Journal of Water Process Engineering 80 (2025) 109168

Contents lists available at ScienceDirect

Journal of Water Process Engineering

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

Assessment of piggery wastewater treatment in vertical flow constructed wetlands: role of plants and aeration

D.O. Corrêa [a], A. Ferreira [a], B. Ribeiro [a], J. Gogoi [b], N. Karan [b], A. Nalwad [b], A. Ganguly [b], S. Mutnuri [b], L. Gouveia [a,c,*]

[a] LNEG, National Laboratory of Energy and Geology I.P., Bioenergy and Biorefineries Unit, Estrada do Paço do Lumiar 22, 1649-038, Lisbon, Portugal
[b] Water Sanitation and Hygiene Laboratory, Department of Biological Sciences, Birla Institute of Technology and Science, KK Birla Goa Campus, NH 17 B, Zuarinagar, Goa, 403 726, India
[c] Green CoLab - Green Ocean Technologies and Products Collaborative Laboratory, Centro de Ciências do Mar do Algarve, Universidade do Algarve, Campus Gambelas, Edifício 7, 8005-139, Faro, Portugal

ARTICLE INFO

Editor: Meng Wang

Keywords:
Constructed wetlands
Swine effluent
Chemical oxygen demand
Nitrogen
Phosphate

ABSTRACT

Piggery wastewater (PWW), rich in pollutants, poses significant environmental risks if not properly treated. Natural treatment processes, such as constructed wetlands (combined action of plants, substrates, and microbes) and microalgae cultivation, offer sustainable and low-cost alternatives for managing these effluents while enabling resource recovery. This study represents an initial step toward optimizing key operational conditions, such as aeration (passive and active), vegetation presence, and the use of single or sequential Vertical Flow Constructed Wetlands (VFCWs), for the treatment of piggery wastewater, using different experimental setups, at a laboratory scale. Indoor experiments were conducted over an 8-week period to optimize operational conditions for the treatment of PWW. The VFCWs, arranged in two stages and operated in series through gravity flow, were fed daily and monitored weekly. The best removal rates of total Kjeldahl nitrogen (42.9 %), ammoniacal nitrogen (50.3 %), and chemical oxygen demand (20.5 %), were observed in the second stage of VFCW without aeration and with plant. Nitrate and phosphorus levels increased during the experiment, likely due to microbial activity within the substrate and plant root zones. The final goal is to treat the piggery wastewater from a rural farm in India, produce electricity (by a Microbial Fuel Cell), to generate an effluent suitable for microalgae cultivation, with the produced biomass intended for use either as a biostimulant to enhance cereal crops included in pig diets or as a direct nutritional supplement in pig feed.

1. Introduction

Animal husbandry and livestock sectors play a critical role in livelihoods and global economic development, particularly in countries like Portugal and India. Among livestock, pigs are economically attractive due to their high fecundity, efficient feed conversion, early maturity, and short generation intervals [1]. However, pig farming generates large volumes of highly pollutant wastewater, containing organic matter, nutrients (N, P, K), heavy metals (e.g., Cu, Fe, Zn), pathogens, and pharmaceuticals (e.g., antibiotics, hormones), which pose serious risks to human health and the environment if not properly treated [2,3].

Conventional wastewater treatment methods are often expensive, energy-intensive, and generate greenhouse gas emissions [4], making them less feasible for small and poor communities. Therefore, there is a growing need for more sustainable and cost-effective alternatives. Recycling and reusing wastewater is a key strategy to alleviate water scarcity while protecting the environment.

Constructed wetlands (CWs) are nature-based solutions that provide cost-effective, low-energy, and environmentally friendly wastewater treatment, particularly suitable for small- to medium-sized communities and decentralized systems [5–7]. Compared to conventional technologies, CWs offer several practical and ecological advantages. Since they are self-sustaining systems that rely on the combined action of natural elements (substrate, plants, and microbes), CWs require minimal chemical or mechanical inputs. Consequently, they have minimal waste generation compared to conventional chemical-heavy treatments.

* Corresponding author at: LNEG, National Laboratory of Energy and Geology I.P., Bioenergy and Biorefineries Unit, Estrada do Paço do Lumiar 22, 1649-038, Lisbon, Portugal.
E-mail address: luisa.gouveia@lneg.pt (L. Gouveia).

https://doi.org/10.1016/j.jwpe.2025.109168
Received 26 June 2025; Received in revised form 30 October 2025; Accepted 18 November 2025
Available online 22 November 2025