison d'une faible infiltration et d'une faible porosité du milieu. Cette étude a utilisé une expérience pilote pour analyser l'effet de l'amendement du sol sur l'amélioration du coefficient de perméabilité du sol. Les résultats expérimentaux ont montré que le sol modifié avait augmenté le taux d'infiltration de 20%, le taux de rétention de 25% à 40% et pouvait supporter une intensité de pluie atteignant 13 mm / h. Le taux d′infiltration moyen du sol modifié était de 2 à 5 cm / h, ce qui était 1,2 à 4 fois plus rapide que le taux d′infiltration du sol initial. En règle générale, l'amendement du sol a augmenté le taux d'infiltration en raison de l'amélioration du temps de rétention d'eau, de l'augmentation de la surface et du volume de stockage.

## ABSTRACT

Rainfall runoff from highways and toll gates are drained through pipes and drainage lines. In order to treat such runoff, high infiltration low impact development (LID) facilities should be applied. However, infiltration facilities usually overflow during high rainfall occurrences due to low infiltration and low media porosity. This study utilized a pilot scale experiment to analyze the effect of soil amendment in improving the permeability coefficient of soil. Experimental results showed that the amended soil had increased infiltration rate by 20%, increased retention rate by 25% to 40%, and can accommodate a rainfall intensity of up to 13 mm/hr. The average infiltration rate of the amended soil was 2-5 cm/hr, which was 1.2 to 4 times faster as compared to the original soil's infiltration rate. Generally, soil amendment increased the infiltration rate as a result of improved water retention time, increased surface area, and storage volume.

## KEYWORDS

Infiltration facility, infiltration rate, soil amendment, water circulation

# 1 INTRODUCTION

Concrete and asphalt roads generate pollutants such as heavy metals and oil due to abrasion of tires, exhaust from vehicles, and engine parts wear and tear. Highway runoff is especially difficult to treat due to its length and relatively-large drainage area resulting to high discharge coefficient compared to normal roads. Moreover, the pollutants generated from roads, parking lots, and toll gates during rainfall events which were directly deposited to aquatic ecosystems are harmful to the environment. In order to solve these problems, low impact development (LID) facilities were used to treat stormwater runoff from highways and toll gates. However, drainage lines were installed along highways to reduce flooding caused rapid flow of water in channels, which in turn disrupts the treatment of non-point source (NPS) pollution and resulted to decreased efficiency of infiltration facilities. In addition, the natural soils around highways and service areas usually has low infiltration rate resulting to overflowing of infiltration facilities during periods of high rainfall. This study analyzed the effect of soil amendment on the infiltration rate and pollutant reduction in highway stormwater runoff.

# 2 MATERIALS AND METHODS

The pilot scale was consisted of a sedimentation tank and test beds made of original soil and amended soil. The facility is 6m long and 2.6m wide. In order to prevent clogging, the facility was equipped with a sedimentation tank capable of treating 30% of the facility's total volume capacity. Both the control and amended test beds have aspect ratio (LxWxH) of 4.5x1x0.95. The test beds were composed of sand, overlain by gravel on the top-most part. A geotextile was also installed at the bottom part to prevent soil loss and mixing. In order to measure the infiltration rate of the control and amended part, a 10-cm diameter pipe was installed 4 m from the inlet to monitor the water level. Monitoring of the change in water level was carried-out to evaluate the effectiveness of soil amendment in improving the infiltration rate of the soil. Monitoring was conducted for rainfall events with greater than 5 mm depth. Flow measurements were conducted every five minutes as soon as the inflow and outflow started. In order to compare the infiltration rate of the two test beds, water level was measured every five minutes from the beginning until the water was completely drained on each pipe.

