**Identification of correlation and relative importance of impacted factors to removal rates of nitrogen and organic matter in constructed wetland**

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**Introduction**

Many factors effect to removal rate of constructed wetland (CW) and these vary widely ([Chan et al., 2008](#_ENREF_2); [Saeed and Sun, 2011](#_ENREF_8)). The misunderstanding of contaminant dynamics in this system can lead to failure design ([Davoodi et al., 2016](#_ENREF_3)). The impact factors include the operating conditions and inputs which influence differently to CW efficiency. Therefore, determination of correlation and relative importance of these variables is necessary for designing and operating of CW.

Regression analysis (RA) has been applied for analysis of CW performance ([Babatunde et al., 2011](#_ENREF_1); [Knight, 2000](#_ENREF_7); [Tomenko et al., 2007](#_ENREF_10)). Many studies mainly determined the correlation coefficient (r) and relative importance between the related predictors and responses by simple linear regression models ([KC et al., 2004](#_ENREF_6); [Knight, 2000](#_ENREF_7); [Son et al., 2010](#_ENREF_9)).

The purpose of this study is to identity the correlation and quantify the relative importance of related variables to removal rates of nitrogen and organic matter of constructed wetland.

**Material and methods**

*Characteristics of constructed wetland:*

A pilot-scale CW was located at the sewer of Dong Ha city, Vietnam. The system included a vertical flow tank and horizontal flow tank. VF had dimensions 1.2 m wide, long and height and HF 1.0 wide by 3.0 long and 0.7 height. *Canna indica* planted in VF and *Colocasia esculenta* in HF. CW was tested with three hydraulic loading rates (HLR or q): the first period was at 0.1 m/d (HLR1), the second at 0.2 m/d (HLR2), and the final one at 0.15 m/d (HLR3) (01/2016 – 06/2016).

*Statistical analysis:*

All statistical analyses were performed using the computing environment R (R Version 3.4.0). The statistical differences were evaluated by ANOVA, and post-hoc test (Tukey HSD). LMG measure and bootstrap confidence intervals used for identifying the relative importance.

**Results and Conclusions:**

*Data of constructed wetland:*

Figure 1 indicates that the removal rates changed corresponding to various HLRs. The highest efficiencies at HLR3 (0.15 m/d) were 15.8 g BOD5/m2.d and 3.1 g NH4 -N/m2.d. BOD5 effluent concentration reached the lowest value at HLR3 (16.4 mg/L) and had significantly difference between three HLRs (P <0.05). NH4-N concentration was inversely proportional to HLRs.



**Figure 1**: Error bar (95% Confidence interval) of BOD5 and NH4

*Regression analysis:*

q and Cits (TSS inlet concentration) had the relatively high correlation with Lrb (BOD5 removal rate) with r = 0.56 and 0.47, respectively. The role of q to effluent concentration and removal efficiency confirmed by [Kadlec and Knight (1996)](#_ENREF_5). Cib (BOD5 inlet concentration) is a main factor for constituting Lrb but surprisingly it only contributed a low value r of 0.11. pH showed the negative low correlation, with r value of - 0.03 (Figure 2a).

Influent of NH4-N (Cin) and TN (Cit) had the highest correlation with NH4-N removal rate (Lrn) (r = 0.83 and 0.69, respectively). However, Cit correlated highly to Cin (r = 0.85) which might happen multicollinearity of RA. q also correlated strongly to Lrn with r of 0.46. Cip and pH showed the negative correlations to Lrn, with r = - 0.35 and - 0.08, respectively, while the correlations between the other predictors were quite low (Figure 2b).

