Ecological Engineering 99 (2017) 525–529

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Municipal wastewater treatment using sequential activated sludge reactor and vegetated submerged bed constructed wetland planted with *Vetiveria zizanioides*

Adedayo A. Badejo[a,b,*], David O. Omole[a,c], Julius M. Ndambuki[a], Williams K. Kupolati[a]

[a] Department of Civil Engineering, Tshwane University of Technology, Private Bag X680, Pretoria, 0001, South Africa
[b] Department of Civil Engineering, Federal University of Agriculture, Abeokuta, P.M.B 2240, Ogun State, Nigeria
[c] Department of Civil Engineering, Covenant University, P.M.B. 1023, Ota, Nigeria

ARTICLE INFO

Article history:
Received 15 December 2015
Received in revised form
21 September 2016
Accepted 13 November 2016

Keywords:
Biological nutrient removal activated sludge
Vegetated submerged bed constructed wetland
Municipal wastewater
Vetiveria zizanioides

ABSTRACT

This study investigated a sequential system consisting of Biological Nutrient Removal Activated Sludge (BNRAS) and Vegetated Submerged Bed Constructed Wetlands (VSBCW). The BNRAS/VSBCW combination removing pollutants from municipal wastewater in a developing country was examined. Wastewater from the anaerobic, anoxic and aerobic zones of the BNRAS was fed into 12 pilot VSBCW consisting of 1000 L plastic tanks having 500 mm deep 10–15 mm diameter granite substrate planted with *Vetiveria Zizanioides*. Irrigation of macrophytes using effluent from the BNRAS was done after 3 months of planting and the VSBCW effluent analyzed. Wastewater samples were collected and analyzed using standard procedures. Percentage removal of 96.6, 96.93, and 97.21% of COD; 33.33, 85.71, and 92.48% of Nitrate/Nitrite; 53.51, 46.45, and 88.78% of Sulphate; and 98.34, 99.72, and 99.6% of TSS were obtained from the anaerobic, anoxic and aerobic zones respectively. Removal efficiency from the anaerobic zone effluent was highest during the study period. VSBCW using locally available macrophytes *V. Zizanioides* in combination with BNRAS was found efficient in municipal wastewater treatment.

1. Introduction

The Biological Nutrient Removal Activated Sludge (BNRAS) process comprising of biological reactor and a secondary settler is used widely as secondary treatment for both municipal and industrial wastewaters. There are problems associated with BNRAS which makes it difficult to recycle its effluents directly. According to Martins et al. (2004); Graham and Smith (2004), unsuccessful sludge settlement and failure of wastewater treatment due to loss or inactivation of key populations are some of the problems associated with BNRAS effluents. Wastewater treatment using conventional BNRAS requires long sludge age for nitrification and there is always difficulty in near complete nitrogen removal (Muller et al., 2004). To achieve higher effluent quality, membrane systems such as microfiltration, ultra filtration and reverse osmosis are used (Bai and Leow, 2002). This treatment processes are expensive and requires high level of skill workers. External Nitrification is employed in some cases as observed in Muller et al. (2004). However, there is need for low cost alternative tertiary wastewater treatment systems which Constructed Wetlands provide.

Constructed Wetland (CW) is a cost-effective wastewater treatment alternative with promising performance to treat domestic, agricultural and industrial wastewater (Badejo et al., 2015: Kouawa et al., 2015). CWs act as bio-filters to remove nutrients, pathogenic microorganisms, persistent organic pollutants and trace elements from industrial and domestic wastewater (Kadlec and Wallace, 2009; Brix, 1997). They are engineered ecosystems that use natural processes involving wetland vegetation, soils and microbial assemblages in improving the quality of water usually in a controlled environment (Maine et al., 2007; Vymazal, 2011).

CWs are complex matrix of distinct aerobic and anaerobic treatment zones. They are wastewater treatment facilities duplicating the processes occurring in natural wetlands. Constructed wetlands can be classified based on the type of macrophytic growth (emergent, submerged, free floating and rooted with floating leaves) or the water flow regime (surface flow, sub-surface, vertical or horizontal flow). They are classified broadly as Free water surface (FWS) wetlands or surface flow (SF) constructed wetlands, and

* Corresponding author at: Department of Civil Engineering, Federal University of Agriculture, Abeokuta, P.M.B. 2240, Ogun State, Nigeria.
E-mail address: badejoaa@funaab.edu.ng (A.A. Badejo).

http://dx.doi.org/10.1016/j.ecoleng.2016.11.012
0925-8574/