

LONG-TERM PERFORMANCE OF A CONSTRUCTED WETLAND SYSTEM FOR MUNICIPAL WASTEWATER TREATMENT IN UKRAINE

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Abstract

Long-term performance of a full-scale constructed wetland system receiving domestic wastewater effluent in Kharkiv region, Ukraine was evaluated. The system (capacity of 40 m³/d) consisting of three constructed wetland units – vertical filtration, horizontal filtration, and subsurface flow – was established in 1998 as an experimental site, and from 2001 it has been operating at a full capacity. More than 360 laboratory measurements were analysed in 1998-2014 for BOD₅ and COD, 350 - for suspended solids content, 230 - for ammonia nitrogen and orthophosphate contents in the wastewater at different treatment stages in full-scale constructed wetland system and different seasons. The basic Strittr-Phelps equation was applied to model decomposition of pollutants. Hydraulic residence time was calculated following the Dupuit's equation. Differences between decomposition coefficients derived at different scenarios were analysed with use of Fisher's F-criterion and Student's t-criterion. The Principal Component Analysis of decomposition coefficients carried out for series obtained at vertical, horizontal flow and free-surface systems separately have shown that more than 95% of explained variance is attributed to joint influence of season and temperature. Differences in input concentration did not significantly influence decomposition coefficients. Mean values of pollutant content at different units and the coefficients derived from both data reorganized according to the calculated hydraulic residence time (true time series), and data taken without such sorting, i.e. 'pseudo'-time series, were not significantly different (t- and F-tests). Model has been validated with the use of data on treatment performance from published sources on similarly designed constructed wetlands in temperate climates. The highest removal efficiency (80-99%) has been observed for organic matters and pathogen microorganisms in the wastewater, while nutrients were removed less effective (37-50%). The highest efficiency is achieved when vertical, horizontal flow and free-surface systems operated together. Performance efficiency of studied constructed wetland system remained quite stable over whole period of operation for 18 years.