** a)  b)**

**Figure 2:** Correlation coefficient of variables with removal rate BOD5 (a) NH4-N (b)

The result by LMG analysis (Table 1) indicates that 71.7% of total variation in Lrb explained by 7 chosen predictor variables. q was considered as the most importance variable which contributed 35.6% for total variation of Lrb. Cits and Cib had a lower role while Cin, Cip (PO4-P inlet concentration) and Cit impacted weakly for variation. pH might not contributed to variation of Lrb.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Influent | Cib | q | Cin | Cip | Cit | C­its | pH | Total |
| Relative importance (R2, %) | 8.8 | 35.6 | 3.7 | 2.1 | 2.7 | 18.1 | 0.7 | 71.7 |

**Table 1:** The relative importance of related predictors to BOD5 removal rate by LMG analysis

Table 2 presents that Cin had the highest relative importance to Lrn (41%) which contributed nearly a half of total R2 (90.6%). C­its and q explained to 22.1% and 14.2% for total variation in Lrn. pH was lowest relative “weight” (0.6%) to variation of L­rn. According to ([Hijosa-Valsero et al. (2011)](#_ENREF_4)), the model had R2 above 0.5 which considered as a good regression model.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Influent | Cib | q | Cin | Cip | C­its | Cit | pH | Total |
| Relative importance (R2, %) | 3.1 | 14.2 | 41 | 5 | 22.1 | 4.6 | 0.6 | 90.6 |

**Table 2:** The relative importance of related predictors to NH4 -N removal rate by LMG analysis

In general, RA determined the correlation of related variables and drivers to removal rates of CW. q played big role to variation of BOD5 and NH4-N removal efficiency rates which considered as control key of CW. Cin, Cits and Cib were referenced for determining the effluent concentration and performance of CW system. The chosen variables are suitable for regression model (R2 >0.5).

**References**

Babatunde, A.O., Zhao, Y.Q., Doyle, R.J., Rackard, S.M., Kumar, J.L., Hu, Y.S., (2011), On the fit of statistical and the k-C\* models to projecting treatment performance in a constructed wetland system. *Journal of environmental science and health. Part A, Toxic/hazardous substances & environmental engineering*, **46**(5), 490-499.

Chan, S.Y., Tsang, Y.F., Cui, L.H., Chua, H., (2008), Domestic wastewater treatment using batch-fed constructed wetland and predictive model development for NH3-N removal. *Process Biochemistry*, **43**(3), 297-305.

Davoodi, R., Almasi, A., Mohammad, M., HoseiniAhagh, Dargahi, A., Karami, A., (2016), A mathematical model for organic matter removal in constructed wetlands case study: Wastewater treatment plant of Qasr-E Shirin, Iran. *International Journal Of Pharmacy & Technology*, **8**(2), 55-67.

Hijosa-Valsero, M., Sidrach-Cardona, R., Martín-Villacorta, J., Valsero-Blanco, M.C., Bayona, J.M., Bécares, E., (2011), Statistical modelling of organic matter and emerging pollutants removal in constructed wetlands. *Bioresource Technology*, **102**(8), 4981–4988.

Kadlec, R.H., Knight, R.L., (1996). Treatment Wetlands. Lewis Publishers, Boca Raton, FL.

KC, S., ME, P., PG, H., GB, R., (2004), Marsh-pond-marsh constructed wetland design analysis for swine lagoon wastewater treatment *Ecological Engineering*, **23**(2), 127-133.

Knight, R.L., Payne, V., Borer, R.E., Clarke Jr., R.A., Pries, J.H., (2000), Constructed wetlands for livestock wastewater management. *Ecological Engineering*, **15**(1), 41-55.

Saeed, T., Sun, G., (2011), Kinetic modelling of nitrogen and organics removal in vertical and horizontal flow wetlands. *Water Research*, **45**(10), 3137–3152.

Son, Y.K., Yoon, C.G., Kim, H.C., Jang, J.H., Lee, S.B., (2010), Determination of regression model parameter for constructed wetland using operating data. *Paddy and Water Environment*, **8**(4), 325-332.

Tomenko, V., Sirajuddin, A., Viktor, P., (2007), Modelling constructed wetland treatment system performance. *Ecological Modelling*, **205**(3-4), 355-361.