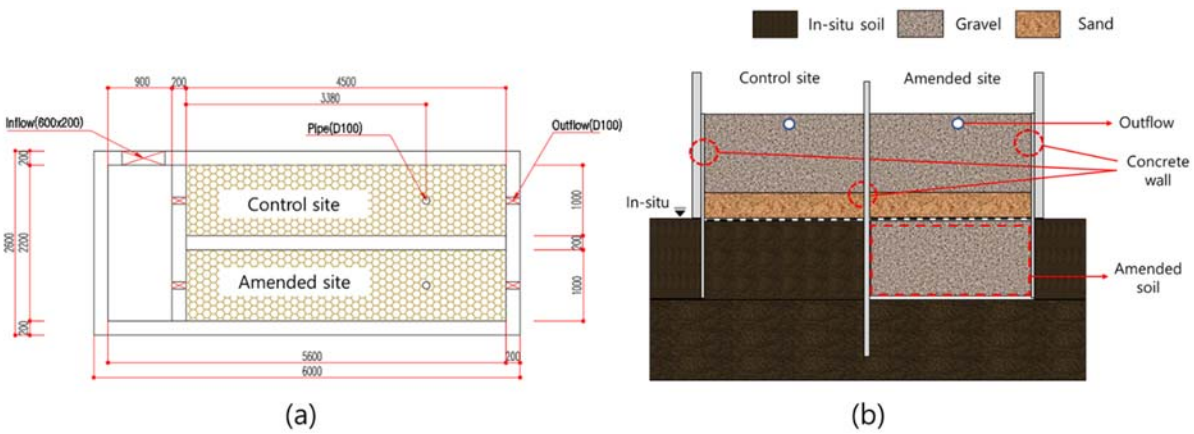



Figure 1. Schematic diagram of Pilot scale: (a) Top view (b) Side view

# 3 RESULTS AND DISCUSSION

In order to analyze the effects of soil amendment, water balance analysis was performed (Fig. 2). For all the monitored events, the control group produced an outflow. The average outflow rate in the control group was 0.40±0.45 $m^3$/min, time to peak was 36±18 min, and the runoff delay time was about 26±19 min. The average volume reduction was noted to be 50±32.9%. In case of the amended soil group, the outflow occurred on four out of five events. The average outflow rate was 0.21±0.22 $m^3$/min, time to peak was 47±8 min, and runoff delay was 30±19 min. While event 3 did not produce any outflow due to longer antecedent dry days and weak rainfall intensity, the average volume reduction was 70±23.5%. The groundwater level was measured over time to compare the permeability of the control and amended group as shown in Figure 3. It has been noted that the rise in groundwater for the amended soil occurred 2 to 10 minutes later than control group. The average groundwater level, time to peak, and complete water dissipation time in the control group was 86±4cm, 0.5±0.4 hours, and 14±6 hours, respectively. On the other hand, the amended group exhibited an average groundwater level, time to peak, and complete water dissipation time of 75±5cm, 0.7±0.5 hour, and 8.8±3 hours, respectively. Basically, the amended soil had groundwater level that is 11±1.1 cm lower than the control group, and an average delay time of groundwater level rise of 0.2±0.05 hours. Groundwater level rise on events 1 and 3 was almost similar for the amended and control group, but the peak water level and complete water dissipation time of the amended group was about 25±40% lower as compared to the control group.

