Nitrogen and Phosphorus Removal Models for a Wetland Receiving Stormwater from Rural Areas

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1. Introduction

Nitrogen and phosphorus pollution are caused by the excessive amount of these nutrients entering water bodies from different sources. It leads to water quality degradation which, in turn, affects human and animal health and may induce a significant economical impact. On the other hand, stormwater runoff coming from different sources including rural areas is one of the many sources of diffuse pollution contributing to water quality degradation. In view of this, treatment wetlands, one of the best management practices (BMPs), are used to control and reduce the nutrient content of stormwater runoff before discharge to receiving waters. However, wetland design and effectiveness have been studied through costly experiments and methods. Thus, modeling of pollutant removal capability of these systems have been increasingly preferred as an economical alternative. This study aims to develop model equations for nitrogen and phosphorus removal suitable for use in wetland design procedures in the future.

2. Methods

Water samples were collected from a constructed wetland in Jeongeup City, South Korea. These samples were collected at eight monitoring points within the wetland during dry days. Concentrations of TP, NH₃-N and TN were measured using the Standard Methods for the Examination of Water and Wastewater, 19th edition (APHA et al., 1995). Base modeling formulas were adopted from different literatures on wastewater modelling and appropriate affecting parameters were analyzed and considered. The coefficients were obtained using regression analysis and MS Excel Solver.

3. Results and Discussion

An exponential equation in terms of temperature and hydraulic loading rate (HLR) is effective in predicting normalized concentrations of TP with $R^2=0.785$. On the other hand, nitrogen species removal showed a good response to the base equations proposed by Reed et al. (1995) and the Water Environment Federation (WEF). These equations are also exponential equations wherein the affecting factors are temperature, HLR and hydraulic retention time (HRT). All the models developed gave favorable predictions of the concentration of the nutrients even though they were developed using data from wastewater wetlands. Measured and predicted normalized concentration of TP and as well as effluent TN are shown in Fig 1. while the summary of the developed models are shown in Table 1.

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### Table 1. Established Models

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model Equation</th>
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<tr>
<td>TP</td>
<td>$C = C_0 \exp(-30.462T^{-1.924}/\text{HLR})$</td>
</tr>
<tr>
<td>NH$_3$-N</td>
<td>$C = \exp(0.7661\ln C_0 + 0.1921\text{HLR} - 0.2276)$ or $C = C_0 \exp(-kt)$ where $k = 0.2187(1.048)^{T-20}$</td>
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<tr>
<td>TKN</td>
<td>$C = \exp(0.258\ln C_0 + 0.066\text{HLR} - 0.321)$</td>
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<tr>
<td>TN</td>
<td>$C = 1.0029\ln C_0 + 0.2251\text{HLR}$ or $C = C_0 \exp(-kt)$ where $k = 0.127T^{0.338} + 0.304\text{pH}^{0.112}$</td>
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### 4. Conclusion

1) The removal of total phosphorus in the studied wetland is affected by temperature and HLR while that of the nitrogen species can be affected by temperature, HLR and HRT.
2) The removal mechanism for TP in the wetland is sedimentation while that of TN is biological nitrification-denitrification process.
3) Model equations developed from wastewater wetlands are also applicable to stormwater wetlands.

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### References


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