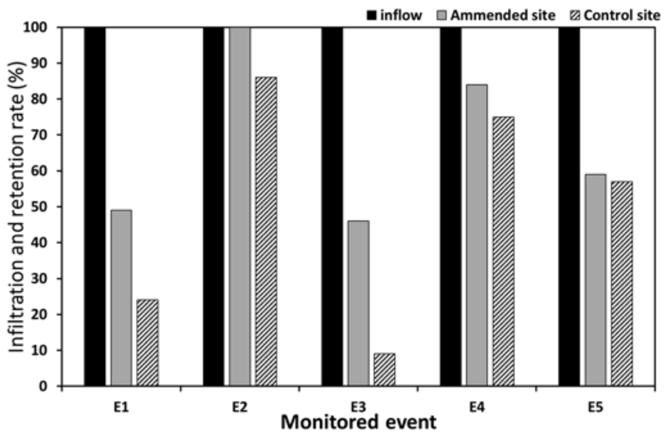
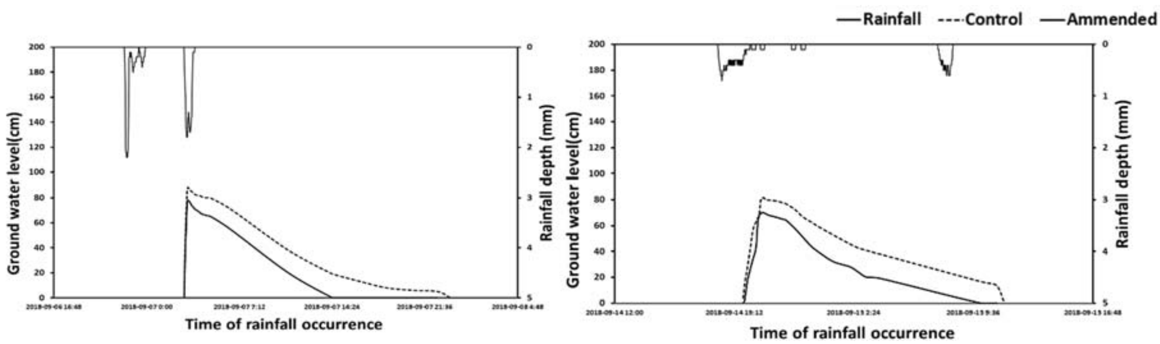



Figure 2. Water balance for each monitored event

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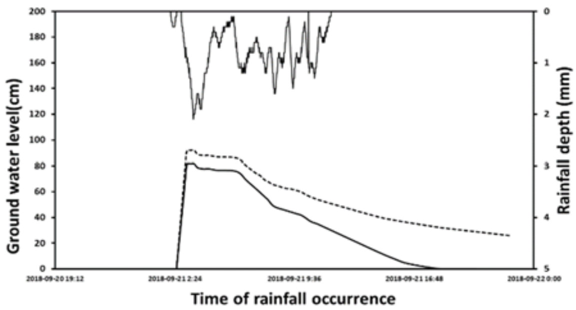
E2. 2018.08.26

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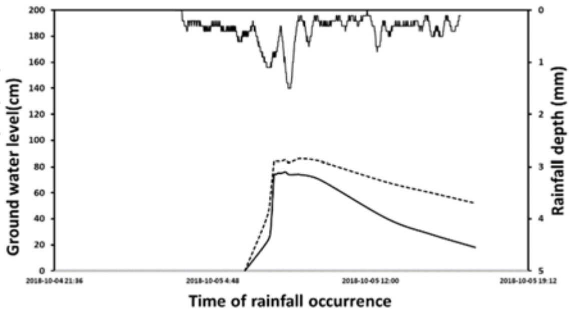


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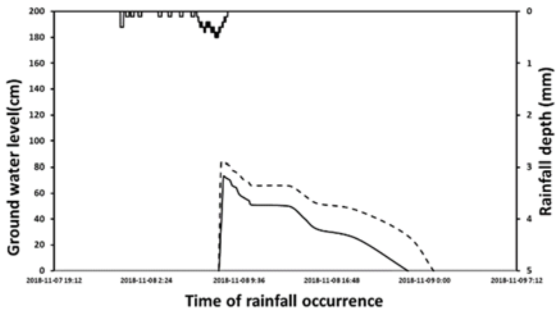


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Figure 3. Change in groundwater level over time

## 4 CONCLUSION

Pilot scale monitoring and experiments were conducted to analyze the effect of soil amendment in improving LID facilities' infiltration rate. Based on the results, the following conclusions were drawn:

1. 70% reduction in the runoff volume and 20% increase in storage volume can be achieved if soil amended was performed. For rainfall intensities of 13 mm/hr or greater, the amended soil had 25% to 40% higher retention rate as compared to the control group. Generally, the ammended soil has higher retention rate for greater rainfall intensities and longer rainfall durations.
2. The average infiltration rate of the amended soil was 2-5 cm/hr , which was 1.2 to 4 times faster than the control group. By using soil amendment, higher infiltration rate, improved residence time, and increased storage volume capacity can be attained.

## 5 ACKNOWLEDGEMENT

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